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Human Health and Ecological Risk Assessment for the Operation of the Explosives Waste Treatment Facility at Site 300 of the Lawrence Livermore National Laboratory

Volume 1: Report of Results

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Background Information about Types of Explosives

(adapted from Mitchell, 1999)

High Explosive. An energetic material in which the decomposition process (detonation wave) proceeds through the entire material at supersonic speed. The rate at which the detonation wave passes through the energetic material depends on a large number of parameters, including the density of the energetic material, the heat released by the detonation, the geometric shape or dimensions of the energetic material, the degree of confinement, and the purity of the energetic material(s). High explosives can be divided into two subcategories: primary high explosives that detonate easily when exposed to an ignition source, and secondary high explosives that require the detonation of a primary high explosive before they detonate. Fuses and boosting charges are examples of primary high explosives. Trinitrotoluene (TNT), Research Department Explosive (RDX), tetryl, and nitroglycerin are examples of secondary explosives.

Low Explosive. An energetic material in which the decomposition process (deflagration) occurs at subsonic speed. The decomposition occurs only on the surface of the energetic material; and, unlike the high explosive, there is no shock wave. The rate determining factors for decomposition of a low explosive are the rate of heat transfer into the energetic material from the decomposition occurring on its surface and the rate of decomposition of the energetic material itself. The pressure that the decomposition products exert on the energetic material also affects the rate of heat transfer. Low explosives are usually divided into three largely unrelated categories: black powder (a mixture of sulfur, charcoal and potassium nitrate), pyrotechnics (materials used to produce light, smoke, heat or sound effects), and propellants (materials used for the propulsion of projectiles or rockets).

Propellant. A low-explosive energetic material. Some of the most commonly used propellant ingredients are nitrocellulose, nitroglycerin, and ammonium perchlorate. Propellants are placed into five subcategories based on their energetic composition: (1) single base, which contains only nitrocellulose; (2) double-base, which contains nitrocellulose and nitroglycerin; (3) triple-base, which contains nitrocellulose, nitroglycerin, and nitroguanidine; (4) ammonium perchlorate; and (5) composite, which contains an oxidizer, such as ammonium perchlorate, and a metal additive (e.g., powdered aluminum) held together by a polymeric substance, such as polybutadiene.

Human Health and Ecological Risk Assessment for the Operation of the Explosives Waste Treatment Facility at Site 300 of the Lawrence Livermore National Laboratory

Executive Summary

Human health and ecological risk assessments are required as part of the Resource Recovery and Conservation Act (RCRA) permit renewal process for waste treatment units. This risk assessment is prepared in support of the RCRA permit renewal for the Explosives Waste Treatment Facility (EWTF) at Site 300 of the Lawrence Livermore National Laboratory (LLNL).

The human health risk assessment is based on U.S. Environmental Protection Agency-(U.S. EPA) approved emissions factors and on California Environmental Protection Agency (CalEPA), California Air Resources Board (CARB) and U.S. EPA assessment and air dispersion models. This risk assessment identifies the receptors of concern and evaluates theoretical carcinogenic risk, and theoretical acute and chronic non-carcinogenic hazard, following those guidelines. The carcinogenic risk to a 30-year resident at the maximum off-site receptor location is 0.0000006 or 0.6 in 1 million. The carcinogenic risk to a 25-year worker at the maximum bystander on-site receptor location is also 0.0000006 or 0.6 in 1 million. Any risk of less than 1 in a million is below the level of regulatory concern. The acute non-carcinogenic hazard for the 30-year resident is 0.01, and the chronic non-carcinogenic hazard is 0.01. The acute non-carcinogenic hazard for the 25-year worker is 0.3, and the chronic non-carcinogenic hazard is 0.2. The point of comparison for acute and chronic non-carcinogenic hazard is 1.0; an estimate less than 1.0 is below the level of regulatory concern. The estimates of health effects are based on health conservative assumptions and represent an upper bound of the possible exposures to the receptors. Based on these results, emissions from the operations of the EWTF should not be of concern for human health.

For the ecological risk assessment (ERA), nine receptor species, representing members of the trophic levels in the habitat of Site 300, were evaluated for the possibility of potential detrimental effects from EWTF emissions. The ecological hazard quotients (EHQs) at a location closest to the EWTF suggest a potential for adverse consequences. However, the conservatisms incorporated into the analysis may overestimate potential consequences and may explain the potential for impacts. Using less conservative, but equally applicable, avian toxic reference values (TRV) for cadmium and lead suggests that no additional impact will occur from the continuing operation of the EWTF.

Human Health and Ecological Risk Assessment for the Operation of the Explosives Waste Treatment Facility at Site 300 of the Lawrence Livermore National Laboratory

1. Introduction

This document contains the human health and ecological risk assessment for the Resource Recovery and Conservation Act (RCRA) permit renewal for the Explosives Waste Treatment Facility (EWTF). Volume 1 is the text of the risk assessment, and Volume 2 (provided on a compact disc) is the supporting modeling data. The EWTF is operated by the Lawrence Livermore National Laboratory (LLNL) at Site 300, which is located in the foothills between the cities of Livermore and Tracy, approximately 17 miles east of Livermore and 8 miles southwest of Tracy. Figure 1 is a map of the San Francisco Bay Area, showing the location of Site 300 and other points of reference.

One of the principal activities of Site 300 is to test what are known as "high explosives" for nuclear weapons. These are the highly energetic materials that provide the force to drive fissionable material to criticality. LLNL scientists develop and test the explosives and the integrated non-nuclear components in support of the United States nuclear stockpile stewardship program as well as in support of conventional weapons and the aircraft, mining, oil exploration, and construction industries.

Many Site 300 facilities are used in support of high explosives research. Some facilities are used in the chemical formulation of explosives; others are locations where explosive charges are mechanically pressed; others are locations where the materials are inspected radiographically for such defects as cracks and voids. Finally, some facilities are locations where the machined charges are assembled before they are sent to the on-site test firing facilities, and additional facilities are locations where materials are stored.

Wastes generated from high-explosives research are treated by open burning (OB) and open detonation (OD). OB and OD treatments are necessary because they are the safest methods for treating explosives wastes generated at these facilities, and they eliminate the requirement for further handling and transportation that would be required if the wastes were treated off site.

Figure 1. Location of Site 300.

2. OB/OD Operations at Site 300

OB/OD operations are conducted at the EWTF located at the Building 845 Complex at Site 300. The EWTF consists of three units: the detonation pad, the burn pan, and the burn cage.

The detonation pad, shown in Figure 2, is used for the treatment of those waste explosives whose configuration requires treatment by open detonation, i.e., those wastes in a form that cannot be safely treated by open burning. The materials treated are 90 to 100 percent explosive materials. The detonation pad consists of a level, 30-foot x 30-foot (9-m x 9-m) gravel pad with minimum gravel pack about 8 feet (2.4 m) thick. Detonation of explosives waste is accomplished with the use of detonators or other initiating devices, and the process is controlled remotely from the Building 845 control bunker under observation by surveillance cameras. No more than 350 pounds (159 kg) of explosives waste (net explosive weight) may be detonated at one time. The detonation process is virtually instantaneous.

Figure 2. EWTF detonation pad.

The burn pan is used for the treatment of small pieces and powders of explosives wastes. These materials are 80 to 100 percent explosive materials that will not detonate during the thermal treatment process. The burn pan is a 4-foot x 8-foot x 0.5-foot-deep, rectangular, welded steel, watertight pan mounted on steel legs. The pan is equipped with a remotely controlled, removable cover. Pieces of explosives waste are placed in the pan, and cellulose material or other combustible materials are used to initiate treatment by burning. No more than 100 pounds (45 kg) of explosives waste (net explosive weight) may be treated at one time. The duration of the combustion treatment is 10 minutes or less. Figure 3 is a photograph of the burn pan.

Figure 3. EWTF burn pan, covered. (UCRL-Photo-213179, July 16, 2005)

The burn cage is used for the treatment of explosives-containing process waste sludge, explosives-contaminated packaging, and explosives-contaminated laboratory waste. The explosive content of the material treated in the burn cage ranges from 1 to 80 percent. The burn cage is an 8-foot-diameter, ventilated, metal enclosure with a refractory lining and an elevated metal base. Propane fuel from a protected supply tank is supplied to the burn cage to assist the combustion process. No more than 260 pounds (118 kg) of total waste and 50 pounds (23 kg) net explosive waste may be treated in the burn cage at one time. Combustion treatments at the burn cage are completed in 35 minutes. Figure 4 is a photograph of the burn cage.

EWTF operations and controls are handled from a concrete and steel control bunker at Building 845 (see Figure 5).

Figure 4. EWTF burn cage. (UCRL-Photo-213179, July 16, 2005)

Figure 5. EWTF control bunker (Building 845A). Detonation pad is in the background.

Figure 6 is a site map for Site 300, showing the central location of the EWTF; this location maximizes the distance to off-site receptors. The inset in Figure 6 shows the relative locations of the detonation pad, the burn pan, and the burn cage.

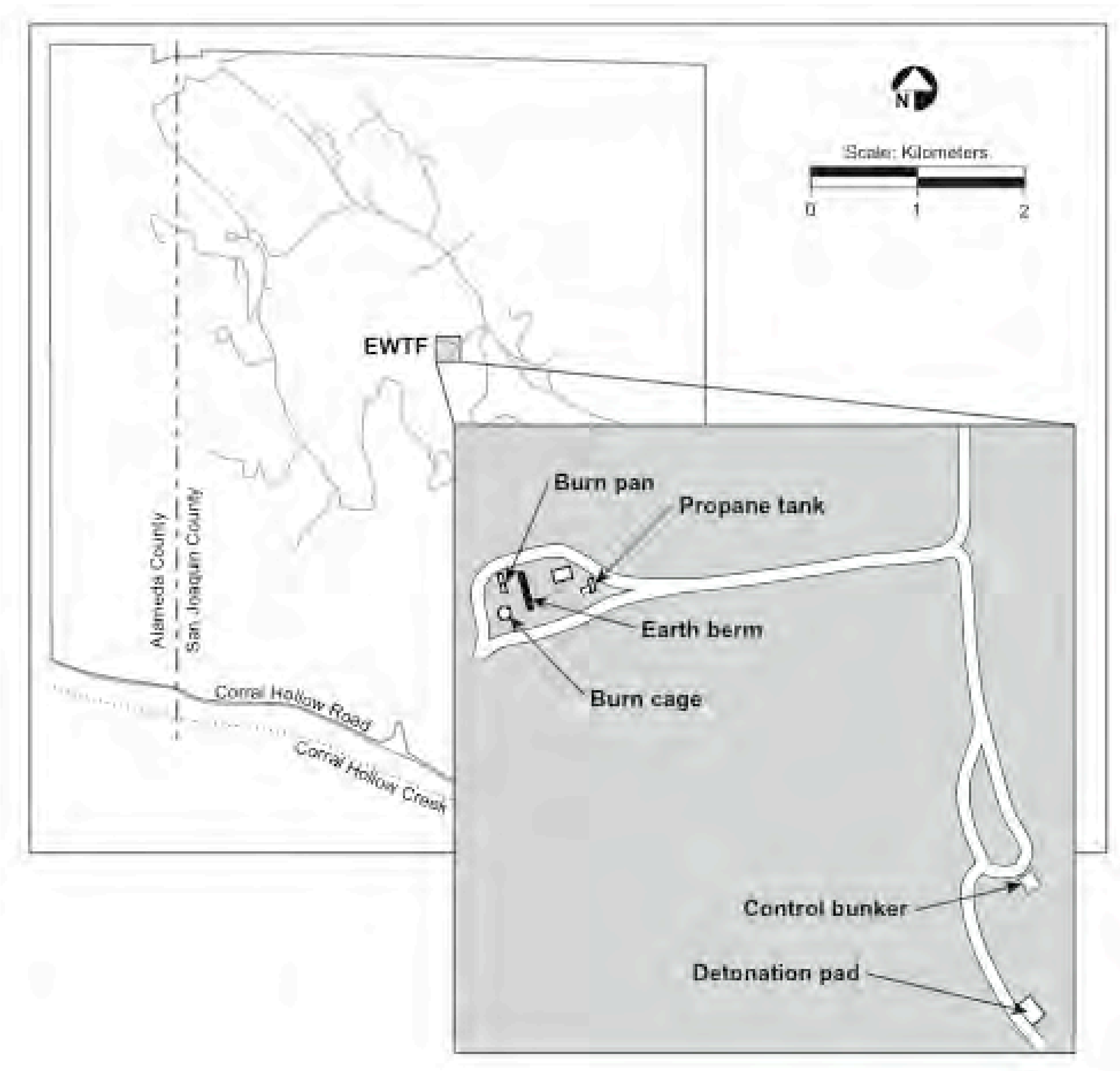

Figure 6. Location of the EWTF at Site 300.

3. Approach

The standard approach for a human health risk assessment is a four-step process stated by the National Academy of Sciences in *Risk Assessment in the Federal Government: Managing the Process* (NAS, 1983) and reiterated in *The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments* (Office of Environmental Health Hazard Assessment [OEHHA], 2003). The four steps in the process are (1) hazard identification, (2) exposure assessment, (3) dose-response assessment, and (4) risk characterization.

For the operations at the EWTF, the first step, hazard identification, involves identifying emissions from the operations, i.e., the source term of specific pollutants of concern. Exposure assessment, the second step, involves emission quantification, modeling of environmental transport and fate, identification of exposure routes, identification of maximally exposed individuals, and estimation of short- and long-term exposures. The third step, dose-response assessment, characterizes the relationship between the exposure to a pollutant and any potential resulting health effect. For quantitative theoretical carcinogenic risk assessment, the dose-response relationship is estimated using cancer potency factors (CPFs) compiled by OEHHA and the U.S. Environmental Protection Agency (U.S. EPA) to calculate the theoretical risk of cancer associated with the estimated exposure. For non-carcinogenic acute and chronic effects, the dose-response relationship is quantified by comparison of modeled air concentrations with OEHHA- and U.S. EPA-defined acute and chronic reference exposure levels (RELs) for the inhalation pathway; and for the ingestion pathway, modeled dose is compared with a reference dose (RfD). The fourth and final step, risk characterization, combines the modeled exposures of the specific pollutants of concern with the dose-response relationship defined by a regulatory authority to estimate the potential health risks associated with the exposures. Each of these steps is discussed in this risk assessment.

3.1 Hazard Identification

The EWTF is a support facility at LLNL's Site 300 where wastes resulting from research activities involving explosives are treated. Most of the explosive wastes treated at Site 300 involve high explosives, such as the compounds Research Department Explosive (RDX), high melting explosive (HMX), and pentaerythritol tetranitrate (PETN), in a variety of formulations. Explosives other than high explosives are treated more rarely. The wastes treated at the EWTF are categorized into four forms described below:

Form 1 Waste. Waste explosives that, because of configuration or composition, are best treated by open detonation. Examples are explosive assemblies or devices that may detonate during open burning.

Form 2 Waste. Waste explosives that, because of configuration or composition, are best treated by open burning in the open burn pan. Examples are explosive parts and pieces generated during explosives formulation, processing, testing, or by removal from inventory.

Form 3 Waste. Waste explosives that, because of configuration or composition, are best treated by open burning in the thermal treatment unit (burn cage). Examples are wet machine fines generated during explosives processing, wet explosives-contaminated sludge from weirs and settling basins, and wet expendable filters from recycle systems.

Form 4 Waste. Waste material contaminated with energetic materials that are best treated by open burning in the thermal treatment unit (burn cage). Examples are paper, rags, plastic tubing, dry expendable filters from vacuum systems, and personal protective equipment used in explosives operations. The waste is judged to retain explosives hazards and is, therefore, considered to be a reactive waste.

Current permit limits allow 100 open detonations (Form 1 waste) and 100 open burn treatments (Forms 2, 3, or 4) annually. Table 1 presents the maximum mass amounts of treated material by treatment unit and waste form.

Table 1. Mass amounts of treated material by treatment unit and waste form.

Treatment unit/Waste form	Annual number of treatments	Maximum single treatment (lb)	Annual treatment (lb)
Detonation Pad/Form 1	100	350	35,000
Burn Pan/Form 2		100	10,000[a]
Burn Cage/Form 3	100	50	5,000[a]
Burn Cage/Form 4		260	26,000[a]

[a] Assuming 100 treatments at each unit; no accounting is made for the allocation of 100 permitted burn treatments among the three burn treatment options.

The estimation of potential emissions for explosives wastes is a subject of interest to both the EPA and the U.S. Department of Defense (DoD). The DoD has been seriously studying emissions from OB/OD operations since 1984. In the first comprehensive test, helicopters equipped with air sampling equipment were flown through plumes from OB and OD tests. The results were inconclusive. In 1988, the DoD began a series of studies that were contained in a large chamber called a "BangBox" at Sandia National Laboratories, Albuquerque, NM. After the first two studies, " the DoD concluded that the emission factors derived from the BangBox tests were: (1) more reliable and reproducible than those from the field tests; (2) were *[sic]* statistically equivalent to these determined from the field tests; and (3) supported the original assumption that the detonations and burns were producing emission products consistent with detonation theory" (Mitchell and Suggs, 1998, p. 9). The DoD also determined that the materials emitted from field tests and BangBox studies were similar for all materials tested and were primarily N_2, CO_2, H_2O, particles, metals, and small quantities of CO, NO, NO_2, low molecular weight volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) often found in ambient air.

In 1992, the EPA agreed to accept emission factors for OB/OD based on BangBox studies. The DoD built a BangBox at Dugway Proving Grounds in Dugway, UT, and conducted an additional series of studies that encompassed the open burning of 16 energetic materials and open detonation of 23 energetic materials. In 1998, EPA released a report summarizing the results and presenting emissions factors for OB/OD operations (Mitchell and Suggs, 1998). These emissions factors were incorporated into the Open Burn/Open Detonation Dispersion Model (OBODM) developed expressly for modeling OB/OD operations (Bjorklund et al., 1998). The emission factors in the OBODM were used to characterize air emissions due to the EWTF treatment activities.

Table 2 lists all 39 energetic materials that are contained in the OBODM. Although some of the 39 energetic materials are not treated at the EWTF, they are listed for completeness so that the method for source term identification would be totally transparent. Table 2 also lists the EWTF waste form in which the materials could be found, the methods by which the materials can be treated at the EWTF, and the frequency that the materials are treated at the EWTF. As seen in Table 2, three materials are routinely treated, 15 materials are treated with less than 5 percent frequency, and six materials are treated with less than 1 percent frequency. Two other materials could be treated after additional internal review, but they are not expected to be treated. Thirteen other materials are not treated at the EWTF.

This risk assessment used a reasonable[1] yet conservative approach to characterize air emissions due to EWTF treatment activities (i.e., emissions from Form 1 waste treatment at the detonation pad, Form 2 waste treatment at the burn pan, Form 3 waste treatment at the burn cage, and Form 4 waste treatment at the burn cage). First, a subset of the energetic materials contained in the OBODM, with similar compositions to those treated at the EWTF, was identified. Second, the identified materials were mapped to the EWTF waste form in which they could be present. Third, the energetic materials (and their emission factors) were grouped by type of treatment and waste form. For example, the energetic materials (and their emission factors) for Form 1 waste treatment at the detonation pad include TNT, RDX, Explosive D, Composition B, Tritanol, Amatol, HBX, etc. (see Table 2). Finally, the maximum chemical-specific emission factor was selected for each type of treatment and waste form.

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[1] This is similar to the approach taken by the U.S. Navy and affirmed by the Agency for Toxic Substances Disease Registry (ATSDR) in evaluating emissions from Isla de Vieques, Puerto Rico, bombing range (http://www.atsdr.cdc.gov/HAC/PHA/vieques4/vbr_p5.html): "ATSDR further believes the Navy contractor's approach used to select emission factors from the available Bangbox studies was appropriate. For instance, to characterize emissions from air-to-ground exercises, the Navy contractor first identified the subset of Bangbox studies that tested explosives with similar compositions to those used at Vieques, and then selected the highest emission factor for every chemical from the various tests. As a result, the emission factors used are the highest measured releases of chemical by-products from the available Bangbox studies."

Table 2. Materials tested in the BangBox experiments, the treatment frequency at the EWTF, type of treatment at the EWTF, and associated EWTF waste form.

Tested material	Frequency of material[a] treatment at the EWTF	Type of treatment at the EWTF	EWTF waste form
TNT (2,4,6-Trinitrotoluene)	Routinely treated	Detonation Pad (Form 1), Burn Pan (Form 2)	1 and 2
RDX (cyclotrimethylenetrinitramine)	Routinely treated	Detonation Pad (Form 1), Burn Pan (Form 2)	1 and 2
Manufacturer's Waste (65% propell.)	Routinely treated	Burn Cage	3 and 4
Triple Base (M30-28% Nitrocellulose	<5%	Burn Pan	2
M1 (85% Nitrocellulose)	<5%	Burn Pan	2
Double Base (50% nitrocellulose)	<5%	Burn Pan	2
Propellant, ammonium perc., alum.	<5%	Burn Pan	2
Propellant, ammonium perc., nonal.	<5%	Burn Pan	2
Propellant, M-43	<5%	Burn Pan	2
Propellant, M-9	<5%	Burn Pan	2
Propellant, MK-23	<5%	Burn Pan	2
Propellant, M31A1E1	<5%	Burn Pan	2
Propellant, PBXN-110	<5%	Burn Pan	2
Smokeless Powder	<5%	Burn Pan	2
Propellant, Composite (MK-6)	<5%	Burn Pan	2
Propellant, M-3	<5%	Burn Pan	2
M6 (87.7% Nitrocellulose)	<5%	Burn Pan	2
Explosive D (ammonium picrate)	<5%	Detonation Pad (Form 1), Burn Pan (Form 2)	1 and 2
Composition B (56/38/6 RDX-TNT-WAX)	<1%	Detonation Pad	1
Tritonal (79% TNT, 21% Aluminum)	<1%	Detonation Pad	1
Tritonal with 2.5% Calcium Stearate	<1%	Detonation Pad	1
Amatol (50% TNT, 50% Ammn. Nitrate)	<1%	Detonation Pad	1
HBX (48/31/17/4 RDX-TNT-Al-WAX)	<1%	Detonation Pad	1
Propellant, Smokey Sam	<1%	Burn Pan	2
Detonating train	Only with additional internal review	Detonation Pad	1
40 mm HEI Cartridge	Only with additional internal review	Detonation Pad	1
Ground Illum. Signal, Red Star, M158	Not treated	Not treated	Not applicable
Signal, Illum, Arcrft, Rd Str, AN-M43A2	Not treated	Not treated	Not applicable
20 mm HEI Cartridge	Not treated	Not treated	Not applicable

Tested material	Frequency of material[a] treatment at the EWTF	Type of treatment at the EWTF	EWTF waste form
Impluse Cartridge, ARD 446-1	Not treated	Not treated	Not applicable
Impluse BBU-368 Cartridge	Not treated	Not treated	Not applicable
GGU-2/A Gas prss Prop. Act. Gen.	Not treated	Not treated	Not applicable
Impulse Cartridge, MK107 MOD01	Not treated	Not treated	Not applicable
Fuze, Inertia Tail, Bomb, FMU 54A/B	Not treated	Not treated	Not applicable
Flare, Cntermeas., Aircraft, M206	Not treated	Not treated	Not applicable
Fuze, Bomb, Tail, FMU 139A/B	Not treated	Not treated	Not applicable
Mine, Claymore, M18A1	Not treated	Not treated	Not applicable
T45E7 Adapter Booster	Not treated	Not treated	Not applicable
Diesel and Dunnage	Not treated	Not treated	Not applicable

[a] Material representative of materials treated at the EWTF.

The resulting emissions factors by type of treatment are presented in Table 3. As previously mentioned, the detonation pad only treats Form 1 wastes, the burn pan treats only Form 2 wastes and the burn cage treats only Form 3 and Form 4 wastes.

The emissions factors were used to calculate maximum hourly and annual average emissions from the EWTF. Maximum hourly emissions were calculated as follows: The maximum treatment amount for a single treatment was multiplied times the emission factor for each emitted chemical for each waste form. Annual average emissions were calculated in a similar manner: The annual treatment amount was multiplied by the emission factor for each emitted chemical for each waste form.

Table 3. Emissions factors for the burn pan, burn cage, and detonation pad at the EWTF.

Analyte ID	Analyte name	Burn pan emission factor (lb/lb)	Burn cage emission factor (lb/lb)	Detonation pad emission factor (lb/lb)
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran		3.40E-08	
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran		7.90E-09	
70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran		2.10E-08	
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran		9.50E-09	
39001-02-0	Octachlorinated dibenzofuran		4.00E-08	
106-99-0	1,3-Butadiene	1.70E-06		9.00E-06
121-14-2	2,4-Dinitrotoluene	1.20E-09		
606-20-2	2,6-Dinitrotoluene	1.00E-10		
95-57-8	2-Chlorophenol	1.00E-05		
7429-90-5	Aluminum	1.10E-02	3.60E-02	2.50E-02
7440-36-0	Antimony	6.70E-07		6.70E-07
7440-39-3	Barium	8.20E-03	8.60E-05	8.20E-03
71-43-2	Benzene	1.20E-04	4.50E-04	1.10E-04

Analyte ID	Analyte name	Burn pan emission factor (lb/lb)	Burn cage emission factor (lb/lb)	Detonation pad emission factor (lb/lb)
7440-43-9	Cadmium	4.00E-05		4.00E-05
56-23-5	Carbon tetrachloride	1.10E-06	5.60E-06	4.50E-06
67-66-3	Chloroform	4.20E-07	2.30E-06	3.80E-07
7440-47-3	Chromium[a]	4.80E-05		8.80E-05
7782-50-5	Cl_2	9.20E-03	2.00E-04	
630-08-0	CO	7.20E-02	2.00E-02	5.30E-02
7440-50-8	Copper	3.70E-02	1.50E-05	8.90E-03
110-82-7	Cyclohexane	1.60E-06	2.00E-06	7.50E-06
122-39-4	Diphenylamine	2.60E-10		
75-00-3	Ethyl chloride			6.90E-07
100-41-4	Ethylbenzene	1.20E-06	2.40E-06	2.50E-06
206-44-0	Fluoranthene		2.00E-04	
7647-01-0	HCL	2.15E-01	8.30E-02	
98-82-8	i-Propylbenzene			7.30E-07
7439-92-1	Lead	1.20E-02	2.80E-04	1.10E-03
74-87-3	Methyl chloride	5.70E-06	2.00E-05	7.50E-07
71-55-6	Methyl chloroform			3.80E-07
108-87-2	Methylcyclohexane	5.10E-06	8.00E-06	7.00E-06
75-09-2	Methylenechloride	1.80E-04	1.20E-05	8.70E-04
91-20-3	Naphthalene	7.50E-08		
110-54-3	n-Hexane	1.90E-05	4.80E-06	1.90E-05
10102-44-0	Nitrogen dioxide (peroxide)	5.20E-03	6.60E-06	4.40E-03
78-11-5	Pentaerythritol tetranitrate (PETN)			5.60E-04
108-95-2	Phenol	3.43E-09		
115-07-1	Propene	7.20E-06	2.60E-05	7.30E-05
121-82-4	RDX	9.60E-06		7.40E-03
100-42-5	Styrene	1.50E-06		4.20E-05
7446-09-5	Sulfur dioxide	3.20E-03	8.60E-04	1.10E-03
127-18-4	Tetrachloroethylene		1.70E-06	1.80E-05
108-88-3	Toluene	8.60E-06	2.80E-05	2.60E-05
75-01-4	Vinyl chloride	1.50E-06		1.30E-06
7440-66-6	Zinc	4.00E-05	5.70E-04	1.10E-03
208-96-8	Acenaphthylene		1.60E-04	
86-57-7	n-Nitronaphthalene	1.40E-10		
620-14-4	m-Ethyltoluene	2.00E-06	2.60E-06	4.80E-07
622-96-8	p-Ethyltoluene	7.10E-06	5.00E-06	7.60E-06
106-98-9	1-Butene	1.60E-06	8.30E-06	3.10E-05

Analyte ID	Analyte name	Burn pan emission factor (lb/lb)	Burn cage emission factor (lb/lb)	Detonation pad emission factor (lb/lb)
592-41-6	1-Hexene			2.40E-05
109-67-1	1-Pentene	1.40E-06	5.10E-06	1.40E-05
74-86-2	Acetylene	8.30E-04	1.60E-03	1.30E-04
627-20-3	cis-2-Pentene	4.60E-07	5.60E-07	8.30E-07
287-92-3	Cyclopentane	4.70E-07	2.50E-07	1.70E-06
142-29-0	Cyclopentene	4.60E-07	9.40E-07	3.70E-06
74-84-0	Ethane	1.30E-06	9.50E-06	3.00E-05
74-85-1	Ethylene	7.20E-05	2.30E-04	3.90E-04
75-28-5	i-Butane	4.60E-07	1.40E-06	1.60E-06
115-11-7	i-Butene	1.00E-05	5.80E-06	2.40E-05
78-78-4	i-Pentane	2.60E-06	2.30E-05	9.10E-06
74-82-8	Methane	8.00E-03		2.40E-03
96-37-7	Methylcyclopentane	2.50E-06	1.10E-06	9.10E-06
106-97-8	n-Butane	4.80E-07	9.30E-06	3.10E-06
124-18-5	n-Decane	5.90E-06	1.40E-05	5.20E-06
142-82-5	n-Heptane	2.00E-06	4.70E-06	5.00E-06
111-84-2	n-Nonane	1.20E-06	1.30E-05	1.90E-06
111-65-9	n-Octane	2.90E-06	7.60E-06	3.60E-06
109-66-0	n-Pentane	3.30E-06	4.30E-06	1.30E-05
74-98-6	Propane	1.60E-06	4.50E-06	4.70E-06
624-64-6	trans-2-Butene	2.40E-06	2.10E-05	4.50E-06
646-04-8	trans-2-Pentene	4.60E-07	9.60E-07	5.00E-06

[a] Total Chromium

Also worthy of comment is the selection of emissions factors to represent Form 4 waste. The treatment of Form 4 waste in the burn cage was represented by the Bjorklund et al. (1998) emissions factors for ammonium perchlorate (AP) manufacturing waste surrogate. The AP manufacturing waste surrogate included plastic gloves, cotton rags, paper, wood, and similar material, and was burned using diesel fuel (Mitchell and Suggs, 1998). The burn cage at the EWTF does not use diesel fuel, but rather propane. It is expected that the combustion temperatures of propane minimize dioxin and furan formation; nevertheless, furan species were included for purposes of conservatism. Among the possible materials that could be used to represent Form 4 waste, the AP manufacturing waste surrogate is the most reasonable choice.

The resulting maximum hourly and annual average emissions for each waste form are shown in Tables 4 and 5. Although only a total of 100 burn treatments are permitted, all burn operations were calculated at 100 burns per year at this point in the assessment to enable comparison of effects later in the analysis.

Table 4. Maximum hourly estimated emissions for the burn pan, burn cage (Forms 3 and 4), and detonation pad at the EWTF.

Analyte ID	Analyte name	Burn pan	Burn cage Form 3	Burn cage Form 4	Detonation pad
67562-39-4	1,2,3,4,6,7,8-HpCDF	0.00E+00	1.70E-06	8.84E-06	0.00E+00
55673-89-7	1,2,3,4,7,8,9-HpCDF	0.00E+00	3.95E-07	2.05E-06	0.00E+00
70648-26-9	1,2,3,4,7,8-HxCDF	0.00E+00	1.05E-06	5.46E-06	0.00E+00
57117-44-9	1,2,3,6,7,8-HxCDF	0.00E+00	4.75E-07	2.47E-06	0.00E+00
39001-02-0	OCDF	0.00E+00	2.00E-06	1.04E-05	0.00E+00
106-99-0	1,3-Butadiene	1.70E-04	0.00E+00	0.00E+00	3.15E-03
121-14-2	2,4-Dinitrotoluene	1.20E-07	0.00E+00	0.00E+00	0.00E+00
606-20-2	2,6-Dinitrotoluene	1.00E-08	0.00E+00	0.00E+00	0.00E+00
95-57-8	2-Chlorophenol	1.00E-03	0.00E+00	0.00E+00	0.00E+00
7429-90-5	Aluminum	1.10E+00	1.80E+00	9.36E+00	8.75E+00
7440-36-0	Antimony	6.70E-05	0.00E+00	0.00E+00	2.35E-04
7440-39-3	Barium	8.20E-01	4.30E-03	2.24E-02	2.87E+00
71-43-2	Benzene	1.20E-02	2.25E-02	1.17E-01	3.85E-02
7440-43-9	Cadmium	4.00E-03	0.00E+00	0.00E+00	1.40E-02
56-23-5	Carbon tetrachloride	1.10E-04	2.80E-04	1.46E-03	1.58E-03
67-66-3	Chloroform	4.20E-05	1.15E-04	5.98E-04	1.33E-04
7440-47-3	Chromium	4.80E-03	0.00E+00	0.00E+00	3.08E-02
7782-50-5	Cl_2	9.20E-01	1.00E-02	5.20E-02	0.00E+00
630-08-0	CO	7.20E+00	1.00E+00	5.20E+00	1.86E+01
7440-50-8	Copper	3.70E+00	7.50E-04	3.90E-03	3.12E+00
110-82-7	Cyclohexane	1.60E-04	1.00E-04	5.20E-04	2.63E-03
122-39-4	Diphenylamine	2.60E-08	0.00E+00	0.00E+00	0.00E+00
75-00-3	Ethyl chloride	0.00E+00	0.00E+00	0.00E+00	2.42E-04
100-41-4	Ethylbenzene	1.20E-04	1.20E-04	6.24E-04	8.75E-04
206-44-0	Fluoranthene	0.00E+00	1.00E-02	5.20E-02	0.00E+00
7647-01-0	HCL	2.15E+01	4.15E+00	2.16E+01	0.00E+00
98-82-8	i-Propylbenzene	0.00E+00	0.00E+00	0.00E+00	2.56E-04
7439-92-1	Lead	1.20E+00	1.40E-02	7.28E-02	3.85E-01
74-87-3	Methyl chloride	5.70E-04	1.00E-03	5.20E-03	2.63E-04
71-55-6	Methyl chloroform	0.00E+00	0.00E+00	0.00E+00	1.33E-04
108-87-2	Methylcyclohexane	5.10E-04	4.00E-04	2.08E-03	2.45E-03
75-09-2	Methylenechloride	1.80E-02	6.00E-04	3.12E-03	3.05E-01
91-20-3	Naphthalene	7.50E-06	0.00E+00	0.00E+00	0.00E+00
110-54-3	n-Hexane	1.90E-03	2.40E-04	1.25E-03	6.65E-03
10102-44-0	Nitrogen dioxide (peroxide)	5.20E-01	3.30E-04	1.72E-03	1.54E+00

Analyte ID	Analyte name	Burn pan	Burn cage Form 3	Burn cage Form 4	Detonation pad
78-11-5	Pentaerythritol tetranitrate (PETN)	0.00E+00	0.00E+00	0.00E+00	1.96E-01
108-95-2	Phenol	3.43E-07	0.00E+00	0.00E+00	0.00E+00
115-07-1	Propene	7.20E-04	1.30E-03	6.76E-03	2.56E-02
121-82-4	RDX	9.60E-04	0.00E+00	0.00E+00	2.59E+00
100-42-5	Styrene	1.50E-04	0.00E+00	0.00E+00	1.47E-02
7446-09-5	Sulfur dioxide	3.20E-01	4.30E-02	2.24E-01	3.85E-01
127-18-4	Tetrachloroethylene	0.00E+00	8.50E-05	4.42E-04	6.30E-03
108-88-3	Toluene	8.60E-04	1.40E-03	7.28E-03	9.10E-03
75-01-4	Vinyl chloride	1.50E-04	0.00E+00	0.00E+00	4.55E-04
7440-66-6	Zinc	4.00E-03	2.85E-02	1.48E-01	3.85E-01
208-96-8	Acenaphthylene	0.00E+00	8.00E-03	4.16E-02	0.00E+00
86-57-7	n-Nitronaphthalene	1.40E-08	0.00E+00	0.00E+00	0.00E+00
620-14-4	m-Ethyltoluene	2.00E-04	1.30E-04	6.76E-04	1.68E-04
622-96-8	p-Ethyltoluene	7.10E-04	2.50E-04	1.30E-03	2.66E-03
106-98-9	1-Butene	1.60E-04	4.15E-04	2.16E-03	1.09E-02
592-41-6	1-Hexene	0.00E+00	0.00E+00	0.00E+00	8.40E-03
109-67-1	1-Pentene	1.40E-04	2.55E-04	1.33E-03	4.90E-03
74-86-2	Acetylene	8.30E-02	8.00E-02	4.16E-01	4.55E-02
627-20-3	cis-2-Pentene	4.60E-05	2.80E-05	1.46E-04	2.91E-04
287-92-3	Cyclopentane	4.70E-05	1.25E-05	6.50E-05	5.95E-04
142-29-0	Cyclopentene	4.60E-05	4.70E-05	2.44E-04	1.30E-03
74-84-0	Ethane	1.30E-04	4.75E-04	2.47E-03	1.05E-02
74-85-1	Ethylene	7.20E-03	1.15E-02	5.98E-02	1.37E-01
75-28-5	i-Butane	4.60E-05	7.00E-05	3.64E-04	5.60E-04
115-11-7	i-Butene	1.00E-03	2.90E-04	1.51E-03	8.40E-03
78-78-4	i-Pentane	2.60E-04	1.15E-03	5.98E-03	3.19E-03
74-82-8	Methane	8.00E-01	0.00E+00	0.00E+00	8.40E-01
96-37-7	Methylcyclopentane	2.50E-04	5.50E-05	2.86E-04	3.19E-03
106-97-8	n-Butane	4.80E-05	4.65E-04	2.42E-03	1.09E-03
124-18-5	n-Decane	5.90E-04	7.00E-04	3.64E-03	1.82E-03
142-82-5	n-Heptane	2.00E-04	2.35E-04	1.22E-03	1.75E-03
111-84-2	n-Nonane	1.20E-04	6.50E-04	3.38E-03	6.65E-04
111-65-9	n-Octane	2.90E-04	3.80E-04	1.98E-03	1.26E-03
109-66-0	n-Pentane	3.30E-04	2.15E-04	1.12E-03	4.55E-03
74-98-6	Propane	1.60E-04	2.25E-04	1.17E-03	1.65E-03
624-64-6	trans-2-Butene	2.40E-04	1.05E-03	5.46E-03	1.58E-03
646-04-8	trans-2-Pentene	4.60E-05	4.80E-05	2.50E-04	1.75E-03

Table 5. Maximum annual estimated emissions for the burn pan, burn cage (Forms 3 and 4), and detonation pad at the EWTF

Analyte ID	Analyte name	Burn pan	Burn cage Form 3	Burn cage Form 4	Detonation pad
67562-39-4	1234678-HpCDF	0.00E+00	1.70E-04	8.84E-04	0.00E+00
55673-89-7	1234789-HpCDF	0.00E+00	3.95E-05	2.05E-04	0.00E+00
70648-26-9	123478-HxCDF	0.00E+00	1.05E-04	5.46E-04	0.00E+00
57117-44-9	123678-HxCDF	0.00E+00	4.75E-05	2.47E-04	0.00E+00
39001-02-0	OCDF	0.00E+00	2.00E-04	1.04E-03	0.00E+00
106-99-0	1,3-Butadiene	1.70E-02	0.00E+00	0.00E+00	3.15E-01
121-14-2	2,4-Dinitrotoluene	1.20E-05	0.00E+00	0.00E+00	0.00E+00
606-20-2	2,6-Dinitrotoluene	1.00E-06	0.00E+00	0.00E+00	0.00E+00
95-57-8	2-Chlorophenol	1.00E-01	0.00E+00	0.00E+00	0.00E+00
7429-90-5	Aluminum	1.10E+02	1.80E+02	9.36E+02	8.75E+02
7440-36-0	Antimony	6.70E-03	0.00E+00	0.00E+00	2.35E-02
7440-39-3	Barium	8.20E+01	4.30E-01	2.24E+00	2.87E+02
71-43-2	Benzene	1.20E+00	2.25E+00	1.17E+01	3.85E+00
7440-43-9	Cadmium	4.00E-01	0.00E+00	0.00E+00	1.40E+00
56-23-5	Carbon tetrachloride	1.10E-02	2.80E-02	1.46E-01	1.58E-01
67-66-3	Chloroform	4.20E-03	1.15E-02	5.98E-02	1.33E-02
7440-47-3	Chromium	4.80E-01	0.00E+00	0.00E+00	3.08E+00
7782-50-5	Cl_2	9.20E+01	1.00E+00	5.20E+00	0.00E+00
630-08-0	CO	7.20E+02	1.00E+02	5.20E+02	1.86E+03
7440-50-8	Copper	3.70E+02	7.50E-02	3.90E-01	3.12E+02
110-82-7	Cyclohexane	1.60E-02	1.00E-02	5.20E-02	2.63E-01
122-39-4	Diphenylamine	2.60E-06	0.00E+00	0.00E+00	0.00E+00
75-00-3	Ethyl chloride	0.00E+00	0.00E+00	0.00E+00	2.42E-02
100-41-4	Ethylbenzene	1.20E-02	1.20E-02	6.24E-02	8.75E-02
206-44-0	Fluoranthene	0.00E+00	1.00E+00	5.20E+00	0.00E+00
7647-01-0	HCL	2.15E+03	4.15E+02	2.16E+03	0.00E+00
98-82-8	i-Propylbenzene	0.00E+00	0.00E+00	0.00E+00	2.56E-02
7439-92-1	Lead	1.20E+02	1.40E+00	7.28E+00	3.85E+01
74-87-3	Methyl chloride	5.70E-02	1.00E-01	5.20E-01	2.63E-02
71-55-6	Methyl chloroform	0.00E+00	0.00E+00	0.00E+00	1.33E-02
108-87-2	Methylcyclohexane	5.10E-02	4.00E-02	2.08E-01	2.45E-01
75-09-2	Methylenechloride	1.80E+00	6.00E-02	3.12E-01	3.05E+01
91-20-3	Naphthalene	7.50E-04	0.00E+00	0.00E+00	0.00E+00
110-54-3	n-Hexane	1.90E-01	2.40E-02	1.25E-01	6.65E-01
10102-44-0	Nitrogen dioxide (peroxide)	5.20E+01	3.30E-02	1.72E-01	1.54E+02

Analyte ID	Analyte name	Burn pan	Burn cage Form 3	Burn cage Form 4	Detonation pad
78-11-5	Pentaerythritol tetranitrate (PETN)	0.00E+00	0.00E+00	0.00E+00	1.96E+01
108-95-2	Phenol	3.43E-05	0.00E+00	0.00E+00	0.00E+00
115-07-1	Propene	7.20E-02	1.30E-01	6.76E-01	2.56E+00
121-82-4	RDX	9.60E-02	0.00E+00	0.00E+00	2.59E+02
100-42-5	Styrene	1.50E-02	0.00E+00	0.00E+00	1.47E+00
7446-09-5	Sulfur dioxide	3.20E+01	4.30E+00	2.24E+01	3.85E+01
127-18-4	Tetrachloroethylene	0.00E+00	8.50E-03	4.42E-02	6.30E-01
108-88-3	Toluene	8.60E-02	1.40E-01	7.28E-01	9.10E-01
75-01-4	Vinyl chloride	1.50E-02	0.00E+00	0.00E+00	4.55E-02
7440-66-6	Zinc	4.00E-01	2.85E+00	1.48E+01	3.85E+01
208-96-8	Acenaphthylene	0.00E+00	8.00E-01	4.16E+00	0.00E+00
86-57-7	n-Nitronaphthalene	1.40E-06	0.00E+00	0.00E+00	0.00E+00
620-14-4	m-Ethyltoluene	2.00E-02	1.30E-02	6.76E-02	1.68E-02
622-96-8	p-Ethyltoluene	7.10E-02	2.50E-02	1.30E-01	2.66E-01
106-98-9	1-Butene	1.60E-02	4.15E-02	2.16E-01	1.09E+00
592-41-6	1-Hexene	0.00E+00	0.00E+00	0.00E+00	8.40E-01
109-67-1	1-Pentene	1.40E-02	2.55E-02	1.33E-01	4.90E-01
74-86-2	Acetylene	8.30E+00	8.00E+00	4.16E+01	4.55E+00
627-20-3	cis-2-Pentene	4.60E-03	2.80E-03	1.46E-02	2.91E-02
287-92-3	Cyclopentane	4.70E-03	1.25E-03	6.50E-03	5.95E-02
142-29-0	Cyclopentene	4.60E-03	4.70E-03	2.44E-02	1.30E-01
74-84-0	Ethane	1.30E-02	4.75E-02	2.47E-01	1.05E+00
74-85-1	Ethylene	7.20E-01	1.15E+00	5.98E+00	1.37E+01
75-28-5	i-Butane	4.60E-03	7.00E-03	3.64E-02	5.60E-02
115-11-7	i-Butene	1.00E-01	2.90E-02	1.51E-01	8.40E-01
78-78-4	i-Pentane	2.60E-02	1.15E-01	5.98E-01	3.19E-01
74-82-8	Methane	8.00E+01	0.00E+00	0.00E+00	8.40E+01
96-37-7	Methylcyclopentane	2.50E-02	5.50E-03	2.86E-02	3.19E-01
106-97-8	n-Butane	4.80E-03	4.65E-02	2.42E-01	1.09E-01
124-18-5	n-Decane	5.90E-02	7.00E-02	3.64E-01	1.82E-01
142-82-5	n-Heptane	2.00E-02	2.35E-02	1.22E-01	1.75E-01
111-84-2	n-Nonane	1.20E-02	6.50E-02	3.38E-01	6.65E-02
111-65-9	n-Octane	2.90E-02	3.80E-02	1.98E-01	1.26E-01
109-66-0	n-Pentane	3.30E-02	2.15E-02	1.12E-01	4.55E-01
74-98-6	Propane	1.60E-02	2.25E-02	1.17E-01	1.65E-01
624-64-6	trans-2-Butene	2.40E-02	1.05E-01	5.46E-01	1.58E-01
646-04-8	trans-2-Pentene	4.60E-03	4.80E-03	2.50E-02	1.75E-01

Source term estimation is a difficult process for any waste treatment facility because the exact identity of the particular wastes that will be treated cannot be predicted with absolute certainty. The use of emissions factors, such as those presented in Bjorklund et al. (1998), enabled health conservative factors to be identified and used to set an upper bound on the possible future conditions. Further benefits of using the Bjorklund et al. (1998) data are that the data are approved by the U.S. EPA and available to the public, making calculations easily reproducible and transparent.

3.2 Exposure Assessment

3.2.1 Air Dispersion

The release of constituents of concern from OB/OD operations is to air. Generally, air dispersion modeling begins with (1) a stack height and (2) a plume rise associated with any momentum or temperature-induced flux that are added together and called the "effective release height." However, because open burns and open detonations do not occur in buildings with stacks, the air dispersion models that are commonly used in risk assessment, such as Industrial Source Complex Short-Term (ISCST) model, are not applicable, unless appropriate adjustments are made. Moreover, most air dispersion models assume continuous releases, not short-term releases such as those associated with OB/OD treatments. The Open Burn Open Detonation Dispersion Model (OBODM, Bjorklund et al., 1998) was developed specifically for OB/OD operations. The OBODM takes into account the short-term nature of OB/OD treatments (i. e., quasi-continuous and instantaneous releases) and incorporates unique equations specifically developed to model the effective release height for burns and detonations. This analysis used the OBODM to simulate the atmospheric release and dispersion of the constituents of concern from OB/OD operations at the EWTF.

The OBODM allows the user to input various treatment-specific data, including the mass of the material treated, duration of treatment, and whether the treatment is a burn or detonation. The OBODM allows the user to create a grid of receptors as well as up to 100 individual receptors not on the grid. It can be run in a mode that allows only one meteorological condition, or in a mode that allows many years of meteorological data to be taken into account. There are many output options available to the user; specific options used in this analysis are discussed below.

The OBODM was used to model the four different waste forms/treatments at the EWTF. Waste Form 1 was modeled as an instantaneous open detonation. Waste Forms 2, 3, and 4 were modeled as quasi-continuous open burns. The source material modeled was TNT. TNT was chosen because it had the lowest heat release of the commonly treated munitions, which, in turn, lowers the plume rise and the dispersion and increases the estimated concentrations to the downwind receptors.

The OBODM models one source material and chemical of concern per model run. However, because resulting air concentrations scale linearly with input emission rates, the OBODM output can be scaled to estimate the concentrations of all chemicals of concern for all waste forms. This type of scaling is consistent with the HotSpots Analysis and Reporting Program (HARP) model (described below), which was used to calculate theoretical cancer risks, chronic hazards and acute hazards. Barium was chosen as the scaling chemical. It was modeled at two different emission factor levels: 0.0082 for Forms 1 and 2 treatments, and at 0.000086 for Forms 3 and 4 treatments. The OBODM outputs were then input to the HARP model for scaling (see Appendix A for a description of the scaling approach). The OBODM and HARP input and output files are contained in Volume 2 (provided on the attached compact disc).

Four individual receptor locations were modeled (see Section 3.2.3) as well as locations necessary to complete the exposure pathways other than inhalation. Because the modeling region is located in complex terrain, the complex terrain option was employed, and the receptor elevations were input to the OBODM. The hours modeled were limited so that no operations would occur prior to 7:00 a.m. or after 6:00 p.m. PST. No limitations on wind speed were incorporated into the modeling because the OBODM warns that if such limitations were attempted the results may be invalidated. (The warning in the OBODM meteorological data limits menu states: "If any value in this menu is changed, program results may be invalid and cannot be supported by the authors of the OBODM program" [Bjorklund et al., 1998].)

Five years (2000-2004) of on-site hourly meteorological data were used in the modeling analysis. The Site 300 meteorological monitoring tower sensors record 15-minute average wind speed (from which average hourly wind speed is calculated), wind direction, sigma theta (standard deviation of the horizontal wind direction), temperature, delta temperature (delta-T is the difference in temperature between 2 and 10 meters), solar radiation and other parameters. The sensors meet or exceed the performance requirements found in the U.S. EPA document, *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (U.S. EPA, 2000). The tower's equipment undergoes annual audits and calibrations. Data completeness for each of the 5 years far exceeds 90 percent. Prior to December 2003, the atmospheric stability class was calculated using the sigma theta and mean wind speed method. After December 2003, the atmospheric stability class was calculated using the solar radiation/delta-T method.

Hourly, site-specific mixing height data are not available for Site 300. Therefore, a reasonable, yet conservative mixing height value of 600 meters was assumed for the entire 5-year dataset. A 600-meter mixing height is reasonable yet conservative choice because 600 meters is lower than the mixing height that would be applied in common practice,[2] thus resulting in a lower vertical mixing layer, less vertical dispersion and higher air concentrations. For the open burns, maximum plume height is less than 100 meters and, for the open detonations, less than 264 meters; therefore, the use of a 600-meter mixing height ensured that the plume would neither be above the mixing layer where the plume would remain trapped nor mix downward to contribute to ground-level concentrations.

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[2] For mixing heights in rural areas, the common practice is to apply the mean afternoon mixing height given by Holzworth (1972) to stability classes B, C and D, and 1.5 times the mean afternoon mixing height to stability class A (U. S. EPA, 1995). Holzworth (1972) indicates that the annual average afternoon mixing height, for the Site 300 area, is approximately 1200 meters. Following common practice would result in mixing height values of 1600 meters for stability class A and 1200 meters for stability classes B, C and D. Furthermore, the Industrial Source Complex Long-Term model assumes unlimited mixing for stability classes E and F for both rural and urban conditions, and a large value such as 10,000 meters may be input for those classes (U. S. EPA, 1995).

The meteorological data was entered into the OBODM (and ISCST) model-ready format. The meteorological data file (Sit3y5.vec) is on the compact disk provided with this risk assessment.

3.2.2 Receptors

Site 300 is located in a scarcely populated area, and only about 5 percent of the area is developed (see Figure 7). However, two residences are located very near the southern boundary of the site. One is located to the southeast of the Site 300 boundary; the other, the residence of the park rangers for the Carnegie Vehicle Recreation Park, is located near the middle of Site 300's southern boundary. Both locations were evaluated to determine the location of maximum impact. Similarly, two other locations on site at Site 300 were evaluated. These locations were the Building 812 Complex and Building 895 where bystander workers—i.e., workers who are not conducting EWTF operations—are present (see Figure 8).

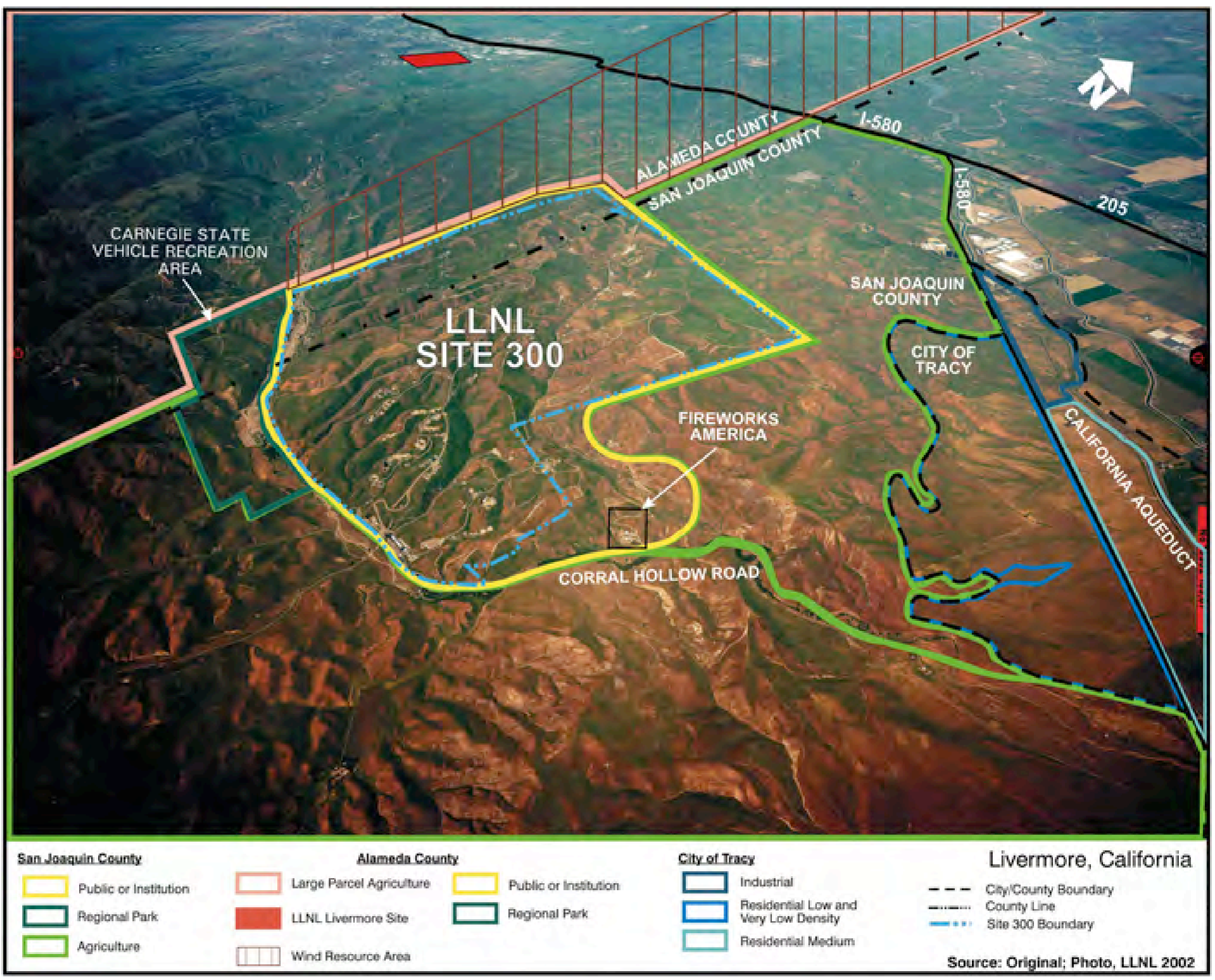

Figure 7. Site 300 environs.

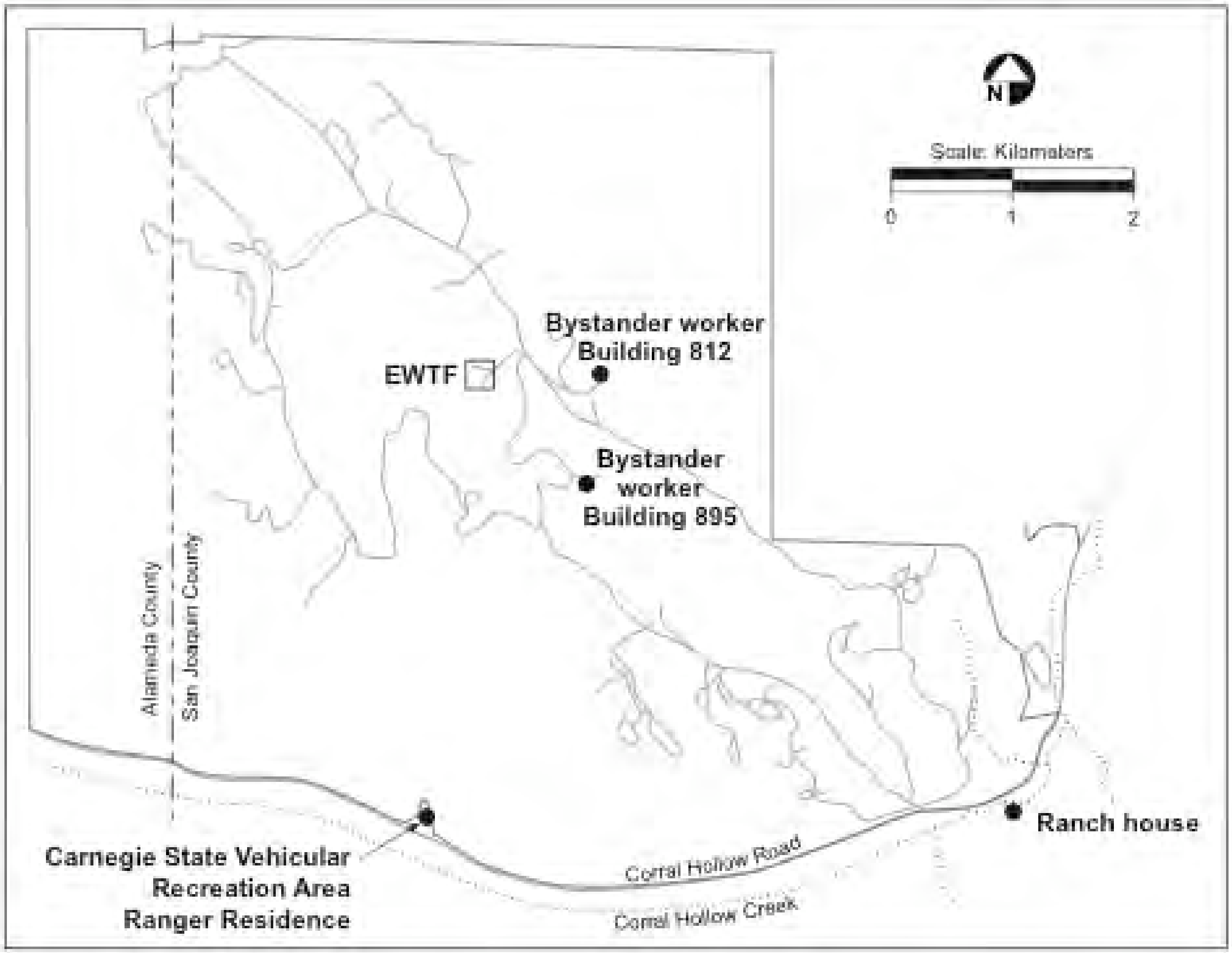

Figure 8. Locations of potentially maximally exposed receptors.

Two types of off-site receptors were evaluated for theoretical carcinogenic risk: a child for the first 9 years of life and a child/adult for a 30-year residence period. A 30-year residency is the 95th-percentile estimate of population mobility stated in the *Exposure Factors Handbook* (U.S. EPA, 1997). The on-site bystander worker was evaluated for a 25-year work duration for theoretical carcinogenic risk—a tenure that is well above the U.S. EPA-recommended occupational tenure value of 6.6 years (U.S. EPA, 1997). For non-carcinogenic hazard, because of the limitations of the risk assessment tool (California Air Resources Board [CARB], 2003), only the adult 70-year exposure was considered.

3.2.3 Exposure Pathways

Inhalation was the primary exposure pathway of concern for all receptors. The residential receptors also have the possibility of dermal exposure, ingestion of homegrown produce and meats, and incidental soil ingestion. Because furans have been included as constituents of concern, this assessment followed OEHHA guidance and evaluated the mother's milk exposure pathway (OEHHA, 2003, p. 5-3).

OEHHA guidance on worker exposure is that those individuals have potential exposure due to incidental soil ingestion and dermal exposure. However, dermal exposure is an exposure pathway for which exposure factors have been developed for outside workers, such as construction workers, gardeners, and utility workers (U.S. EPA, 2004b, p. 3–15). Bystander worker areas identified for the EWTF are for inside workers. In view of the lack of exposure factor data available for indoor workers and the low probability that indoor workers have dermal exposure to soil, this risk assessment did not calculate the dermal exposure pathway for bystander worker.The HARP model (CARB, 2003) was used to calculate theoretical carcinogenic risk and acute and chronic non-carcinogenic hazard. The HARP model, a multi-pathway model, includes calculations for inhalation, ingestion, dermal and mother's milk pathways. The model contains default CARB/OEHHA-recommended exposure parameters, which, in some cases, can be adjusted to better fit the factual situation. The exposure parameters used in this risk assessment along with their regulatory sources are listed in Table 6. In addition, the HARP model offers a choice of analysis methods for theoretical carcinogenic risk, including average and high-end point estimates and stochastic estimates. For this risk assessment, the high-end point estimate was used, and the high-end exposure parameters are listed in Table 6.

Table 6. Exposure parameters used in the EWTF risk assessment[a].

Exposure parameter	Child (9-year exposure)	Adult resident (30-year exposure)	Adult worker (25-year exposure)
Body weight (kg)	18	63	70
Exposure frequency (d/y)	350	350	245
Inhalation rate [L/(kg•d); 95th percentile]	581 (10.46 m^3/day)	393 (24.76 m^3/day)	149 (10.4 m^3/day)
Soil Loading [mg/(cm^2•d); 95th percentile]	1.0	1.0	1.0
Exposed skin surface area (cm^2; 95th percentile)	3044	5500	Not applicable
Soil Ingestion Rate [mg/(kg•d)]	8. 7	1.7 [b]	0.7[c]

[a] Unless otherwise noted, all parameters are implemented in the HARP (CARB, 2003) as described in OEHHA (2003) and represent high endpoints.

[b] Corresponds to 100 mg/day.

[c] U.S. EPA, 1997; corresponds to 50 mg/day.

The HARP (CARB, 2003) contains detailed calculations for the ingestion pathway, including the portions of the various types of foods ingested and the uptake of contaminants by agricultural animals. The home-produced fractions of the diet were adjusted to reflect local conditions. Table 7 shows the fractions that were changed for this risk assessment and their default values. (Although some of the default factors were set at 1, a common screening model representation of a hypothetical exposure, it is unlikely that any individual in California obtains all of his beef, pork, chicken, dairy, and eggs from one location.) The fractions used in the assessment were all obtained from the U.S. EPA's *Exposure Factors Handbook*, Table 13-71 (U.S. EPA, 1997), using the values stated for non-metropolitan areas.

Table 7. Food consumption fraction estimated to be affected by the EWTF.

Food type	Value used in risk assessment[a]	HARP default value[b]
Exposed produce	0.207	0.15
Leafy produce	0.082 (cabbage)	0.15
Protected produce	0.134	0.15
Root produce	0.088	0.15
Beef	0.107	1.0
Chicken	0.026	1.0
Pork	0.04	1.0
Dairy	0 (Not applicable)	1.0
Eggs	0.029	1.0

[a] U.S. EPA, 1997, Table 13-71, non-metropolitan.
[b] CARB, 2003.

The concentrations of contaminants of concern in the non-inhalation pathways were calculated in the HARP, based on a single deposition velocity for all contaminants of concern, and did not take into account particle size or mass. The default deposition velocity in the HARP is 0.05 m/s for uncontrolled sources—an extremely conservative value. An authoritative review article by Sehmel (1980) on particle dry deposition indicates that only the largest particles would have such a deposition velocity. Moreover, particles with a deposition velocity of 0.05 m/s would, in reality, deposit very close to the source and would not deposit at the distances to residences of interest in this risk assessment. To be conservative, but realistic, a deposition velocity measured for dioxin was chosen to represent all contaminants of concern; this deposition velocity is 0.0072 m/s (Wevers et al., 2004).

3.3 Dose-Response Assessment

The dose-response effects of chemicals in the environment are the subject of state and federal regulatory guidance. The cancer potency factors (CPFs), the acute and chronic inhalation reference exposure levels (RELs), and the chronic oral reference doses (RfDs) used in this assessment were compiled, first, from the OEHHA guidance as incorporated into the HARP model in the file called the health.mdb file, with a secondary source of such data obtained from a table in the U.S. EPA Region 9 Preliminary Remediation Goal (PRG; U.S. EPA, 2004a). The U.S. EPA (2004a) table lists the CPFs and RELs used in deriving the preliminary remediation goals. Table 8 presents the CPFs, RELs, and RfDs used in this risk assessment.

Table 8. Cancer potency factors, relative exposure levels, and reference doses for chemicals of concern for the EWTF.

Material CAS Number	Material name	Inhalation cancer slope factor [a] [1/(mg/kg-d)]	Oral cancer slope factor [a] [1/(mg/kg-d)]	Inhalation chronic REL [a] (µg/m3)	Oral chronic RfD [a] (mg/kg-d)	Acute REL (µg/m3)
106-99-0	1,3-Butadiene	6.00E-01		2.00E+01		
67562-39-4	1234678-HpCDF	1.30E+03	1.30E+03	4.00E-03	1.00E-06	
55673-89-7	1234789-HpCDF	1.30E+03	1.30E+03	4.00E-03	1.00E-06	
70648-26-9	123478-HxCDF	1.30E+04	1.30E+04	4.00E-04	1.00E-07	
57117-44-9	123678-HxCDF	1.30E+04	1.30E+04	4.00E-04	1.00E-07	
121-14-2	2,4-Dinitrotoluene	3.10E-01	*6.10E-01*	*7.30E+00*	*2.00E-03*	
606-20-2	2,6-Dinitrotoluene	*6.80E-01*	*6.80E-01*	*3.70E+00*	*1.00E-03*	
95-57-8	2-Chlorophenol			1.80E+01	*5.00E-03*	
7429-90-5	Aluminum			*5.10E+00*	*1.00E+00*	
7440-36-0	Antimony			2.00E-01		
7440-39-3	Barium			*5.20E-01*	*7.00E-02*	
71-43-2	Benzene	1.00E-01		6.00E+01		1.30E+03
7440-43-9	Cadmium	1.50E+01		2.00E-02	5.00E-04	
56-23-5	Carbon Tetrachloride	1.50E-01		4.00E+01		1.90E+03
67-66-3	Chloroform	1.90E-02		3.00E+02		1.50E+02
7440-47-3	Chromium				*1.50E+00*	
7782-50-5	Cl_2			2.00E-01		2.10E+02
630-08-0	CO					2.30E+04
7440-50-8	Copper			2.40E+00	*4.00E-02*	1.00E+02
110-82-7	Cyclohexane			*6.20E+03*	*1.70E+00*	
122-39-4	Diphenylamine			*9.10E+01*	*2.50E-02*	
75-00-3	Ethyl chloride	*2.90E-03*		3.00E+04		
100-41-4	Ethylbenzene			2.00E+03		
206-44-0	Fluoranthene			*1.50E+02*	*4.00E-02*	
7647-01-0	HCL			9.00E+00		2.10E+03
98-82-8	i-Propylbenzene (cumene)			*4.00E+02*	*1.00E-01*	
7439-92-1	Lead	4.20E-02	8.50E-03			
74-87-3	Methyl chloride (Chloromethane)			*4.50E+01*		
71-55-6	Methyl chloroform (1,1,1-TCA)			1.00E+03		6.80E+04
108-87-2	Methylcyclohexane			*3.10E+03*		
75-09-2	Methylenechloride	3.50E-03		4.00E+02		1.40E+04
91-20-3	Naphthalene	1.20E-01		9.00E+00		

Material CAS Number	Material name	Inhalation cancer slope factor [a] [1/(mg/kg-d)]	Oral cancer slope factor [a] [1/(mg/kg-d)]	Inhalation chronic REL [a] (μg/m3)	Oral chronic RfD [a] (mg/kg-d)	Acute REL (μg/m3)
110-54-3	n-Hexane			7.00E+03		
10102-44-0	Nitrogen dioxide (peroxide)			4.70E+02		4.70E+02
39001-02-0	OCDF	1.30E+01	1.30E+01	4.00E-01	1.00E-04	
108-95-2	Phenol			2.00E+02	*3.00E-01*	5.80E+03
115-07-1	Propene			3.00E+03		
121-82-4	RDX	*1.10E-01*	*1.10E-01*	*6.10E-02*	*3.00E-03*	
100-42-5	Styrene			9.00E+02		2.10E+04
7446-09-5	Sulfur dioxide			6.60E+02		6.60E+02
127-18-4	Tetrachloroethylene	2.10E-02		3.50E+01		2.00E+04
108-88-3	Toluene			3.00E+02		3.70E+04
75-01-4	Vinyl chloride	2.70E-01		2.60E+01		1.80E+05
7440-66-6	Zinc			3.50E+01	*5.00E-02*	

[a] Toxicity factors in italics are from U.S. EPA (2004a) all others are from CARB (2003).

Neither the HARP model nor the U.S. EPA PRG table had toxicity data available for 27 constituents of concern. Because of the uncertainty in the source term, it seemed reasonable to choose surrogates from the other constituents based on the fundamental structure of the molecule for which toxicity data were unavailable. On that basis, RDX was chosen as a surrogate for PETN; naphthalene was chosen as a surrogate for acenaphthalene and 1-nitronaphthalene; ethylbenzene was chosen as a surrogate for m- and p–ethyltoluene; and hexane was chosen as a surrogate for short-chain and cyclic aliphatic hydrocarbons. A petroleum-industry toxicological review undertaken by the Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG, 1997, p. 8) to develop reference doses and reference concentrations evaluates materials by number of carbons in the compound and whether or not the material is aromatic or aliphatic. Consequently, hexane is a reasonable surrogate for these compounds.

3.4 Risk Characterization

3.4.1 OBODM/HARP Interface

As previously mentioned, the OBODM is limited to the evaluation of one constituent of concern at a time; and it has no capability for assessing risk or hazard. On the other hand, the HARP is capable of handling many chemicals simultaneously; and it incorporates the OEHHA methodology for assessing theoretical carcinogenic risk and non-carcinogenic hazard for the inhalation, food and incidental soil ingestion, and dermal and mother's milk exposure pathways. (In this risk assessment, HARPExpress, a commercial user interface to the HARP model was actually used.)

The HARP model is, in fact, three separate computer programs linked together. The first program is a database program in which the user enters site-specific data, such as building locations, emissions locations, emissions characteristics (usually stack height, diameter and release rate) and annual and maximum emissions. The second program is the ISCST model, a U.S. EPA continuous emission model for dispersion of air pollutants based on the Gaussian plume dispersion equations. The third program is the OEHHA-approved risk assessment equations combined with a database of OEHHA-approved toxicity factors, by which theoretical carcinogenic risk and acute and chronic non-carcinogenic hazard are calculated.

Because, for reasons previously discussed, the ISCST model is not the most reasonable model to use for OB/OD operations, the OBODM model is the preferred model for these operations. However, because the HARP model is functionally three separate models linked together, it was possible to run both the HARP model and the OBODM model with the same emissions scenarios and replace the ISCST output with the OBODM output. The details of the HARP/OBODM interface are presented in Appendix A.

3.4.2 Identification of Maximally Exposed Receptors

Theoretical carcinogenic risk and acute and chronic non-carcinogenic hazard were calculated within the HARP (with the OBODM dispersion results), using OEHHA-approved equations. The calculations were conducted for the two possible off-site residential receptors and for the two closest on-site locations of bystander workers. When the HARP provides the results for more than one receptor, the HARP output cannot be interrogated by source contribution. Because the contribution of each waste form was not known before the HARP model was run, all waste forms were modeled as if 100 events occurred annually in order to screen the waste forms and identify the maximally exposed receptors. Therefore, the screening level health effects for identifying the maximally exposed receptors were for a total of 100 detonations and 300 burns (100 from each form of waste). These screening results yielded greater health effects than would occur under the permit condition limits of no more than 100 detonations and 100 burns. (Historically, annual treatments are much less, both in frequency and mass, than the permitted limits.) The results of the HARP model screening runs are shown in Table 9. Output from the runs is in Volume 2 of this risk assessment (provided on a compact disc.)

Table 9. Screening results for identification of maximally exposed receptors.

Receptor	Carcinogenic risk	Chronic hazard index	Acute hazard index
Carnegie Ranger Station (SW)	0.0000007	0.02	0.02
Ranch Residence (SE)	0.0000004	0.01	0.01
Bystander Worker Building 812 (E)	0.0000006	0.3	0.2
Bystander Worker Building 895 (SE)	0.0000007	0.3	0.3

3.4.3 Effects on Maximally Exposed Receptors

After the maximally exposed receptors were identified, the HARP model was run again for the two individual receptors—the resident at the Carnegie State Vehicular Park ranger residence and the bystander worker at Building 895—to determine the contribution of each of the EWTF sources to the risk, and the risk outcome for the permitted level of treatments of 100 open detonations and 100 open burns. The

100 burns were represented by the greatest value among the three waste forms that are treated by burning. Because the acute hazard index is a measure of the greatest possible 1-hour exposure, the result of interest is the highest 1-hour hazard index for a single waste form, not the total of all waste forms. These results are presented in Table 10. The HARP output is contained in Volume 2 (provided on a compact disc).

In contrast to the 30-year exposure duration for the assessment of theoretical carcinogenic risk, chronic hazard values were calculated for a 70-year exposure because the HARP model uses chronic RELs based on ambient air concentrations, rather than RfDs based on exposures, receptor body weight, and exposure duration. When an REL is developed, an exposure duration is assumed. In the case of the RELs used in the HARP model, the exposure duration is 70 years. This also means that a chronic hazard specific to childhood exposure cannot be calculated. In addition, the acute hazard calculation, while fundamentally the same for both the bystander worker and residential receptors, uses a greater inhalation rate for the worker than for the resident (1.3 m^3/h for the worker and 1.0 m^3/h for the resident). The result for the chronic hazard index reported by the HARP model is the maximum value among the target organs or systems evaluated. In all cases in this EWTF health evaluation, the maximally affected organ/system was the respiratory system.

Table 10. Theoretical health effects for maximally exposed receptors.

Receptor	Treatment unit (waste form)	Risk adult (30-year exposure)	Risk child (9-year exposure)	Chronic hazard index	Acute hazard index
Carnegie ranger residence (SW)	Open Detonation (Form 1)	0.0000004	0.0000003	0.002	0.02
	Burn Pan (Form 2)	0.00000004	0.00000002	0.01	0.01
	Burn Cage (Form 3)	0.00000004	0.00000002	0.0008	0.0004
	Burn Cage (Form 4)	0.0000002	0.0000001	0.004	0.002
	Total (100 OD + 300 OB)	0.0000007	0.0000004	0.02	Max: 0.02
	Current permit limits (100 OD + 100 OB)	0.0000006	0.0000004	0.01	Max: 0.01
Bystander worker (Building 895)	Open Detonation (Form 1)	0.0000004	Not applicable	0.02	0.1
	Burn Pan (Form 2)	0.0000001	Not applicable	0.2	0.2
	Burn Cage (Form 3)	0.00000003	Not applicable	0.01	0.006
	Burn Cage (Form 4)	0.0000001	Not applicable	0.05	0.03
	Total (100 OD + 300 OB)	0.0000007		0.3	Max: 0.3
	Current permit limits (100 OD + 100 OB)	0.0000006		0.2	Max: 0.3

The carcinogenic risk to a 30-year resident at the maximum off-site receptor location is 0.0000006 or 0.6 in 1 million. The carcinogenic risk to a 25-year worker at the maximum bystander on-site receptor location is also 0.0000006 or 0.6 in 1 million. Any risk of less than 1 in a million is below the level of regulatory concern. The acute non-carcinogenic hazard for the 30-year resident is 0.01, and the chronic non-carcinogenic hazard is 0.01. The acute non-carcinogenic hazard for the 25-year worker is 0.3, and the chronic non-carcinogenic hazard is 0.2. The point of comparison for acute and chronic non-carcinogenic hazard is 1.0; an estimate less than 1.0 is below the level of regulatory concern. The estimates of health effects are based on health conservative assumptions and represent an upper bound of the possible exposures to the receptors.

3.5 Lead

Possible emissions from OB/OD operations at the EWTF of Site 300 include elemental lead (Pb). The chronic non-cancer effects of lead exposure are related to blood-lead levels (as opposed to ambient air concentrations). The health risk from exposure to lead in this risk assessment was determined using the lead risk assessment spreadsheet obtained from the California Department of Toxic Substances Control (DTSC, 2000).

The DTSC Lead Risk Assessment Spreadsheet—LeadSpread 7 (DTSC, 2000)—is a model for estimating blood-lead concentrations resulting from exposure to lead via dietary intake, soil and dust ingestion, inhalation, and dermal contact. The modeled concentrations of lead in air and soil 1 cm deep at the Carnegie State Vehicular Park ranger residence and at the bystander worker location (Building 895) were used in the LeadSpread 7 calculations.

LeadSpread 7 contains equations that relate incremental blood-lead increase to a concentration in an environmental medium, using currently accepted contact rates and empirically determined ratios. Exposure-pathway contributions to blood-lead levels were summed to arrive at an estimate of the median blood-lead concentration for multiple exposure pathways. The 99th-percentile concentration was then estimated from the median value by assuming a lognormal distribution for blood-lead concentration with a geometric standard deviation (GSD) of 1.6. The blood-lead concentration of concern for children and adults is 10 μg Pb/dL, and risk management is considered applicable if there is a 0.01 risk of exceeding this value (DTSC, 1996).

Table 11 contains the values for the input factors required for performing the necessary calculations using LeadSpread 7. The air and soil/dust were obtained from the OBODM/HARP atmospheric dispersion and deposition modeling (Bjorklund et al., 1998; CARB, 2003), and the percentage of homegrown produce consumed for the residence is the average of the data presented in Table 7. The default value for respirable dust already incorporated into LeadSpread 7 was not changed.

Table 11. Values for input factors required for the lead risk assessment spreadsheet model, LeadSpread 7.

Environmental medium	Carnegie ranger residence	Bystander worker (Bldg. 895)
Air	0.00182 μg Pb/m^3	0.0286 μg Pb/m^3
Soil/dust	1.09 μg Pb/g	17.0 μg Pb/g
Home-grown produce	13% of diet	0% of diet
Respirable dust	1.5 μg Pb/m^3	1.5 μg Pb/m^3

Table 12 contains the 99th-percentile blood-lead levels predicted from lead emissions for adult and child exposures at the ranger residence location and for adult-worker exposures at Building 895. None of the receptors, even the pica-child, is expected to achieve a blood-lead level that equals the 10 μg Pb/dL level at the 99th-percentile upper confidence limit. Consequently, no receptor is considered to attain a concentration of lead in blood that would be considered to be of concern.

Table 12. Predicted blood-lead levels for adult and child exposures at the ranger residence location and for adult-worker exposures at the Building 895 location using the lead risk assessment spreadsheet model, LeadSpread 7.

Percentile estimate of blood lead concentration	Adult exposure at Carnegie ranger residence (μg/dL)	Child exposure at Carnegie ranger residence (μg/dL)	Pica-child exposure at Carnegie ranger residence (μg/dL)	Bystander worker exposure at Building 895 (μg/dL)
99th	0.6	1.5	1.5	0.8

4. Ecological Risk Assessment

The Ecological Risk Assessment (ERA) for the EWTF was conducted following currently accepted practice. This practice involves four steps. The first step is to identify each contaminant of potential ecological concern (CPEC) in emissions from OB/OD operations and estimate its soil concentration from atmospheric dispersion and deposition modeling. Then representative receptors of ecological interest (RREIs) with a distinct diet type were selected for each tropic level. Next, an Ecological Soil Screening Level (ESSL) protective of each RREI was determined. Then the calculation of an ecological hazard quotient (EHQ), (i.e., the ratio of soil concentration over a 6-inch [15cm] depth predicted from modeling to the ESSL determined for each CPEC and RREI) was determined and used as a quantitative metric for evaluating the potential for serious adverse effects on RREI populations in the habitat near and around the EWTF. The details of the calculations for the ecological risk assessment are provided in Appendix B. A summary of the various ecological site investigations that have been conducted at Site 300 is presented in Appendix C. The 21 CPECs emitted from the EWTF that are to be evaluated are categorized in Table 13.

Table 13. The 21 Contaminants of Potential Ecological Concern (CPECs) at the EWTF.

Five PCDFs	Three energetics and other thermally labile compounds	Eight metals	Five SVOCs
1-4, 6-8 HpCDF	2,4-Dinitrotoluene	Aluminum	2-Chlorophenol
1-4, 7-9 HpCDF	2,6-Dinitrotoluene	Antimony	Diphenylamine
1-4, 7, 8 HxCDF	RDX	Barium	Fluoranthene
1-3, 6-8 HxCDF		Cadmium	Naphthalene
1-9 OCDF		Chromium	Phenol
		Copper	
		Lead	
		Zinc	

The nine RREIs addressed are the mammals, the reptile, the birds, and the soil invertebrate listed in Table 14 (see Figure B-1 in Appendix B). The individual exposure pathways considered relevant for each RREI were incidental ingestion of contaminated soil particles and ingestion of forage or prey for which uptake of a CPEC from soil or forage or prey was estimated using a calculated bioaccumulation factor (BAF). For purposes of conservatism, all the living, foraging, and prey capturing by the RREIs were considered to occur in the habitat nearest OB/OD operations, where highest concentrations of each CPEC are predicted to be deposited, and the absorption fraction of each CPEC for each RREI was considered to be 100 percent.

Table 15 shows the nine organisms and their body weight and dietary behavior. This information was used to derive a chemical-specific ESSL for each organism (see Appendix B). Regulatory agencies have not developed ESSLs for amphibians that may be present near the EWTF, such as the California Red-legged Frog (*Rana aurora draytonii*) and the California Tiger Salamander (*Ambystoma californiense*). However, as discussed in Appendix B, serious impacts to amphibians in the area of the EWTF would be unlikely.

Table 14. Nine representative receptors of ecological interest (RREIs) at the EWTF.

Mammals	Reptile	Birds	Soil Invetebrate
Omnivorous small mammal (Deer Mouse [*Permyscus maniculatus*])	Insectivorous reptile (Side-Blotched Lizard Lizard [*Uta stansubriana*])	Omnivorous bird (Savannah Sparrow [*Passerculus sandwichensis*])	Earthworm
Granivorous small mammal (Ground Squirrel [*Spermophilus beecheyi*])		Carnviorous bird (Burrowing Owl [*Athene cunicularia*])	
Herbivorous small mammal (Pocket Gopher [*Thomomys bottae*])			
Herbivorous large mammal (Black-Tailed [Mule] Deer [*Odocoileus hemionus columbianus*])			
Carnivorous mammal (San Joaquin Kit Fox [*Vulpes macrotis mutica*])			

The technical basis for this ecological risk assessment was n analysis that included the overwhelmingly dominant exposure pathway (ingestion) for each CPEC with respect to its EHQ for a particular receptor. An EQH with a value greater than or equal to 1.0 suggests a potential for producing an adverse effect in each individual or population of receptor species, and the assumptions made are conservative at this time. Appendix B contains a detailed description of the ERA analysis and input data.

Table 15. Representative receptors of ecological interest (RREI) and respective physiological characteristics, including body weight (BW) and dietary dry-matter intake (DMI).

Organism	BW (kg)	Daily DMI intake (kg_{dmi}/d)	Daily DMI intake per unit BW (kg_{dmi}/d per kg_{bw})	Fraction of total dietary dry-matter intake (DMI)				
				Vege-tation	Inverte-brate	Reptile	Mammal	Soil
Mammals								
Omnivorous small mammal (Deer Mouse)	0.0179	0.00381	0.2128	0.7	0.3	0	0	0.1
Granivorous small mammal (Ground Squirrel)	0.56	0.0383	0.0683	1	0	0	0	0.077
Herbivorous small mammal (Pocket Gopher)	0.104	0.013	0.1250	1	0	0	0	0.1
Herbivorous large mammal (Black-Tailed [Mule] Deer)	39.1	0.01565	0.0004	1	0	0	0	0.02
Carnivorous mammal (San Joaquin Kit Fox)	1.48	0.0702	0.0474	0	0	0.5	0.5	0.028
Reptile								
Insectivorous reptile (Side-Blotched Lizard)	0.0032	0.000037	0.011563	0	1	0	0	0.1
Birds								
Omnivorous bird (Savannah Sparrow)	0.0187	0.00574	0.3070	0.39	0.61	0	0	0.04
Carnviorous bird (Burrowing Owl)	0.157	0.00777	0.0495	0	0.333	0.333	0.333	0.05

Note: The soil invertebrate (earthworm) does not appear in Table 15 because an ESSL for it was taken directly from literature values (see Tables B-6a and B-6b in Appendix B).

The results of the ERA are summarized in Table 16. Although several substances would suggest a potential ecological hazard exists at the location of the EWTF, lead appears to be a problem at all locations where modeling determined soil concentrations. However, EHQs were also determined for the Burrowing Owl using avian toxic reference values (TRVs) for cadmium and lead taken from U. S. EPA documents (2005a,b). The value for the avian TRV for cadmium is a geometric mean; and the value for lead is the highest bounded no-observed adverse effect level (NOAEL) that is below the lowest bounded Lowest Observed Adverse Effect Level (LOAEL). Using these values (1.47 for cadmium and 1.63 for lead) as the wildlife TRVs for cadmium and lead yielded ESSLs that were then used along with soil concentration predicted over a 6-inch (15-cm) depth to produce EHQs for these chemicals. In both cases, the values at the EWTF are both less than 1.0 (0.011 for cadmium and 0.18 for lead). Accordingly, the more conservative choices for TRVs may indicate a potential for impact, but the more recent and potentially more applicable values for TRVs for cadmium and lead strongly suggest no ecological impact is likely to occur from continuing operation of the EWTF, particularly with respect to cadmium and lead.

Table 16. Ecological hazard quotients (EHQs) for chemicals of potential concern at different receptor locations. Each EHQ is derived from the lowest ESSL for all organisms evaluated.

	Receptor Location					
Chemical	**EHQ (EWTF/ ESSL)**	**EHQ (Bldg 812/ ESSL)**	**EHQ (Bldg 895/ ESSL)**	**EHQ (EstPst/ ESSL)**	**EHQ (Crnge/ ESSL)**	**EHQ (Ranch/ ESSL)**
Polychlorinated dibenzofurans (PCDFs)						
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	*1.16E+00*	1.42E-01	1.31E-01	5.99E-03	6.67E-03	3.00E-03
1-4, 7-9 HpCDF (1,2,3,4,7,8,9-HpCDF)	2.30E-01	2.86E-02	2.65E-02	1.25E-03	1.39E-03	6.31E-04
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	*6.80E+00*	8.33E-01	7.72E-01	3.57E-02	3.97E-02	1.79E-02
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	*2.82E+00*	3.49E-01	3.24E-01	1.52E-02	1.69E-02	7.67E-03
1-9 OCDF (OCDF)	1.40E-02	1.70E-03	1.57E-03	7.14E-05	7.95E-05	3.57E-05
Energetics & other thermally labile compounds						
2,4-Dinitrotoluene	1.22E-08	1.57E-09	1.47E-09	9.20E-11	8.85E-11	4.28E-11
2,6-Dinitrotoluene	5.10E-10	6.55E-11	6.14E-11	3.83E-12	3.69E-12	1.78E-12
RDX	1.12E-01	1.55E-02	2.20E-02	1.90E-03	1.98E-03	1.14E-03
Metals						
Aluminum	*3.83E+00*	5.61E-01	5.69E-01	3.73E-02	4.01E-02	2.03E-02
Antimony	1.23E-03	1.64E-04	1.93E-04	1.48E-05	1.51E-05	8.27E-06
Barium	1.09E-01	1.46E-02	1.71E-02	1.31E-03	1.33E-03	7.30E-04

Chemical	Receptor Location					
	EHQ (EWTF/ ESSL)	EHQ (Bldg 812/ ESSL)	EHQ (Bldg 895/ ESSL)	EHQ (EstPst/ ESSL)	EHQ (Crnge/ ESSL)	EHQ (Ranch/ ESSL)
Cadmium	*9.87E+00*	*2.10E+00*	*2.38E+00*	3.45E-01	3.50E-01	2.25E-01
Chromium	5.21E-06	7.04E-07	8.79E-07	7.01E-08	7.21E-08	4.03E-08
Copper	*1.60E+00*	8.11E-01	8.19E-01	3.70E-01	3.69E-01	3.06E-01
Lead	*3.92E+02*	*7.83E+01*	*7.67E+01*	*9.51E+00*	*9.39E+00*	*5.61E+00*
Zinc	*1.16E+00*	6.05E-01	6.27E-01	2.61E-01	2.67E-01	2.17E-01
Semi-volatile organic compounds (SVOCs)						
2-Chlorophenol	3.03E-04	3.90E-05	3.65E-05	2.28E-06	2.19E-06	1.06E-06
Diphenylamine	1.06E-08	1.36E-09	1.27E-09	7.95E-11	7.65E-11	3.70E-11
Fluoranthene	5.86E-04	8.80E-05	8.22E-05	4.85E-06	5.36E-06	2.55E-06
Naphthalene	8.35E-05	1.25E-05	1.17E-05	6.91E-07	7.63E-07	3.63E-07
Phenol	6.28E-07	8.06E-08	7.56E-08	4.72E-09	4.54E-09	2.20E-09

Note: EHQ values greater than 1 appear in italics (e.g. see EHQ values for Pb).

In summary, for this ecological risk assessment (ERA), nine receptor species, representing members of trophic levels in the habitat of Site 300, were evaluated for the possibility of potential detrimental effects from EWTF emissions, using very conservative TRVs and exposure concentrations. However, using the less conservative, but equally applicable, avian toxic reference values (TRV) for cadmium and lead suggest that no additional impact will occur from the continuing operation of the EWTF with respect to these chemicals. Consequently, the calculated potential for ecological impacts may be explained by the conservatisms incorporated into the analysis, which would overestimate potential consequences.

5. Uncertainties and Conservatisms

Quantification of health risk from the operation of the EWTF involved:

- Estimating the magnitude of emissions.
- The concentrations of the constituents of concern in various environmental media.
- The magnitude of exposure as well as the exposure frequency and duration for exposure pathways of concern for specific receptors.

This risk assessment implemented 95th-percentile estimates, when possible, and health-conservative estimates, when the distribution of the parameter was unknown, for the parameters that could be controlled within the models used.

Quantification of the source term for the EWTF is uncertain because it is difficult to predict the exact nature of the explosives that will be treated. This risk assessment addressed this uncertainty by using the most conservative emissions factors that can be reasonably justified. The continued research conducted by the DoD in this area will improve emission factors for future permitting efforts and reduce the uncertainty from the emission factors, but the inherent uncertainty in exactly predicting releases from waste treatment operations at a research institution will remain.

Quantification of the air concentrations is uncertain. This uncertainty has been addressed by using the most health conservative munition, TNT, in the OBODM model. TNT is the most health conservative because it has the lowest heat of combustion, leading to the least plume rise, and, therefore, the greatest downwind concentrations. The uncertainty in the prediction of air concentrations was reduced by using 5 years of site-specific meteorological data in the air dispersion modeling.

Quantification of the soil concentrations is uncertain. This risk assessment addressed this uncertainty by using a deposition velocity for the constituents of greatest health concern, polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs).

There are uncertainties as to the magnitude of exposure. These uncertainties were addressed through the use of 95th-percentile inhalation rates for residential receptors and bystander workers, for the incidental soil ingestion rate for residential receptors, for the skin surface area and dermal adhesion factor for the dermal exposure route for residential receptors. The dermal exposure route is uncertain for the indoor receptors because there are no recommended exposure factors for this route/receptor combination; however, it is unlikely that any indoor worker would have a significant dermal exposure to resuspended soil.

The 30-year residency exposure assumption is the 95th-percentile estimate of population mobility stated in the U.S. EPA's *Exposure Factors Handbook* (U.S. EPA, 1997). The average residence in one place is estimated to be significantly less, at 11.4 years for homeowners and 2.4 years for renters (Israeli and Nelson, 1992). The on-site bystander worker was evaluated for a 25-year work duration, well above the U.S. EPA-recommended occupational tenure value of 6.6 years (U.S. EPA, 1997). It should also be noted that the HARP model does not have distinct point estimates and data distributions for the 30-year and 70-year exposure scenarios. The documentation states:

> However, in the interest of simplicity, the 30-year exposure duration scenario uses the same exposure point-estimates and data distributions as the 70-year exposure duration scenario. This assumption to use the 70-year exposure point-estimate for both 30 and 70-year exposures probably results in a small underestimation of dose for the 30-year exposure scenario, since the exposure parameters for earlier years are higher than years spent as an adult (OEHHA, 2003).

Quantification of toxic effects involves applying appropriate toxicity data to the constituents of potential concern. However, not all constituents of concern for the EWTF have toxicity data. This uncertainty was addressed by identifying surrogate materials and using the toxicity data for the surrogate material to estimate risk and hazard.

Cancer potency factors were estimated from long-term animal studies where the dose is typically held constant and the exposure is conducted continuously over a major portion of the life span of the animals (i.e., lifetime exposure). Human cancer risk assessments, on the other hand, typically involve estimating exposures over less than a lifetime (e. g., 9 years, 25 years, or 30 years) and multiplying the lifetime average daily dose (less than lifetime exposure total dose averaged over a 70-year lifetime) times the cancer potency factor. Although the U. S. EPA and OEHHA support the use of cancer potency factors for estimating cancer risk for these exposure durations, uncertainties are associated with applying the cancer potency factors to less than lifetime exposures or to exposures that are not continuous but intermittent (i.e., like OB/OD operations). Some chemicals are more potent carcinogens when exposures occur early in life but have little or no effect later in life; other chemicals are more potent carcinogens when exposures occur late in life but have little or no effect earlier in life. Thus, depending on when the actual less than lifetime (or intermittent) exposure occurs during one's lifetime, using lifetime average daily dose and cancer potency factors can lead to under- or overestimating theoretical cancer risks. Halmes et al. (2000) indicate that although typical linear adjustments for less-than-lifetime exposure in cancer risk assessment can theoretically result in under- or overestimation of risks, underestimation of risks from short-term exposures is more likely.

Studies of the compounding of conservatism in probabilistic risk assessments show that setting as few as two factors at high-end levels (e.g., near the 90th percentile), and setting the remaining variables at less conservative, or expected values, result in a product of all input variables that approximate a maximum exposure value (e.g., 99th-percentile value) (Cullen, 1994). This risk assessment used 95th-percentile estimates for inhalation rates, residential ingestion rates, and skin surface exposure. As a result, it provides a very conservative estimate of health effects that are, nonetheless, below any level of concern.

Quantification of the ecological risk posed by release of a particular contaminant to a specific habitat is complicated by additional uncertainties related to limited data concerning the physiological and behavioral characteristics of those wildlife species that were considered to be present. To overcome such difficulties, ecological risk assessments, as currently practiced, focus on modeling potential total dose and developing an EHQ for an individual organism of one or more species (and most often only for adults due to data limitations) in the affected habitat. This approach allows any impact to an individual of a particular species to be translated to an impact to the population, and, by inference, to a potential impact on the entire local ecosystem.

This ERA followed a similar approach, examining the potential for impact from a contaminant of potential ecological concern for an individual receptor from more than one species, and each species was considered to be at a different trophic level in the local ecosystem near the EWTF. Additional conservatism was added to these calculations by:

- Maximizing the amount of material deposited (by considering a habitat location at Site 300 quite close to the OB/OD operations—the source of emissions).
- Optimizing the receptor behavior to maximize exposures (i.e., living, foraging, and capturing prey exclusively in that immediate habitat).
- Using concentrations of CPECs that represented a depth of 6 inches (15 cm). Although 2 feet (60 cm) is a common depth for evaluating the effects on fossorial

animals, soil at that depth would not be expected to have the same level of air-deposited contamination as would be present at the surface.

- Fixing the absorption fraction of each contaminant of each receptor at 100 percent.

Furthermore, this ERA employed very conservative values for wildlife TRVs, especially for each avian RREI with respect to cadmium and lead (i.e., 0.011 mg/kg d for cadmium and 0.18 mg/kg d for lead) (see avian BTAG values presented in DTSC [2000]). In fact, the U.S. EPA TRVs for cadmium and lead, (1.47 mg/kg d and 1.63 mg/kg d, respectively) as derived in Ecological Soils Screening Level documents (U.S. EPA, 2005a,b), still represent NOAEL levels but are not as conservative as those presented by DTSC (2000). These U.S. EPA documents identify the avian wildlife TRV for cadmium as a geometric mean value, and the highest bounded NOAEL that is below the lowest bounded LOAEL as the avian TRV for lead. Accordingly, the EHQs at the EWTF for cadmium and lead that are derived using these TRVs from U.S. EPA (2005a,b), respectively, are actually lower than unity, indicating no ecological risk from these materials.

6. Summary of Risks and Hazards

Source term estimation is a difficult process for any waste treatment facility because the exact identity of the particular wastes that will be treated cannot be predicted with absolute certainty. The use of publicly available emissions factors, such as those presented here, enables health conservative factors to be identified and used to set an upper bound on the possible future conditions, and makes calculations easily reproducible and transparent.

The calculations evaluating human health risk in this assessment are based on health conservative assumptions for nearly every parameter. The use of conservative assumptions yields a very conservative upper bound estimate of potential health effects. The calculations demonstrate that the operations at the EWTF do not constitute a human health risk: the carcinogenic risk is less than 1 in 1 million, and the acute and chronic hazard indices are less than 1. In addition, the modeled 99th percentile blood-lead levels used to assess non-carcinogenic hazard are all well below the 99th percentile upper confidence limit for a blood-lead level of 10 μg Pb/dL, which represents the threshold that would be considered of concern.

The EHQs calculated based on DTSC guidance exceed 1. However, it is likely that the conservatisms used in the modeling overestimate the consequences significantly. In fact, using more realistic avian TRVs for both cadmium and lead produces ESSLs that yield EHQs for cadmium and lead that are less than unity. Therefore, it appears equally likely that operation of the EWTF will actually not contribute to any future ecological impacts at Site 300.

Based on these results, emissions from the operations of the EWTF should not be of concern for human health and may also be of *de minimis* concern with regard to ecological impacts. The latter conclusion is further supported by the fact that when less conservative but equally applicable TRV values for the sensitive avian species (the

Burrowing Owl) are used for cadmium and lead at the EWTF, the results indicate no potential consequence is likely to occur.

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List of Acronyms and Abbreviations

AP	Ammonium perchlorate
ATSDR	Agency for Toxic Substances Disease Registry
B	Building
BAF	Bioaccumulation factors
BJC	Bechtel Jacobs Company, LLC
brd	bird
BTAG	Biological Technical Assistance Group
BW	Body weight
CalEPA	California Environmental Protection Agency
CARB	California Air Resources Board
CAS	Chemical Abstract Service
CAS	Chemical Abstract Service
Cd	Cadmium
Cl_2	Chlorine
CO	Carbon monoxide
CO_2	Carbon dioxide
CPEC	Contaminant of potential ecological concern
CPF	Cancer Potency Factor
CPF	Cancer potency factor
Cu	Copper
DF	Dietary fraction
DMI	Dietary dry-matter intake
DMI	Dry-matter intake
DOD	U.S. Department of Defense
DTSC	Department of Toxic Substances Control
EHQ	Ecological hazard quotient
EPA	U.S. Environmental Protection Agency
ERA	Ecological risk assessment
ESSL	Ecological soil screening level
ETS	Experimental Test Species
EWTF	Explosives Waste Treatment Facility
GSD	Geometric standard deviation
H_2O	water
HARP	HotSpots Analysis and Reporting Program
HCL	Hydrogen chloride
HERD	Human and Ecological Risk Division
HMX	High melting explosive

ID	Identification
inv	invertebrate
IRIS	Integrated Risk Information System
ISCST	Industrial Source Code/Complex Short-Term
LLNL	Lawrence Livermore National Laboratory
mam	mammalian
N_22	Nitrogen
NAS	National Academy of Sciences
NM	New Mexico
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
NOEC	No-observed effect concentrations
OB	Open Burn
OBODM	Open Burn/Open Detonation Dispersion Model
OD	Open Detonation
OEHHA	Office of Environmental Health Hazard Assessment
Pb	Lead
PCDF	Polychlorinated dibenzofuran
PCDP	Polychlorinated dibenzopdioxin
PETN	Pentaerythritol tetranitrate
PRG	Preliminary Remediation Goal
PST	Pacific Standard Time
RCRA	Resource Conservation and Recovery Act
RDX	Research Department explosive (cyclotrimethylenetrinitramine)
REL	Reference Exposure Levels
rep	reptile
RfD	Reference dose
RREI	Representative receptor of ecological interest
RWBB	Red-Winged Black Bird
SF	Scaling factor
SO_2	Sulfur dioxide
SVOC	Semi-volatile organic compound
TCDD	2,3,7,8-Tetrachlorodibenzo-p-dioxin
TCDF	2,3,7,8-Tetrachlorodibenzofuran
TEF	Toxicity equivalency factor
TNT	Trinitrotoluene
TPHCWG	Total Petroleum Hydrocarbon Criteria Working Group
TRV	Toxic reference value
U.S.	United States

UF	Uncertainty factor
UT	Utah
veg	vegetation
VOC	Volatile organic compound
wlf	wildlife
Zn	Zinc

Appendix A. Integration of OBODM into the HARP

As stated in the main body of this risk assessment, the standard approach for human health risk assessment is a four-step process stated by the National Academy of Sciences in *Risk Assessment in the Federal Government: Managing the Process* (NAS, 1983) and reiterated in *The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments* (OEHHA, 2003). The four steps in the process are (1) hazard identification, (2) exposure assessment, (3) dose-response assessment, and (4) risk characterization.

For this risk assessment for the EWTF, the DTSC recommended the use of the Open Burn Open Detonation Dispersion Model (OBODM; Bjorklund et al., 1998). Region III of the U.S. EPA (2002) also recommends its use. The OBODM has components that allow completion of steps 1 and 2 (i.e., it contains emissions factors for many chemicals based on tests of 39 types of munitions [see also Mitchell and Suggs, 1998]); and it contains a Gaussian-plume air dispersion model developed specifically for short-term episodic releases, such as open burns and open detonations. The OBODM emission factors have been widely used to estimate the hazards from OB/OD and similar operations.[3] It is more common for a risk assessor to identify the hazards through developing source-specific information and/or through the use of approved emissions factors not specifically included in the air dispersion model. Unfortunately, the OBODM only allows the estimation of one released chemical for each treated material for each model run. If, for example, an OB/OD treatment involved the release of ten materials, the OBODM would have to be run ten times. Because the model is linear with respect to the initial released chemical, the OBODM could also be run once, and a scaling factor could then be used to scale the result up or down, depending on the ratio of the initial chemical to the chemical in question. (For example, if chemical A has an emission factor of 1, and chemical B has an emission factor of 2, the OBODM could be run for chemical A, and the air concentrations would then be used without adjustment for chemical A and would be multiplied by 2 for chemical B.)

To complete this risk assessment, the Hotspot Analysis Reporting Program (HARP) (CARB, 2003) was used. The OEHHA and the California Air Resources Board (CARB) developed this model for compliance with the AB2588 Hotspots reporting requirements. The HARP provides assistance with steps 2, 3 and 4 of risk assessment: (2) exposure assessment, (3) dose-response assessment, and (4) risk characterization.

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[3] For example, OBODM emission factors have been used by the U.S. Navy and affirmed by the Agency for Toxic Substances Disease Registry (ATSDR) in evaluating emissions from Isla de Vieques, Puerto Rico, bombing range (http://www.atsdr.cdc.gov/HAC/PHA/vieques4/vbr_p5.html): "The Navy contractor used emission factors derived from Bangbox studies to estimate emissions of chemical by-products of bombing activities. These emission factors have been widely used to assess environmental impacts from open burning and open detonation activities. For instance, the Open Burn/Open Detonation Model (OBODM), available from EPA's clearinghouse of dispersion models on the agency's technology transfer network, also estimates air emissions from the Bangbox emission factors. ATSDR acknowledges that the representativeness of static detonation tests to live bombing exercises has not been established. However, source testing (or emissions measurements) during live bombing exercises is an extremely complicated endeavor, given the potential safety hazards associated with placing field surveying equipment in the proximity of bombing targets. In the absence of such source testing results, ATSDR believes the Bangbox emission factors are reasonable indicators of chemical releases from explosions."

The HARP model is available in two formats: a free, self-contained version and a commercial version (called HARPExpress) that relies on Microsoft Excel to provide a user-friendly interface for entering information into the program. This risk assessment used HARPExpress; however, this risk assessment refers to the model as “HARP.”

To accomplish the exposure assessment portion of the risk assessment, the HARP incorporates the Industrial Source Code, Short Term (ISCST) model. ISCST is the U.S. EPA regulatory model most commonly used in permitting actions. It includes the common assumptions that emissions are continuous and that they are vented through a stack. Consequently, the air dispersion modeling output of the HARP could not be used (at least not without some manipulation). However, the HARP is quite robust in its treatment of dose-response assessment and risk characterization. It allows modeling of many chemicals at the same time (in this case, 51) and is limited only by the availability of toxicological information.

The problem that arose in this risk assessment was how to integrate the source term and the atmospheric modeling capabilities of the OBODM together with the exposure assessment, dose response and risk characterization attributes of the HARP.

The integration of the emissions factors information was straightforward. The emissions factors from the OBODM were read into a Microsoft Access database file. The database file was queried for the munitions that were identified as those representative of waste Forms 1 through 4, and the highest emission factor for each emitted chemical was selected. These emissions factors were multiplied by the amount of material treated, and the emissions estimates for each chemical for each waste form were copied into the HARP.

The integration of the air dispersion modeling was somewhat more complex. First, it is important to remember that the HARP is written in a modular form and that the modules operate independently. The HARP modules are the source term calculations, the air dispersion calculations (which is the ISCST model), and the risk and hazard calculations. However, only the air dispersion modeling of the HARP needed to be changed from ISCST output to the OBODM output.

Fortunately (from the point of view of inserting the OBODM results into the HARP), ISCST (within the HARP) begins all of its air dispersion calculations from the assumption that 1 gram per second (1 g/s) is being released from a facility. It does not use the actual emissions until later in the modeling code. From the starting point of a 1-g/s release (also called a unit-source release), ISCST then calculates the concentrations at all the receptor locations identified in the input file, in micrograms per cubic meter of air (μg/m^3) for that 1-g/s release. The result is called the unit source “X/Q,” where “X” (the Greek letter “chi”) is the concentration at the receptor location, and “Q” is the emission rate for the material of interest. The X/Q data are located in an ISCST file named “filename.XOQ” where “filename” represents the file name of the particular model run.

Therefore, to incorporate the OBODM results into the HARP, the modeler needs to acquire a unit source “X/Q” from the OBODM for all receptor locations and substitute that data into the filename.XOQ file. After the substitution is made, the risk and the hazard assessments modules of the HARP can be run based on OBODM X/Q data. The OBODM does not have an intermediate “X/Q” file that is obviously accessible. However, the OBODM primary output, ground-level concentrations, can be used with the input emissions concentrations to calculate the X/Q for each location. This was the approach that was taken. It was used for both maximum hourly X/Q and annual average X/Q.

The chemical barium was selected for the calculation because it had an emission factor for all four waste forms. The emission factor for barium for Forms 1 and 2 was 0.0082, and the emission factor for Forms 3 and 4 was 0.000086. The OBODM model was run for each of these emission factors for all four forms. Because a “unit” X/Q was being calculated, the results should be the same without regard to the initial emission factor. The use of actual emission factors enabled checking the concentration of barium for each of the waste forms in the HARP after the substitution was made.

To reiterate, the concentration output of the OBODM model must be divided by the emission rate for each of the waste forms to yield a unit source X/Q. However, this step requires the availability of the source emission rates. These emission rates were calculated from the estimated masses of the quantities emitted per second. The calculations and the resulting emission rates are shown in Table A-1. Table A-2 shows the unit source X/Q calculations based on the 0.0082 barium emission factor, and Table A-3 shows the unit source X/Q calculations based on the 0.000086 barium emission factor. A comparison of Tables A-2 and A-3 shows that the unit source X/Qs are calculated to be the same to five significant digits. Exact agreement to more significant digits was not expected because only three significant digits are presented in the OBODM output. It should be noted that the source order in Tables A-2 and A-3 are as follows: source 1 is the burn pan, source 2 is the burn cage (Form 3), source 3 is the burn cage (Form 4), and source 4 is the detonation pad. The same source order was implemented in the HARP.

Table A-4 shows the modified .XOQ file after the annual average and maximum hourly values were updated with OBODM X/Q values. The validity of the approach was checked by comparing the concentrations calculated by the HARP for barium with those calculated by the OBODM. The results were equal, confirming that the .XOQ file had been modified appropriately. This confirmatory calculation was carried out independently by two of the authors of this report; both of whom obtained the same results. The calculations are shown in Table A-5, where the appropriate ground-level concentrations for each of the sources are summed for the total annual average concentration and the maximum 1-hour concentration for each modeled receptor location. Figure A-1 is a screen shot of the annual average and maximum hourly ground-level concentrations calculated by the HARP.

Table A-1. Calculation of unit source values for two barium emission factors.

	Burn pan	Burn cage (form 3)	Burn cage (form 4)	Detonation pad
Barium factor 0.0082	**Annual average emission rate**			
Pounds per event	100	50	260	350
Events per year	100	100	100	100
Total pounds per year	10000	5000	26000	35000
Total grams per year	4535923	2267962	11793400	15875731
Total seconds per year	31536000	31536000	31536000	31536000
Annual average g/s	0.144	0.072	0.374	0.503
Barium emission factor	0.0082	0.0082	0.0082	0.0082
Barium annual average emission rate (g/s)	0.00118	0.00059	0.00307	0.00413
	Maximum hourly emission rate			
Pounds per event	100	50	260	350
Events per hour	1	1	1	1
Total pounds per hour	100	50	260	350
Total grams per hour	45359	22680	117934	158757
Total seconds per hour	3600	3600	3600	3600
Hourly g/s	12.6	6.3	32.8	44.1
Barium emission factor	0.0082	0.0082	0.0082	0.0082
Barium maximum hourly emission rate (g/s)	0.103	0.052	0.269	0.362
Barium factor 0.000086	**Annual average emission rate**			
Pounds per event	100	50	260	350
Events per year	100	100	100	100
Total pounds per year	10000	5000	26000	35000
Total grams per year	4535923	2267962	11793400	15875731
Total seconds per year	31536000	31536000	31536000	31536000
Annual average g/s	0.144	0.072	0.374	0.503
Barium emission factor	0.000086	0.000086	0.000086	0.000086
Barium annual average emission rate (g/s)	0.0000124	0.0000062	0.0000322	0.0000433
	Maximum hourly emission rate			
Pounds per event	100	50	260	350
Events per hour	1	1	1	1
Total pounds per hour	100	50	260	350
Total grams per hour	45359	22680	117934	158757
Total seconds per hour	3600	3600	3600	3600

	Burn pan	Burn cage (form 3)	Burn cage (form 4)	Detonation pad
Hourly g/s	12.6	6.3	32.8	44.1
Barium emission factor	0.000086	0.000086	0.000086	0.000086
Barium maximum hourly emission rate (g/s)	0.00108	0.00054	0.00282	0.00379

Table A-2. Calculations of X/Q based on barium emission factor of 0.0082.

Emission factor 0.0082 (form12out)		OB Pan	OB Cage 3	OB Cage 4	OD	factors by which to divide Ba emissions to derive unit chi/Q
	annual ave	1.18E-03	5.90E-04	3.07E-03	4.13E-03	
	mxhrly	1.03E-01	5.17E-02	2.69E-01	3.62E-01	

Annual Average Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 1, sources: 1) Burn Pan
(Maximum = .13365E+00 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	
633000	4170500	273.9	1.00E-03	8.52E-01	.8515709E+00	Pasture
628681.5	4165968	201	9.67E-04	8.19E-01	.8194978E+00	Carnegie
632976.6	4166183	158.4	4.68E-04	3.97E-01	.3965510E+00	Ranch
629950	4168674	309.4	1.72E-02	1.46E+01	.1455489E+02	B812
630020	4168179	379.3	1.61E-02	1.36E+01	.1364920E+02	B895
633000	4170500	273.9	1.00E-03	8.52E-01	.8515709E+00	Pasture repeat
629500	4168500	383.9	1.34E-01	1.13E+02	.1133045E+03	Ecological

Table 3
Annual Average Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 2, sources: 2) Burn Cage (form 3)
(Maximum = .66794E-01 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	
633000	4170500	273.9	4.99E-04	8.47E-01	.8469687E+00	Pasture
628681.5	4165968	201	5.69E-04	9.65E-01	.9646185E+00	Carnegie
632976.6	4166183	158.4	2.67E-04	4.52E-01	.4524008E+00	Ranch
629950	4168674	309.4	1.05E-02	1.78E+01	.1782248E+02	B812
630020	4168179	379.3	8.92E-03	1.51E+01	.1511857E+02	B895
633000	4170500	273.9	4.99E-04	8.47E-01	.8469687E+00	Pasture repeat
629500	4168500	383.9	6.68E-02	1.13E+02	.1132647E+03	Ecological

Table 4
Annual Average Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 3, sources: 3) Burn Cage (form 4)
(Maximum = .30209E+00 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	
633000	4170500	273.9	2.55E-03	8.33E-01	.8327705E+00	Pasture
628681.5	4165968	201	2.80E-03	9.14E-01	.9135818E+00	Carnegie
632976.6	4166183	158.4	1.34E-03	4.37E-01	.4366443E+00	Ranch
629950	4168674	309.4	4.49E-02	1.46E+01	.1463560E+02	B812
630020	4168179	379.3	4.28E-02	1.39E+01	.1394625E+02	B895
633000	4170500	273.9	2.55E-03	8.33E-01	.8327705E+00	Pasture repeat
629500	4168500	383.9	3.02E-01	9.85E+01	.9851385E+02	Ecological

Table A-2. Calculations of X/Q based on barium emission factor of 0.0082 (continued).

Table 5
Annual Average Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 4, sources: 4) Detonation Pad
(Maximum = .12371E+00 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	
633000	4170500	273.9	2.10E-03	5.08E-01	.5081017E+00	Pasture
628681.5	4165968	201	2.19E-03	5.31E-01	.5313550E+00	Carnegie
632976.6	4166183	158.4	1.27E-03	3.07E-01	.3067384E+00	Ranch
629950	4168674	309.4	1.72E-02	4.17E+00	.4165249E+01	B812
630020	4168179	379.3	2.44E-02	5.90E+00	.5900564E+01	B895
633000	4170500	273.9	2.10E-03	5.08E-01	.5081017E+00	Pasture repeat
629500	4168500	383.9	1.24E-01	3.00E+01	.2996745E+02	Ecological

Table 6
Highest Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 1, sources: 1) Burn Pan
(Maximum = 11.877 at X,Y,Z =629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Mo/	Dy/	Yr	Jdy	Hr
633000	4170500	273.9	0.12558	1.22E+00	.1215468E+01	3	26	0	68	800
628681.5	4165968	201	0.223714	2.17E+00	.2165290E+01	9	13	1	86	800
632976.6	4166183	158.4	0.114005	1.10E+00	.1103435E+01	3	6	3	65	800
629950	4168674	309.4	2.8726	2.78E+01	.2780341E+02	11	6	2	310	800
630020	4168179	379.3	2.95159	2.86E+01	.2856795E+02	12	20	4	355	800
633000	4170500	273.9	0.12558	1.22E+00	.1215468E+01	3	26	0	86	800
629500	4168500	383.9	11.877	1.15E+02	.1149555E+03	9	11	2	254	800

Table 8
Highest Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 2, sources: 2) Burn Cage (form 3)
(Maximum = 5.0540 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Mo/	Dy/	Yr	Jdy	Hr
633000	4170500	273.9	0.050014	9.68E-01	.9681504E+00	12	6	2	340	800
628681.5	4165968	201	8.33E-02	1.61E+00	.1612033E+01	9	13	1	256	800
632976.6	4166183	158.4	0.040661	7.87E-01	.7870981E+00	3	6	3	65	800
629950	4168674	309.4	1.3717	2.66E+01	.2655291E+02	1	19	4	19	900
630020	4168179	379.3	1.17555	2.28E+01	.2275590E+02	11	25	0	330	800
633000	4170500	273.9	0.050014	9.68E-01	.9681504E+00	12	6	2	340	800
629500	4168500	383.9	5.05396	9.78E+01	.9783286E+02	9	11	2	254	800

Table A-2. Calculations of X/Q based on barium emission factor of 0.0082 (continued).

Table 10
Highest Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 3, sources: 3) Burn Cage (form 4)
(Maximum = 21.001 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Mo/	Dy/	Yr	Jdy	Hr
633000	4170500	273.9	0.246753	9.19E-01	.9185696E+00	12	6	2	340	800
628681.5	4165968	201	0.391287	1.46E+00	.1456616E+01	9	13	1	256	800
632976.6	4166183	158.4	0.198177	7.38E-01	.7377392E+00	3	6	3	65	800
629950	4168674	309.4	4.95688	1.85E+01	.1845262E+02	1	19	4	19	900
630020	4168179	379.3	5.4473	2.03E+01	.2027827E+02	11	25	0	330	900
633000	4170500	273.9	0.246753	9.19E-01	.9185696E+00	12	6	2	340	800
629500	4168500	383.9	21.0008	7.82E+01	.7817816E+02	9	11	2	254	800

Table 12
Highest Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 4, sources: 4) Detonation Pad
(Maximum = 18.767 at X,Y,Z =629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Mo/	Dy/	Yr	Jdy	Hr
633000	4170500	273.9	0.591244	1.64E+00	.1635015E+01	12	8	0	343	900
628681.5	4165968	201	0.435929	1.21E+00	.1205510E+01	9	13	1	256	800
632976.6	4166183	158.4	0.373553	1.03E+00	.1033016E+01	10	16	1	289	800
629950	4168674	309.4	1.92837	5.33E+00	.5332677E+01	1	1	0	1	900
630020	4168179	379.3	8.25488	2.28E+01	.2282789E+02	3	6	3	65	800
633000	4170500	273.9	0.591244	1.64E+00	.1635015E+01	12	8	0	343	900
629500	4168500	383.9	18.767	5.19E+01	.5189790E+02	2	18	0	49	800

Table A-3. Calculations of X/Q based on barium emission factor of 0.000086.

Emission factor 0.000086		OB Pan	OB Cage 3	OB Cage 4	OD	factors by which to divide
(form34out)	annual ave	1.24E-05	6.18E-06	3.22E-05	4.33E-05	Ba emissions to derive
	mxhrly	1.08E-03	5.42E-04	2.82E-03	3.79E-03	unit chi/Q

Annual Average Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 1, sources: 1) Burn Pan
(Maximum = .14015E-02 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	
633000	4170500	273.9	1.05E-05	8.52E-01	.8515679E+00	Pasture
628681.5	4165968	201	1.01E-05	8.19E-01	.8194975E+00	Carnegie
632976.6	4166183	158.4	4.91E-06	3.97E-01	.3965511E+00	Ranch
629950	4168674	309.4	1.80E-04	1.46E+01	.1455489E+02	B812
630020	4168179	379.3	1.69E-04	1.36E+01	.1364921E+02	B895
633000	4170500	273.9	1.05E-05	8.52E-01	.8515679E+00	Pasture repeat
629500	4168500	383.9	1.40E-03	1.13E+02	.1133047E+03	Ecological

Table 3
Annual Average Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 2, sources: 2) Burn Cage (form 3)
(Maximum = .70052E-03 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	
633000	4170500	273.9	5.24E-06	8.47E-01	.8469696E+00	Pasture
628681.5	4165968	201	5.97E-06	9.65E-01	.9646204E+00	Carnegie
632976.6	4166183	158.4	2.80E-06	4.52E-01	.4524023E+00	Ranch
629950	4168674	309.4	1.10E-04	1.78E+01	.1782249E+02	B812
630020	4168179	379.3	9.35E-05	1.51E+01	.1511861E+02	B895
633000	4170500	273.9	5.24E-06	8.47E-01	.8469696E+00	Pasture repeat
629500	4168500	383.9	7.01E-04	1.13E+02	.1132646E+03	Ecological

Table 4
Annual Average Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 3, sources: 3) Burn Cage (form 4)
(Maximum = .31683E-02 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	
633000	4170500	273.9	2.68E-05	8.33E-01	.8327701E+00	Pasture
628681.5	4165968	201	2.94E-05	9.14E-01	.9135820E+00	Carnegie
632976.6	4166183	158.4	1.40E-05	4.37E-01	.4366424E+00	Ranch
629950	4168674	309.4	4.71E-04	1.46E+01	.1463560E+02	B812
630020	4168179	379.3	4.49E-04	1.39E+01	.1394629E+02	B895
633000	4170500	273.9	2.68E-05	8.33E-01	.8327701E+00	Pasture repeat
629500	4168500	383.9	3.17E-03	9.85E+01	.9851374E+02	Ecological

Table A-3. Calculations of X/Q based on barium emission factor of 0.000086 (continued).

Table 5
Annual Average Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 4, sources: 4) Detonation Pad
(Maximum = .12974E-02 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	
633000	4170500	273.9	2.20E-05	5.08E-01	.5081029E+00	Pasture
628681.5	4165968	201	2.30E-05	5.31E-01	.5313557E+00	Carnegie
632976.6	4166183	158.4	1.33E-05	3.07E-01	.3067369E+00	Ranch
629950	4168674	309.4	1.80E-04	4.17E+00	.4165263E+01	B812
630020	4168179	379.3	2.55E-04	5.90E+00	.5900570E+01	B895
633000	4170500	273.9	2.20E-05	5.08E-01	.5081029E+00	Pasture repeat
629500	4168500	383.9	1.30E-03	3.00E+01	.2996758E+02	Ecological

Table 6
Highest Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 1, sources: 1) Burn Pan
(Maximum = .12456E+00 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Mo/	Dy/	Yr	Jdy	Hr
633000	4170500	273.9	1.32E-03	1.22E+00	.1215469E+01	3	26	0	86	800
628681.5	4165968	201	2.35E-03	2.17E+00	.2165291E+01	9	13	1	256	800
632976.6	4166183	158.4	1.20E-03	1.10E+00	.1103433E+01	3	6	3	65	800
629950	4168674	309.4	3.01E-02	2.78E+01	.2780344E+02	11	6	2	310	800
630020	4168179	379.3	3.10E-02	2.86E+01	.2856795E+02	12	20	4	355	800
633000	4170500	273.9	1.32E-03	1.22E+00	.1215469E+01	3	26	0	86	800
629500	4168500	383.9	1.25E-01	1.15E+02	.1149549E+03	9	11	2	254	800

Table 8
Highest Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 2, sources: 2) Burn Cage (form 3)
(Maximum = .53005E-01 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Mo/	Dy/	Yr	Jdy	Hr
633000	4170500	273.9	5.25E-04	9.68E-01	.9681504E+00	12	6	2	340	800
628681.5	4165968	201	8.73E-04	1.61E+00	.1612032E+01	9	13	1	256	800
632976.6	4166183	158.4	4.26E-04	7.87E-01	.7870972E+00	3	6	3	65	800
629950	4168674	309.4	1.44E-02	2.66E+01	.2655287E+02	1	19	4	19	900
630020	4168179	379.3	1.23E-02	2.28E+01	.2275583E+02	11	25	0	330	800
633000	4170500	273.9	5.25E-04	9.68E-01	.9681504E+00	12	6	2	340	800
629500	4168500	383.9	5.30E-02	9.78E+01	.9783278E+02	9	11	2	254	800

Table A-3. Calculations of X/Q based on barium emission factor of 0.000086 (continued).

Table 10

Highest Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)

(Due to source group 3, sources: 3) Burn Cage (form 4)

(Maximum = .22025E+00 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Mo/	Dy/	Yr	Jdy	Hr
633000	4170500	273.9	2.59E-03	9.19E-01	.9185706E+00	12	6	2	340	800
628681.5	4165968	201	4.10E-03	1.46E+00	.1456615E+01	9	13	1	256	800
632976.6	4166183	158.4	2.08E-03	7.38E-01	.7377422E+00	3	6	3	65	800
629950	4168674	309.4	5.20E-02	1.85E+01	.1845262E+02	1	19	4	19	900
630020	4168179	379.3	5.71E-02	2.03E+01	.2027826E+02	11	25	0	330	800
633000	4170500	273.9	2.59E-03	9.19E-01	.9185706E+00	12	6	2	340	800
629500	4168500	383.9	2.20E-01	7.82E+01	.7817806E+02	9	11	2	254	800

Table 12

Highest Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)

(Due to source group 4, sources: 4) Detonation Pad

(Maximum = .19682E+00 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Mo/	Dy/	Yr	Jdy	Hr
633000	4170500	273.9	6.20E-03	1.64E+00	.1635014E+01	12	8	0	343	900
628681.5	4165968	201	4.57E-03	1.21E+00	.1205510E+01	9	13	1	256	800
632976.6	4166183	158.4	3.92E-03	1.03E+00	.1033016E+01	10	16	1	289	800
629950	4168674	309.4	2.02E-02	5.33E+00	.5332686E+01	1	1	0	1	900
630020	4168179	379.3	8.66E-02	2.28E+01	.2282787E+02	3	6	3	65	800
633000	4170500	273.9	6.20E-03	1.64E+00	.1635014E+01	12	8	0	343	900
629500	4168500	383.9	1.97E-01	5.19E+01	.5189800E+02	2	18	0	49	800

Table A-4. Modified .XOQ file after the annual average and maximum hourly values were updated with OBODM X/Q values. (Other values in .XOQ files were not used in this risk assessment).

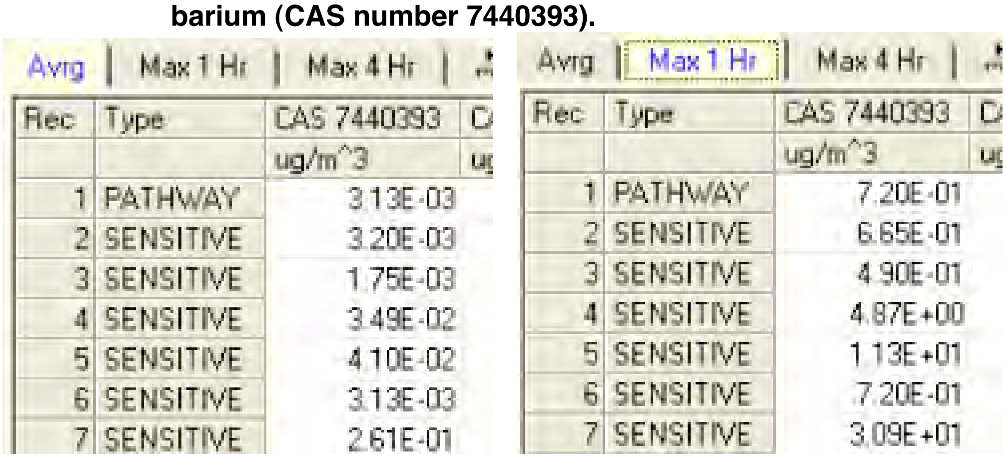
SRC	REC	UNUSED	AVERAGE	1HR_MAX	. . .(additional columns, not used in this assessment)
1	1	0.3961217E+00	0.8515709E+00	0.1215468E+01	. . .
1	2	0.2721988E-02	0.8194978E+00	0.2165290E+01	. . .
1	3	0.2719286E-02	0.3965510E+00	0.1103435E+01	. . .
1	4	0.2839895E-02	0.1455489E+02	0.2780341E+02	. . .
1	5	0.3750449E-01	0.1364920E+02	0.2856795E+02	. . .
1	6	0.2341939E-01	0.8515709E+00	0.1215468E+01	. . .
1	7	0.2341939E-01	0.1133045E+03	0.1149555E+03	. . .
2	1	0.4261317E+00	0.8469687E+00	0.9681504E+00	. . .
2	2	0.3105313E-02	0.9646185E+00	0.1612033E+01	. . .
2	3	0.4173856E-01	0.4524008E+00	0.7870981E+00	. . .
2	4	0.2657336E-01	0.1782248E+02	0.2655291E+02	. . .
2	5	0.8583720E+00	0.1511857E+02	0.2275590E+02	. . .
2	6	0.1174408E+01	0.8469687E+00	0.9681504E+00	. . .
2	7	0.2341939E-01	0.1132647E+03	0.9783286E+02	. . .
3	1	0.4261317E+00	0.8327705E+00	0.9185696E+00	. . .
3	2	0.3105313E-02	0.9135818E+00	0.1456616E+01	. . .
3	3	0.4173856E-01	0.4366443E+00	0.7377392E+00	. . .
3	4	0.2657336E-01	0.1463560E+02	0.1845262E+02	. . .
3	5	0.8583720E+00	0.1394625E+02	0.2027827E+02	. . .
3	6	0.1174408E+01	0.8327705E+00	0.9185696E+00	. . .
3	7	0.2341939E-01	0.9851385E+02	0.7817816E+02	. . .
4	1	0.2331261E+00	0.5051017E+00	0.1635015E+01	. . .
4	2	0.2328404E-02	0.5313550E+00	0.1205510E+01	. . .
4	3	0.3221262E-01	0.3067384E+00	0.1033016E+01	. . .
4	4	0.1822067E-01	0.4165249E+01	0.5332677E+01	. . .
4	5	0.7229874E+00	0.5900564E+01	0.2282789E+02	. . .
4	6	0.9328276E+00	0.5081017E+00	0.1635015E+01	. . .
4	7	0.2341939E-01	0.2996745E+02	0.5189790E+02	. . .

Table A-5. Total ground level concentration of barium for all four sources by receptor location[a].

Location	X (UTM East) (Meters)	Y (UTM North) (Meters)	Z (Elevation) (Meters)	Ground Level Concentration µg/m3
Annual average				
Pasture	633000	4170500	273.9	3.13E-03
Carnegie	628681.5	4165968	201	3.20E-03
Ranch	632976.6	4166183	158.4	1.75E-03
B812	629950	4168674	309.4	3.49E-02
B895	630020	4168179	379.3	4.10E-02
Pasture repeat	633000	4170500	273.9	3.13E-03
Ecological	629500	4168500	383.9	2.61E-01
Maximum 1 hour				
Location	X (UTM East) (Meters)	Y (UTM North) (Meters)	Z (Elevation) (Meters)	Ground Level Concentration µg/m3
Pasture	633000	4170500	273.9	7.20E-01
Carnegie	628681.5	4165968	201	6.65E-01
Ranch	632976.6	4166183	158.4	4.90E-01
B812	629950	4168674	309.4	4.87E+00
B895	630020	4168179	379.3	1.13E+01
Pasture repeat	633000	4170500	273.9	7.20E-01
Ecological	629500	4168500	383.9	3.09E+01

[a] the burn pan (source 1) and detonation pad (source 4) values are obtained from Table A-2, and the burn cage/Form 3 (source 2) and burn cage/Form 4 (source 3) values are obtained from Table A-3.

Figure A-1. Screen captures of total ground level concentrations for the HARP for barium (CAS number 7440393).



Avrg | Max 1 Hr | Max 4 Hr

Rec	Type	CAS 7440393 ug/m^3
1	PATHWAY	3.13E-03
2	SENSITIVE	3.20E-03
3	SENSITIVE	1.75E-03
4	SENSITIVE	3.49E-02
5	SENSITIVE	4.10E-02
6	SENSITIVE	3.13E-03
7	SENSITIVE	2.61E-01

Avrg | Max 1 Hr | Max 4 Hr

Rec	Type	CAS 7440393 ug/m^3
1	PATHWAY	7.20E-01
2	SENSITIVE	6.65E-01
3	SENSITIVE	4.90E-01
4	SENSITIVE	4.87E+00
5	SENSITIVE	1.13E+01
6	SENSITIVE	7.20E-01
7	SENSITIVE	3.09E+01

Note: The pathway location (for the beef ingestion pathway) was repeated as the number 6 "sensitive" location (for a person) in the HARP to assure that the final result was a risk value for a person at that location, and not some other type of receptor, e.g., a cow. The pathway location was necessary for the HARP to calculate a human ingestion dose from the beef pathway.

Appendix B. Ecological Risk Assessment in Support of Renewal of Permit for the Explosive Waste Treatment Facility (EWTF) at Site 300 of Lawrence Livermore National Laboratory

B.1 Introduction

This ecological risk assessment (ERA) is a supplement to the human health risk assessment (HRA) for the Explosive Waste Treatment Facility (EWTF). The EWTF is located near the center of Site 300 in a small, isolated canyon (see Figures 2 through 6 in the text). The ERA described in detail in this Appendix was prepared in accordance with guidance on currently accepted practice provided by the Human and Ecological Risk Division (HERD) at the Department of Toxic Substances Control (DSTC) of the State of California Environmental Protection Agency (CalEPA) in Sacramento, California.

The technical basis for this ERA was an analysis that screened each contaminant of potential ecological concern (CPEC) for its potential to produce an adverse ecological impact in a particular wildlife species at a specific location based on the relationship between its predicted soil concentration and the ecological soil screening levels (ESSLs) determined for each of the nine different wildlife representative receptors of ecological interest (RREI) that are members of the food network. There were four steps in the ERA analysis:

1) Each CPEC in emissions from the Open Burn/Open Detonation (OB/OD) operations at the Site 300 EWTF was identified, and its soil concentration over a 6-inch (15-cm) depth (mg/kg_{soil}) was predicted for a receptor location of interest based on atmospheric dispersion and deposition modeling.
2) An RREI with a distinct diet type was selected in the habitat of interest for each trophic level of the applicable wildlife food web.
3) An ecological soil screening level (ESSL)—i.e., a CPEC-specific concentration in soil that is protective of a particular wildlife (wlf) receptor (e.g., mammal, bird, or invertebrate) that might have contact with such soil, directly or indirectly—was determined. An $ESSL_{wlf}$ for a reptile (wlf = rep), an avian (wlf = brd), and a mammalian (wlf = mam) RREI was based on a species-specific, derived toxic reference value (TRV_{wlf}). The ESSL applicable to soil invertebrates (e.g., earthworms) was based on the no-observed effect concentration in soil that was found in the literature to be applicable to the earthworm.
4) The *lowest* $ESSL_{wlf}$ for each CPEC among those determined to be applicable to the soil invertebrate (wlf = inv), the reptile (wlf = rep), the avian (wlf = brd) and the mammalian (wlf = mam) RREI was compared to the respective CPEC-specific soil concentration predicted from atmospheric dispersion and deposition modeling over a depth of 6 inches (15 cm) at specific receptor locations near and around the EWTF. This was determined by dividing each CPEC-specific soil concentration value at a specific location by the applicable lowest $ESSL_{wlf}$ value, where the result equates to an ESSL-equivalent ecological hazard quotient (EHQ) for each RREI with respect to the CPEC at the selected location. An EHQ greater than unity suggests a possibility for adverse ecological impact. CPEC-specific EHQs also were computed at the

receptor location nearest the EWTF specifically for two species of particular concern at Site 300—i.e., the San Joaquin Kit Fox and the Burrowing Owl—and these EHQs were based on ESSLs derived specifically for these particular organisms.

Forty-five potential contaminants (including surrogates, such as Research Department Explosive (RDX), which represents both RDX and pentaerythritol tetranitrate [PETN]) are considered to be produced from OB/OD operations at the EWTF. Among these 45 substances, 24 are not addressed in this ERA because they are gaseous or gaseous upon emission. These emissions disperse significantly into the atmosphere and do not pose a problem as potential soil contaminants. The 24 emissions falling into this "gaseous emission" category are carbon monoxide (CO), chlorine (Cl), hydrogen chloride (HCl), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and 19 additional volatile organic compounds (VOCs)—allyl chloride; benzene; 1,3-butadiene; carbon tetrachloride; chloroform; cyclohexane; ethylbenzene; ethyl chloride; isopropylbenzene; methyl chloride (or chloromethane); methyl chloroform (or 1,1,1-trichloroethane); methyl cyclohexane; methyl chloride; n-hexane; propene; styrene; tetrachloroethylene (1,1,2,2-tetrchloroethane); toluene; and vinyl chloride. The 21 remaining substances were considered CPECs and consisted of five polychlorinated dibenzofurans (PCDFs), three energetic or other thermally labile compounds, eight metals, and five semi-volatile organic compounds (SVOCs).

This ERA evaluated a total of nine different RREIs:

- Soil invertebrate (represented by the earthworm).
- Ominvorous bird (represented by the Savannah Sparrow [*Passerculus sandwichensis*]).
- Carnivorous bird (represented by the Burrowing Owl [*Athene cunicularia*]).
- Insectivorous reptile (represented by the Side-Blotched Lizard [*Uta stansubriana*]).
- Omnivorous small mammal (Deer Mouse [*Permyscus maniculatus*]).
- Granivorous small mammal (California Ground Squirrel [*Spermophilus beecheyi*]).
- Herbivorous small mammal (Pocket Gopher [*Thomomys bottae*]).
- Herbivorous large mammal (Black-Tailed [Mule] Deer [*Odocoileus hemionus columbianus*]).
- Carnivorous mammal (San Joaquin Kit Fox [*Vulpes macrotis mutica*]).

Each RREI (except for the soil invertebrate) has a distinct diet at its particular level of the food web (conceptualized in Figure B-1).

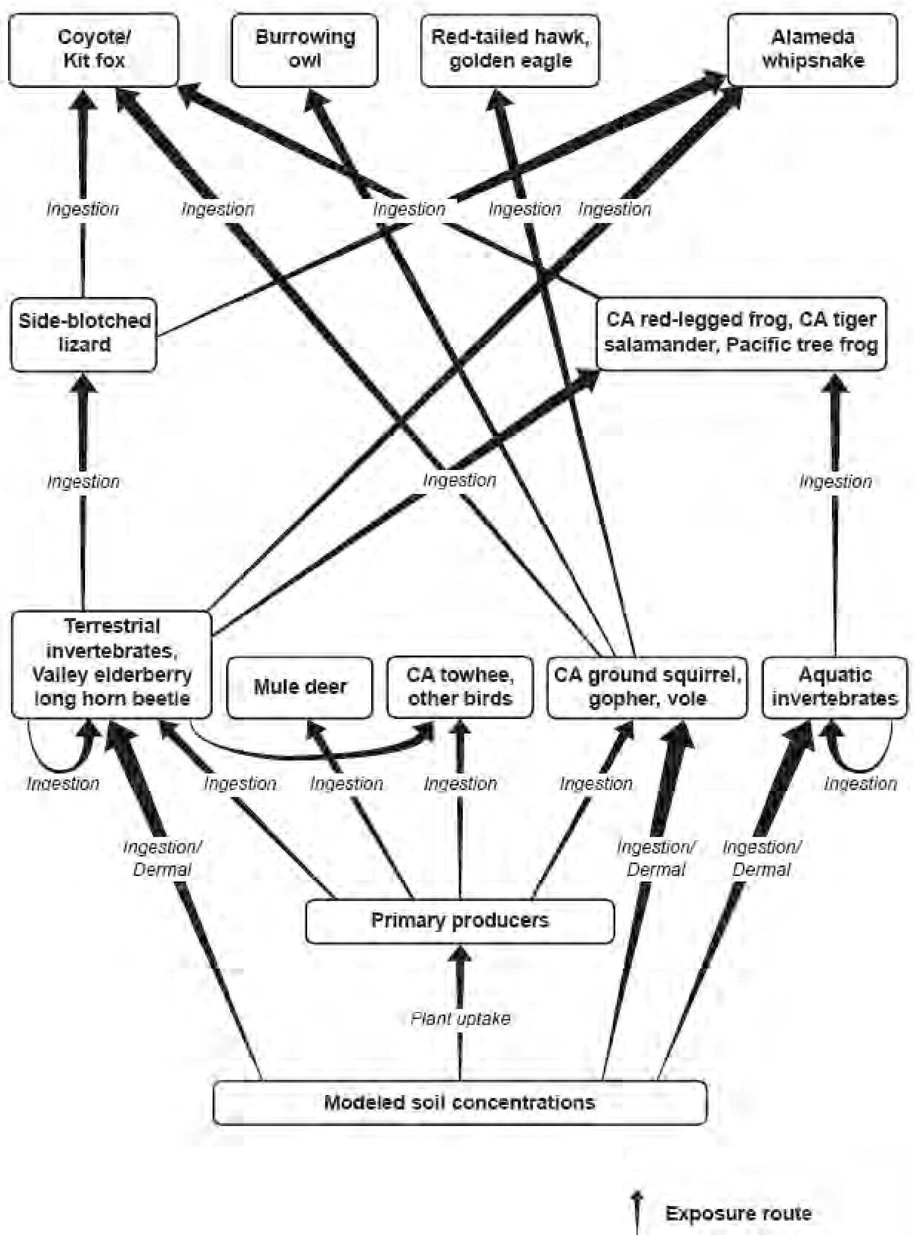


Figure B-1. RREIs of concern in relation to conceptualized food web.

B.1.1 Source Term

The EWTF OB/OD operations at Site 300 represent the source term. As described in the risk assessment text, these operations involve:

- Open detonation of Waste Form 1 (waste explosives that otherwise might detonate during open burning).
- Open burning in a burn pan of Waste Form 2 (waste explosives or explosive parts).
- Open burning in a burn cage of either Waste Form 3 (waste explosives that are wetted in processing or as a result of removal from waste water as sludge from weirs and settling basins or on wetted expendable filters) or Waste Form 4 (explosives-contaminated waste materials, including paper, rags, plastic tubing, gloves and personal protective equipment).

Emissions were estimated based on the planned quantities of materials to be treated annually (see Table 1 in the text):

- Waste Form 1 (OD treatment) is considered to involve 100 annual treatments of 350 pounds (159 kg) each.
- Waste Form 2 (OB pan) is considered to involve 100 annual treatments of 100 pounds (45 kg) each.
- Waste Form 3 (OB cage) is considered to involve 100 annual treatments of 50 pounds (23 kg) each.
- Waste Form 4 (OB cage) is considered to involve 100 annual treatments of 260 pounds (118 kg) each.

For this ERA, the Open Burn/Open Detonation Dispersion Model (OBODM) and HotSpots Analysis and Reporting Program (HARP) models (see Bjorklund et al., 1998; CARB, 2003) were linked to estimate maximum annual soil concentrations for each of the 21 CPECs over a depth of 6 inches (15 cm) at six different receptor locations in the habitat of Site 300, including one location near the OD pad, OB burn pan, and OB burn cage (all of which are in close proximity) at the EWTF site (shown in Figure 6 of the main text).

B.1.2 Relevant Exposure Pathways for Each RREI

Only the ingestion exposure pathway was considered for each RREI. "Ingestion" is defined as dry-matter intake (DMI) of the proportion of vegetation, invertebrate prey and/or vertebrate prey as well as incidental soil ingestion considered representative of the diet of a particular RREI. Potential inhalation and dermal absorption of CPEC-contaminated soil as a result of particulate resuspension into air or contact with soil on the ground or in burrows were considered to contribute significantly lower doses than those associated with the ingestion pathway. The intake of contaminated water by an RREI also was not addressed in this ERA.

For purposes of conservatism, all RREI living, foraging, prey capturing, and incidental soil ingestion were considered to occur at the selected receptor sites, including that habitat nearest OB/OD operations, where modeling predicted that the highest concentrations of each CPEC are deposited. In addition, concentrations of CPECs were calculated over a depth of 6 inches (15 cm). Although 2 feet (60 cm) is a common depth for evaluating the effects on fossorial animals (DTSC, 1998), that depth was not used for two reasons. Because the source of contamination is air deposition, the soil at depth would not be expected to be at the same level of contamination as would be present at the surface. An additional conservative assumption made was that the absorption fraction of each CPEC from the intestinal tract of each RREI was considered to be 100 percent.

B.1.3 Habitat

Site 300 itself is hilly, natural grassland habitat. Only about 5 percent of this 11-square-mile (28-sq-km) site is even developed. Put into perspective, the vast majority of this site is undeveloped and consists mostly of undisturbed land with diverse wildlife (U.S. Department of Energy/National Nuclear Security Administration [DOE/NNSA], 2005). Because it is a high explosives testing area, Site 300 has no public access and is subject to controlled burns. These two factors prevent impacts from grazing and contribute to natural biodiversity.

B.1.4 Identification of CPECs and RREIs

Table B-1 contains the list of the 21 CPECs, along with their Chemical Abstract Service registry identification numbers (CAS ID), applicable toxicity equivalency factors (TEF), and the RREI specific toxicity reference values (TRVs) obtained experimentally for mammalian and avian test species, as well as the body weight associated with each experimental test species (ETS). The 21 CPECs are divided among four chemical categories:

- Five polychlorinated dibenzofurans (PCDFs).
- Three energetic and thermally labile compounds.
- Eight metals.
- Five SVOCs.

For each of the five PCDF congeners, the TEFs that are applicable to humans and mammals with respect to 2,3,7,8 tetrachlorodibenzo-p-dioxin (TCDD), and to birds with respect to 2,3,7,8-tetrachlorodibenzofuran (TCDF) were provided (see Van den Berg et al., 1998). Thus, a TRV that is applicable to a mammal for a particular PCDF can be divided by the TEF for that PCDF to yield the TRV for TCDD that was used to generate it. Similarly, a TRV that is applicable to birds for a particular PCDF can be divided by the TEF for that PCDF to yield the TRV for TCDF that was used to generate it. For the chemicals in the other categories, the TEF is equal to 1.0 because each TRV was derived specifically for that substance.

As a consequence of the location and the habitat of Site 300, the wildlife that were specified in this ERA as RREIs include three fossorial (i.e., burrowing) species:

- California Ground Squirrel, a small, mammalian granivore, which is generally considered to have a home range of one-quarter to one-half an acre (.1 to 0.2 ha (CDFG, 2005a).

- San Joaquin Kit Fox, a mammalian carnivore with a general home range of 1 to 2 square miles (2.6 to 5.2 sq km)(CDFG, 2005a).
- Burrowing Owl, an avian carnivore with a general home range of (1 to 4 acres (0.4 to 1.6 ha) (CDFG, 2005b).

In addition to these organisms, wildlife also of interest in the food web of the habitat (see Figure B-1) are represented by:

- An insectivorous reptile (Side-blotched Lizard).
- An omnivorous bird (Savannah Sparrow).
- An herbivorous small mammal (Pocket Gopher).
- An herbivorous large mammal (Black-tailed [Mule] Deer with a general home range of one-third to 1 square mile (1 to 3 sq km)(CDFG, 2005a).
- An omnivorous small mammal (Deer Mouse).
- The earthworm, a terrestrial soil invertebrate.

The physiological characteristics, including body weight, total dry-matter dietary intake, and proportion of diet from other trophic levels applicable to each of these organisms, except, of course, the earthworm, appear in Table B-2.

B.1.5 Estimated CPEC-Specific Ecological Soil Screening Level (ESSL) for Each RREI

The procedure followed for estimating a CPEC-specific ESSL for an RREI involved two steps:

1) CPEC-specific toxicity reference values, where they exist for an experimental test species (TRV_{ETS}), were converted to a toxicity reference value for each wildlife RREI (TRV_{wlf}), except for the earthworm whose ESSL is specifically a no-observed effect concentration in soil.
2) Then the CPEC-specific TRV_{wlf} for each organism (except the earthworm) was divided by the quantity that consists of the appropriate dietary factors (i.e., sum of products of dietary fraction and bioaccumulation factors [BAF]) multiplied by total daily dry-matter intake per unit body weight, to yield a CPEC-specific ESSL for each wildlife RREI.

For situations where the body weight of the wildlife is within two orders of magnitude of the body weight of the experimental test species (i.e., when $BW_{ETS}/BW_{wlf} < 100$ or $BW_{ETS}/BW_{wlf} > 0.01$), the TRV_{wlf} is equal to the quotient of the TRV_{ETS} divided by the TEF and any applicable uncertainty factors (e.g., for a PCDF, it would be the TRV_{ETS} for a congener of TCDD for mammals or TCDF for birds divided by the applicable TEF). For the situation where the body weight of the wildlife is at least two orders of magnitude different from that of the experimental test species (i.e., when $BW_{ETS}/BW_{wlf} \geq 100$ or $BW_{ETS}/BW_{wlf} \leq 0.01$), allometric scaling was required to derive the TRV_{wlf}, and the following equation was used:

$$TRV_{wlf} = [TRV_{ETS}/(TEF \times UFs)] \times (BW_{ETS}/BW_{wlf})^{1-b} ,$$

where UF is the product of any applicable uncertainty factor(s) (UFs) and "b" in the exponent is the allometric scaling factor (SF) (Sample and Arenal, 1999).

Table B-3 contains the UFs and SFs for mammalian and avian species used to derive the CPEC-specific TRVs for wildlife. The TRVs for the wildlife representing each RREI are presented in Table B-4. Table B-5 contains the appropriate BAFs for plants, invertebrates, and mammals that were used to transform a TRV_{wlf} into an $ESSL_{wlf}$ at each location. This was done using the following mathematical expression:

$$ESSL_{wlf} = (TRV_{wlf}) / \{[(DF_{veg} \times BAF_{veg}) + (DF_{inv} \times BAF_{inv}) + (DF_{rep} \times BAF_{rep}) + (DF_{mam} \times BAF_{mam})] (DMI)\},$$

where DF_{veg}, DF_{inv}, DF_{rep}, DF_{mam}, and DMI are the dietary fractions (DF) for each organism that are represented by vegetation (veg), invertebrates (inv), reptiles (rep), and/or mammals (mam); and DMI is the total dietary dry-matter intake [$mg_{dmi}/(kg_{bw}\ d)$]. These data appear in Table B-2; BAFs appear in Table B-5.

The CPEC-specific $ESSL_{wlf}$ values for each RREI, including the earthworm, are assembled in Tables B-6a and 6b for the EWTF and the Ranch locations (the two locations that are the furthest distances apart). The two parts of Table B-6 serve as examples to show how this type of data was used to select a minimum $ESSL_{wlf}$ for each CPEC and to determine the CPEC-specific ESSL-equivalent EHQ for each location at which a soil concentration was predicted. Table B-7 contains the *minima* for the ESSLs determined for each CPEC at each receptor location of interest. The organism to which each minimum applies is also noted in Table B-7.

The receptor locations and modeled soil concentrations predicted for them appear in Table B-8. Table B-9 contains the CPEC-specific EHQs at these locations, which are obtained by dividing each CPEC-specific soil concentration at each location by the minimum $ESSL_{wlf}$ value obtained from $ESSL_{wlf}$ data appearing in Table B-7.

There are EHQ values appearing in Table B-9 that do exceed unity. For example, the EHQ values for lead suggest a potential to produce ecological impact at all receptor locations for which a soil concentration was estimated. Similarly, the EHQ values for cadmium suggest a potential for ecological impact at the location of the EWTF and also possibly at the Building 812 and Building 895 receptor locations. However, the EHQ values in excess of unity are based on the highly conservative TRVs. In fact, the TRVs for cadmium and lead derived by U.S. EPA for these compounds in Ecological Soil Screening Level documents (U.S. EPA, 2005c,d), still represent NOAEL levels, but they are not as conservative as those presented by DTSC (2000). These U.S. EPA documents identify the avian wildlife TRV for cadmium as a geometric mean value and the highest bounded No-Observed Adverse Effect Level (NOAEL) below the lowest bounded Lowest Observed Adverse Effect Level (LOAEL) as the avian TRV for lead. The EHQs at the EWTF for cadmium and lead are 1.47 and 1.63, respectively, following DTSC guidance. The EHQs that were derived using the TRVs from U.S. EPA (2005c,d) are actually lower than unity, i.e., 0.011 for cadmium and 0.18 for lead.

Another comparison was made between the predicted soil concentrations at the EWTF and the ESSLs specific to two wildlife species considered to be of particular concern at Site 300—the San Joaquin Kit Fox and the Burrowing Owl. These results appear in Table B-10. For the Kit Fox, only aluminum may represent a potential impact and only at the EWTF location (i.e., EHQ > 1). Interestingly, the U.S. EPA regards aluminum only as a CPEC if soil pH is less than 5.5 (U.S. EPA, 2003). The soil pH at Site 300 is greater than 5.5 (measurements have ranged from 6.9 to 9); therefore, aluminum should not be of concern. However, for the Burrowing Owl, the EHQ for lead, as well as for cadmium, exceeds 1 at the EWTF. As stated previously, the U.S. EPA has less conservative TRV values for cadmium and lead, which would lead to EHQs less than 1. Also, the assumption that all soils to which the fossorial animals are exposed have the same concentration as predicted over a depth of 6 inches (15 cm) deep is conservative. If the estimated concentrations were adjusted to include uncontaminated soils at deeper levels, the calculated EHQ could be reduced by a factor of 4 or more.

Additionally, ESSLs have not been developed by regulatory agencies for amphibians, such as the California red-legged frog (*Rana aurora draytonii*) and the California tiger salamander (*Ambystoma californiense*) that may be present near the EWTF. However, in a technical report prepared for the Naval Facility Engineering Command in Port Hueneme, CA, by ENSR International (2004; Table 3-7, p. 3-17), a range for the no-observed effect concentrations (NOECs) in sediments that correspond to sub-lethal endpoints (e.g., growth) applicable to the leopard frog (*Rana* [likely *pipiens*]) were presented for the heavy metals Cd, Cu, Pb, and Zn. For all four of these elements, the lowest sediment NOEC value in the range provided for each element (i.e., Cd = 0.46 mg/kg; Cu = 64 mg/kg; Pb = 2000 mg/kg; and Zn = 900 mg/kg) was always less than the soil concentration predicted near the EWTF from atmospheric dispersion and deposition modeling (i.e., Cd = 0.05 mg/kg; Cu = 29 mg/kg; Pb = 8.9 mg/kg; and Zn = 1.7 mg/kg). On the basis of these results, and assuming *Rana* (likely *pipiens*) to be a suitable surrogate for *Rana aurora draytonii* and *Ambystoma californiense* serious impacts from these elements to amphibians in the area of the EWTF (as well as a distances further away) would appear to be unlikely.

B.2 ERA Conclusions

Quantification of the ecological risk posed by release of a particular contaminant to a specific habitat is complicated by many uncertainties related to limited data. However, this ERA employed very conservative values for wildlife TRVs, especially for avian RREI with respect to cadmium and lead (see avian BTAG values presented in DTSC [2000]).

The TRVs published by the U.S. EPA (2005 c,d) are more recent than the more conservative BTAG values and are based on extensive literature reviews with literally hundreds of data points. The calculated EHQs that suggest potential impacts may occur are most likely overly conservative, and the Burrowing Owl and other wildlife are unlikely to be impacted organisms. Thus, the possibility exists that the EHQs for all CPECs and for each RREI at the EWTF are all actually less than unity, and that it is unlikely that adverse ecological impacts are going to occur.

This ERA focused on developing an EHQ for an individual organism in one or more species (and most often only for adults due to data limitations) in the affected habitat; any impact to an individual of a particular species may translate to an impact to the population and, by inference, to a potential impact on the entire local ecosystem. Following this approach, this ERA examined the potential for impact from a CPEC for an individual RREI from more than one species, with each species considered to be at a different trophic level in the local ecosystem near the EWTF. Additional conservatism was added to these ERA calculations by maximizing the amount of material deposited (by considering a habitat location at Site 300 quite close to the OB/OD operations—the source of emissions—and calculating exposure of animals at soil concentrations estimated over a 6-inch [15-cm] depth); optimizing the RREI behavior to maximize exposures (i.e., living, foraging, and capturing prey exclusively in that immediate habitat); and fixing the absorption fraction of each CPEC from the intestinal tract of each RREI at 100 percent. Adding these conservatisms acts to address uncertainty because they increase the likelihood that each calculated EHQ will be an overestimate.

B.3 References

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Table B-1. Chemicals of potential ecological concern (CPECs) with respect to emissions from the EWTF along with their corresponding Chemical Abstracts Service registry identification numbers (CAS IDs), toxicity equivalency factors (TEFs), and the available mammalian and avian toxicity reference values (TRVs) for identified experimental test species (ETS) with specified body weights (BW).

Chemical	CAS ID	TEF[a]	Mammal ETS	Mammal BW[b] (kg_{bw})	Mammal TRV_{ETS} [c] [mg/(kg d)]	Avian ETS	Avian BW[d] (kg_{bw})	Avian TRV_{ETS} [e] [mg/(kg d)]
PCDFs								
1-4, 6-8 HpCDF	67562-39-4	0.01	Rat	0.35	1×10^{-5}	Chicken	1.5	1×10^{-3}
1-4, 7-9 HpCDF	55673-89-7	0.01	Rat	0.35	1×10^{-5}	Chicken	1.5	1×10^{-3}
1-4, 7, 8 HxCDF	70648-26-9	0.1	Rat	0.35	1×10^{-6}	Chicken	1.5	1×10^{-4}
1-3, 6-8 HxCDF	57117-44-9	0.1	Rat	0.35	1×10^{-6}	Chicken	1.5	1×10^{-4}
1-9 OCDF	39001-02-0	0.0001	Rat	0.35	1×10^{-3}	Chicken	1.5	1×10^{-1}
Energetics and other thermally labile compounds								
2,4-Dinitrotoluene	121-14-2	1.0	Dog	14	0.2	Not Available[f]		
2,6-Dinitrotoluene	606-20-2	1.0	Dog	14	0.4	Not Available[f]		
RDX	121-82-4	1.0	Rat	0.35	10	Not Available[f]		
Metals								
Aluminum	7429-90-5	1.0	Mouse	0.03	1.93	Mallard duck	1.153	109.7
Antimony	7440-36-0	1.0	Shrew	0.044	0.059	Not Available[f]		
Barium	7440-39-3	1.0	Shrew	0.044	51.8	Chicken	1.5	20.8
Cadmium	7440-43-9	1.0	Mouse	0.0322	0.06	Mallard duck	1.153	0.08
Chromium	7440-47-3	1.0	Rat	0.35	1468	Not Available[f]		
Copper	7440-50-8	1.0	Mouse	0.03	2.67	Chicken	1.5	2.3
Lead	7439-92-1	1.0	Rat	0.35	1.0	Quail	0.014	0.014
Zinc	7440-66-6	1.0	Mouse	0.0255	9.6	Mallard duck	1.153	17.2
SVOCs								
2-Chlorophenol	95-57-8	1.0	Rat	0.35	5	Not Available[f]		
Diphenylamine	122-39-4	1.0	Dog	14	2.5	Practically Non-toxic[e]		
Fluoranthene	206-44-0	1.0	Mouse	0.03	125	Not Available[f]		

Chemical	CAS ID	TEF[a]	Mammal ETS	Mammal BW[b] (kg_{bw})	Mammal TRV_{ETS} [c] [mg/(kg d)]	Avian ETS	Avian BW[d] (kg_{bw})	Avian TRV_{ETS} [e] [mg/(kg d)]
Naphthalene	91-20-3	1.0	Rat	0.2765	50	Not Available[f]		
Phenol	108-95-2	1.0	Rat	0.35	60	RWBB[e]	0.96	113

[a] Toxicity equivalency factors (TEFs) for PCDFs from Van den Berg et al. (1998; Table 5) and Denton (2003) for mammalian species; Van den Berg et al. (1998; Table 5) for avian species; experimental test species and body weight for TCDD and TCDF evaluations were taken from Sample et al. (1996) and from DTSC (2005) data submitted for Vandenberg Air Force Base, California.

[b] Experimental test species and corresponding body weight data for mammals taken from ATSDR (1998) for 2,4-dinitrotoluene; and from U.S. EPA (1999) for 2,6-dinitrotoluene; from Talmage et al. (1999) for RDX; from Sample et al., (1996) for Al; from U.S. EPA (2005a,b) for Sb and Ba; from EFA West (1998) for Cd, Cu, Zn, and naphthalene; from the U.S. EPA Integrated Risk Information System (IRIS) database (U.S. EPA, 2006 accessed) for Cr, 2-chlorophenol, diphenylamine, fluoranthene, and phenol; and from DTSC (2002a) for Pb.

[c] Toxicity reference values (TRVs) for mammals that are applicable to Cd, Cu, Pb, Zn, and naphthalene are TRV-lows taken from DTSC (2002a,b); those that are applicable to Sb and Ba are taken from U.S. EPA (2005a,b); and the remainder are derived from literature values.

[d] Experimental test species and corresponding body weight data for avian organisms taken from DTSC (2005) for PCDF congeners, from Sample et al. (1996) for Al, Ba, and Zn; from EFA West (1998) for Cd, Cu, and Pb; and from Schafer et al. (1983) for phenol.

[e] Toxicity reference values for avian organisms were obtained for Al and Ba from Sample et al. (1996); for Cd, Cu, Pb, and Zn from DTSC (2002b); diphenylamine was declared practically non-toxic for avian species by U.S. EPA (1998); and the toxicity reference value for phenol was derived from data taken from Schafer et al. (1983) applicable to the Red-winged Blackbird (RWBB).

[f] Avian data for this substance is not available.

Table B-2. Representative receptors of ecological interest (RREI) and respective physiological characteristics, including body weight (BW) and dietary dry-matter intake (DMI).

Organism	BW[a] (kg)	Daily dietary dry-matter intake (kg_{dmi}/d)	Daily dietary dry-matter intake per unit body weight (kg_{dmi}/d per kg_{bw})	Fraction of total dietary dry-matter intake (DMI)[b]				
				Vege-tation	Inverte-brate	Reptile	Mammal	Soil
Mammals								
Omnivorous small mammal (Deer Mouse)	0.0179	0.00381	0.2128	0.7	0.3	0	0	0.1
Granivorous small mammal (Ground Squirrel)	0.56	0.0383	0.0683	1	0	0	0	0.077
Herbivorous small mammal (Pocket Gopher)	0.104	0.013	0.1250	1	0	0	0	0.1
Herbivorous large mammal [Black-Tailed (Mule) Deer]	39.1	0.01565	0.0004	1	0	0	0	0.02
Carnivorous mammal (San Joaquin Kit Fox)	1.48	0.0702	0.0474	0	0	0.5	0.5	0.028
Reptile								
Insectivorous reptile (Side-Blotched Lizard)	0.0032	0.000037	0.011563	0	1	0	0	0.1
Birds								
Omnivorous bird (Savannah Sparrow)	0.0187	0.00574	0.3070	0.39	0.61	0	0	0.04
Carnviorous bird (Burrowing Owl)	0.157	0.00777	0.0495	0	0.333	0.333	0.333	0.05[c]

[a] Body weight (BW) and dietary dry-matter intake (DMI) for the wildlife organisms appearing in the first column are taken directly from Nagy (2001) for the Deer Mouse, Pocket Gopher, Black-Tailed (Mule) Deer, Kit Fox, Side-Blotched Lizard, and Savannah Sparrow. The body weights of the Burrowing Owl and Ground Squirrel come from Carlsen (1996), and dietary dry-matter intake (DMI) for these two organisms is computed from wet weight given by Carlsen (1996) to dry-matter intake using relationships described Nagy (2001; p. 2-R).

[b] Fraction of total dietary dry-matter intake represented by vegetation (plants), invertebrates, reptiles, mammals, and soil provides reasonable estimates for the organisms being evaluated.

[c] Data from Zarn (1974).

Note: The soil invertebrate category does not appear because an ESSL for that organism (earthworm) was taken directly from literature values (see Tables B-6a and B-6b.

Table B-3. Chemicals of potential ecological concern (CPEC) and factors used for deriving applicable mammalian and avian wildlife toxicity reference values (TRV_{wlf}) from those determined for experimental test species (i.e., TRV_{ETS}).

Chemical	CAS ID	Mammal uncertainty factor (UF_M)	Mammal Scaling factor (SF_M)[a]	Avian uncertainty factor (UF_A)	Avian scaling factor (SF_A)[a]
1-4, 6-8 HpCDF	67562-39-4	1	0.537	1	1.19
1-4, 7-9 HpCDF	55673-89-7	1	0.537	1	1.19
1-4, 7, 8 HxCDF	70648-26-9	1	0.537	1	1.19
1-3, 6-8 HxCDF	57117-44-9	1	0.537	1	1.19
1-9 OCDF	39001-02-0	1	0.537	1	1.19
2,4-Dinitrotoluene	121-14-2	1	0.940	Not Available[b]	Not Available[b]
2,6-Dinitrotoluene	606-20-2	1	0.940	Not Available[b]	Not Available[b]
RDX	121-82-4	1	0.940	1	1.19
Aluminum	7429-90-5	1	0.940	1	1.19
Antimony	7440-36-0	1	0.940	Not Available[b]	Not Available[b]
Barium	7440-39-3	1	0.746	1	1.19
Cadmium	7440-43-9	1	0.440	5[c]	1.19
Chromium	7440-47-3	1	0.940	Not Available[b]	Not Available[b]
Copper	7440-50-8	1	0.940	1	1.19
Lead	7439-92-1	1	0.940	5[c]	1.19
Zinc	7440-66-6	1	0.851	1	1.19
2-Chlorophenol	95-57-8	1	0.940	Not Available[b]	Not Available[b]
Diphenylamine	122-39-4	1	0.940	Not Available[b]	Not Available[b]
Fluoranthene	206-44-0	2[c]	0.940	2[c]	1.19
Naphthalene	91-20-3	1	0.940	Not Available[b]	Not Available[b]
Phenol	108-95-2	1	0.940	100[c]	1.19

[a] Allometric scaling is applied only if the difference in body weight between an experimental test species and a wildlife RREI is more than two orders of magnitude apart. If applied, it is done so according to the equation recommended by Sample and Arenal (1999), where $TRVwlf = [TRV_{ETS}/(TEF \times UFs)] \times (BW_{ETS}/BWwlf)^{1-b}$ and the specified scaling factors for b that appear in the fourth and last columns for mammals and avian organisms, respectively.

[b] Uncertainty and scaling factors applicable to avian species were not available for this substance.

[c] Uncertainty factors (UFs) greater than 1 are applied as noted to convert TRV_{ETS} to a TRV for wildlife in Table B-4. Application of safety factors is described in DTSC (1996), such that a UF = 2 is used when it is necessary to extrapolate from subchronic to chronic exposure studies, and an UF = 5 is applied when extrapolating from lowest observed adverse effect to no observed adverse effect.

Table B-4. Toxicity reference values derived for wildlife (TRV_{wlf}) for chemicals of potential ecological concern (CPEC).[a]

Chemical	Toxicity reference values (TRVs) derived from experimental test species for respective wildlife species							
	Omnivorous small mammal (Deer Mouse)	Granivorous small mammal (Ground Squirrel)	Herbivorous small mammal (Pocket Gopher)	Herbivorous large mammal (Black-Tailed [Mule] Deer)	Carnivorous mammal (San Joaquin Kit Fox)	Insectivorous reptile (Side-Blotched Lizard)	Omnivorous bird (Savannah Sparrow)	Carnivorous bird (Burrowing Owl)
PCDDs/PCDFs								
1-4, 6-8 HpCDF	1.00E-05	1.00E-05	1.00E-05	1.13E-06[b]	1.00E-05	8.79E-05[b]	1.00E-03	1.00E-03
1-4, 7-9 HpCDF	1.00E-06	1.00E-06	1.00E-06	1.13E-07[b]	1.00E-06	8.79E-05[b]	1.00E-03	1.00E-03
1-4, 7, 8 HxCDF	1.00E-06	1.00E-06	1.00E-06	1.13E-07[b]	1.00E-06	8.79E-06[b]	1.00E-04	1.00E-04
1-3, 6-8 HxCDF	1.00E-03	1.00E-03	1.00E-03	1.13E-04[b]	1.00E-03	8.79E-06[b]	1.00E-04	1.00E-04
1-9 OCDF	1.00E-05	1.00E-05	1.00E-05	1.13E-06[b]	1.00E-05	8.79E-03[b]	1.00E-01	1.00E-01
Energetics and other thermally labile compounds								
2,4-Dinitrotoluene	2.98E-01[b]	2.00E-01	2.68E-01[b]	2.00E-01	2.00E-01	3.31E-01[b]	Not Available[c]	Not Available[c]
2,6-Dinitrotoluene	5.97E-01[b]	4.00E-01	5.37E-01[b]	4.00E-01	4.00E-01	6.61E-01[b]	Not Available[c]	Not Available[c]
RDX	1.00E+01	1.00E+01	1.00E+01	7.54E+00[b]	1.00E+01	1.00E+01[b]	Not Available[c]	Not Available[c]
Metals								
Aluminum	1.93E+00	1.93E+00	1.93E+00	1.26E+00[b]	1.93E+00	1.93E+00	1.10E+02	1.10E+02
Antimony	5.90E-02	5.90E-02	5.90E-02	3.93E-02[b]	5.90E-02	5.90E-02	Not Available[c]	Not Available[c]
Barium	5.18E+01	5.18E+01	5.18E+01	9.23E+00[b]	5.18E+01	5.18E+01	2.08E+01	2.08E+01
Cadmium	6.00E-02	6.00E-02	6.00E-02	1.12E-03[b]	6.00E-02	6.00E-02	1.60E-02[d]	1.60E-02[d]
Chromium	1.47E+03	1.47E+03	1.47E+03	1.11E+03	1.47E+03	1.95E+03[b]	Not Available[c]	Not Available[c]
Copper	2.67E+00	2.67E+00	2.67E+00	1.74E+00[b]	2.67E+00	2.67E+00	2.30E+00	2.30E+00
Lead	1.00E+00	1.00E+00	1.00E+00	7.54E-01	1.00E+00	1.33E+00[b]	2.80E-03[d]	2.80E-03[d]

Chemical	Toxicity reference values (TRVs) derived from experimental test species for respective wildlife species							
	Omnivorous small mammal (Deer Mouse)	Granivorous small mammal (Ground Squirrel)	Herbivorous small mammal (Pocket Gopher)	Herbivorous large mammal (Black-Tailed [Mule] Deer)	Carnivorous mammal (San Joaquin Kit Fox)	Insectivorous reptile (Side-Blotched Lizard)	Omnivorous bird (Savannah Sparrow)	Carnivorous bird (Burrowing Owl)
Zinc	9.60E+00	9.60E+00	9.60E+00	3.22E+00[b]	9.60E+00	9.60E+00	1.72E+01	1.72E+01
SVOCs								
2-Chlorophenol	5.00E+00	5.00E+00	5.00E+00	3.77E+00[b]	5.00E+00	6.63E+00[b]	Not Available[c]	Not Available[c]
Diphenylamine	3.73E+00[b]	2.50E+00	3.35E+00	2.50E+00	2.50E+00	4.13E+00	Not toxic[e]	Not toxic[e]
Fluoranthene	6.25E+01[d]	6.25E+01[d]	6.25E+01[d]	4.06E+01[b]	6.25E+01[d]	6.25E+01[d]	Not Available[c]	Not Available[c]
Naphthalene	5.00E+01	5.00E+01	5.00E+01	3.71E+01[b]	5.00E+01	5.00E+01[b]	Not Available[c]	Not Available[c]
Phenol	5.70E+02	5.70E+02	5.70E+02	4.30E+02[b]	5.70E+02	7.95E+01[b]	1.13E+00[d]	1.13E+00[d]

[a] TRV_{wlf} was derived from TRV_{ETS} using applicable uncertainty and scaling factors appearing in Table B-3.

[b] Allometric scaling applied based on ratio of ETS body weight to wlf body weight exceeding two orders of magnitude (see equation in footnote "a" of Table B-3 and body weight information in Tables B-1 and B-2).

[c] TRV_{wlf} applicable to avian species for this chemical could not be computed because derivation depends on data that are not available (see Table B-1).

[d] See footnote "c" in Table B-3, which identifies safety factors greater than 1 for avian species and safety factor greater than 1 for mammalian species and (also applied to insectivorous reptile).

[e] Diphenylamine was declared practically non-toxic for avian species by the U.S. EPA (1998)

Table B-5. Bioaccumulation factors (BAFs) for the six receptor locations at which atmospheric dispersion and deposition modeling was used to determine the soil concentration over a 6-in (15-cm) soil depth.

Chemicals of potential concern	EWTF				Bldg 812 Adult				Bldg 895 ECP			
	Soil concentration (mg/kg)	BAF plant[a]	BAF soil invertebrate[b]	BAF small mammal[c]	Soil concentration (mg/kg)	BAF plant[a]	BAF soil invertebrate[b]	BAF small mammal[c]	Soil concentration (mg/kg)	BAF plant[a]	BAF soil invertebrate[b]	BAF small mammal[c]
PCDDs/PCDFs												
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	2.4E-05	1.0E+00	4.9E+00	1.25E-01	3.6E-06	1.0E+00	3.5E+00	1.25E-01	3.36E-06	1.00E+00	3.45E+00	1.25E-01
1-4, 7-9 HpCDF (1,2,3,4,7,8,9-HpCDF)	5.6E-06	1.0E+00	3.8E+00	1.25E-01	8.4E-07	1.0E+00	2.7E+00	1.25E-01	7.80E-07	1.00E+00	2.65E+00	1.25E-01
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	1.5E-05	1.0E+00	4.5E+00	1.25E-01	2.2E-06	1.0E+00	3.2E+00	1.25E-01	2.07E-06	1.00E+00	3.16E+00	1.25E-01
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	6.7E-06	1.0E+00	3.9E+00	1.25E-01	1.0E-06	1.0E+00	2.8E+00	1.25E-01	9.38E-07	1.00E+00	2.74E+00	1.25E-01
1-9 OCDF (OCDF)	2.8E-05	1.0E+00	5.1E+00	1.25E-01	4.2E-06	1.0E+00	3.601E+00	1.25E-01	3.95E-06	1.00E+00	3.56E+00	1.25E-01
Energetics & other thermally labile compounds												
2,4-Dinitrotoluene	1.6E-08	1.0E+00	1.0E+00	1.0E+00	2.0E-09	1.0E+00	1.0E+00	1.0E+00	1.88E-09	1.00E+00	1.00E+00	1.00E+00
2,6-Dinitrotoluene	1.3E-09	1.0E+00	1.0E+00	1.0E+00	1.7E-10	1.0E+00	1.0E+00	1.0E+00	1.57E-10	1.00E+00	1.00E+00	1.00E+00
RDX	4.8E+00	1.0E+00	1.0E+00	1.0E+00	6.6E-01	1.0E+00	1.0E+00	1.0E+00	9.40E-01	1.00E+00	1.00E+00	1.00E+00
Metals												
Aluminum	8.6E+01	2.870E-03	1.0E+00	2.6E-02	1.3E+01	2.87E-03	1.0E+00	2.6E-02	1.28E+01	2.87E-03	1.00E+00	2.63E-02
Antimony	8.4E-04	1.020E-02	1.0E+00	1.0E+00	1.1E-04	1.02E-02	1.0E+00	1.0E+00	1.31E-04	1.02E-02	1.00E+00	1.00E+00
Barium	1.0E+01	1.560E-01	1.0E+00	5.7E-02	1.4E+00	1.56E-01	1.0E+00	5.7E-02	1.63E+00	1.56E-01	1.00E+00	5.66E-02
Cadmium	5.0E-02	2.385E+00	1.5E+01	3.0E+00	6.7E-03	5.9E+00	2.3E+01	8.5E+00	7.84E-03	5.48E+00	2.24E+01	7.84E+00
Chromium	8.4E-02	4.100E-02	1.0E+00	4.5E-01	1.1E-02	4.10E-02	1.0E+00	7.7E-01	1.41E-02	4.10E-02	1.00E+00	7.22E-01
Copper	2.9E+01	2.489E-01	4.4E-01	4.3E-01	3.8E+00	8.6E-01	2.0E+00	2.4E+00	3.94E+00	8.47E-01	1.95E+00	2.38E+00
Lead	8.9E+00	1.009E-01	5.3E-01	3.2E-01	1.2E+00	2.5E-01	7.8E-01	9.9E-01	1.14E+00	2.50E-01	7.85E-01	1.00E+00
Zinc	1.7E+00	3.840E+00	6.0E+01	5.3E+01	2.5E-01	9.0E+00	2.2E+02	3.2E+02	2.76E-01	8.56E+00	2.03E+02	2.88E+00
SVOCs												
2-Chlorophenol	6.5E-03	1.0E+00	1.0E+00	1.0E+00	8.3E-04	1.0E+00	1.0E+00	1.0E+00	7.80E-04	1.00E+00	1.00E+00	1.00E+00
Diphenylamine	1.7E-07	1.0E+00	1.0E+00	1.0E+00	2.2E-08	1.0E+00	1.0E+00	1.0E+00	2.03E-08	1.00E+00	1.00E+00	1.00E+00
Fluoranthene	2.2E-02	1.0E+00	1.0E+00	1.0E+00	3.3E-03	1.0E+00	1.0E+00	1.0E+00	3.12E-03	1.00E+00	1.00E+00	1.00E+00
Naphthalene	1.8E-02	1.0E+00	1.0E+00	1.0E+00	2.7E-03	1.0E+00	1.0E+00	1.0E+00	2.50E-03	1.00E+00	1.00E+00	1.00E+00
Phenol	2.2E-06	1.0E+00	1.0E+00	1.0E+00	2.9E-07	1.0E+00	1.0E+00	1.0E+00	2.68E-07	1.00E+00	1.00E+00	1.00E+00

Table B5. Continued

Chemicals of potential concern	East Pasture				Carnegie				Ranch			
	Soil concentration (mg/kg)	BAF plant[a]	BAF soil invertebrate[b]	BAF small mammal[c]	Soil concentration (mg/kg)	BAF plant[a]	BAF soil invertebrate[b]	BAF small mammal[c]	Soil concentration (mg/kg)	BAF plant[a]	BAF soil invertebrate[b]	BAF small mammal[c]
PCDFs												
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	2.0E-07	1.0E+00	2.1E+00	1.25E-01	2.2E-07	1.0E+00	2.1E+00	1.25E-01	1.0E-07	1.0E+00	1.8E+00	1.25E-01
1-4, 7-9 HpCDF (1,2,3,4,7,8,9-HpCDF)	4.6E-08	1.0E+00	1.6E+00	1.25E-01	5.1E-08	1.0E+00	1.6E+00	1.25E-01	2.4E-08	1.0E+00	1.4E+00	1.25E-01
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	1.2E-07	1.0E+00	1.9E+00	1.25E-01	1.4E-07	1.0E+00	1.9E+00	1.25E-01	6.4E-08	1.0E+00	1.7E+00	1.25E-01
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	5.5E-08	1.0E+00	1.6E+00	1.25E-01	6.1E-08	1.0E+00	1.7E+00	1.25E-01	2.9E-08	1.0E+00	1.5E+00	1.25E-01
1-9 OCDF (OCDF)	2.3E-07	1.0E+00	2.1E+00	1.25E-01	2.6E-07	1.0E+00	2.2E+00	1.25E-01	1.2E-07	1.0E+00	1.9E+00	1.25E-01
Energetics & other thermally-labile compounds												
2,4-Dinitrotoluene	1.2E-10	1.0E+00	1.0E+00	1.0E+00	1.1E-10	1.0E+00	1.0E+00	1.0E+00	5.5E-11	1.0E+00	1.0E+00	1.0E+00
2,6-Dinitrotoluene	9.8E-12	1.0E+00	1.0E+00	1.0E+00	9.4E-12	1.0E+00	1.0E+00	1.0E+00	4.5E-12	1.0E+00	1.0E+00	1.0E+00
RDX	8.1E-02	1.0E+00	1.0E+00	1.0E+00	8.5E-02	1.0E+00	1.0E+00	1.0E+00	4.9E-02	1.0E+00	1.0E+00	1.0E+00
Heavy Metals												
Aluminum	8.4E-01	2.87E-03	1.0E+00	2.6E-02	9.1E-01	2.87E-03	1.00E+00	2.6E-02	4.6E-01	2.87E-03	1.0E+00	2.6E-02
Antimony	1.0E-05	1.02E-02	1.0E+00	1.0E+00	1.0E-05	1.02E-02	1.00E+00	1.0E+00	5.6E-06	1.02E-02	1.0E+00	1.0E+00
Barium	1.2E-01	1.56E-01	1.0E+00	5.7E-02	1.3E-01	1.56E-01	1.00E+00	5.7E-02	7.0E-02	1.56E-01	1.0E+00	5.7E-02
Cadmium	6.0E-04	1.7E+01	3.8E+01	2.9E+01	6.1E-04	1.727E+01	3.77E+01	2.9E+01	3.4E-04	2.3E+01	4.3E+01	4.0E+01
Chromium	1.1E-03	4.10E-02	1.0E+00	1.4E+00	1.2E-03	4.10E-02	1.00E+00	1.4E+00	6.5E-04	4.10E-02	1.0E+00	1.6E+00
Copper	2.7E-01	4.3E+00	1.4E+01	2.4E+01	2.7E-01	4.4E+00	1.41E+01	2.4E+01	1.4E-01	6.5E+00	2.3E+01	4.2E+01
Lead	7.4E-02	8.3E-01	1.3E+00	4.6E+00	7.2E-02	8.4E-01	1.33E+00	4.7E+00	3.6E-02	1.1E+00	1.5E+00	6.9E+00
Zinc	2.0E-02	2.7E+01	1.2E+03	3.3E+03	2.1E-02	2.6E+01	1.14E+03	3.1E+03	1.1E-02	3.5E+01	1.7E+03	5.6E+03
SVOCs												
2-Chlorophenol	4.9E-05	1.0E+00	1.0E+00	1.0E+00	4.7E-05	1.0E+00	1.0E+00	1.0E+00	2.3E-05	1.0E+00	1.0E+00	1.0E+00
Diphenylamine	1.3E-09	1.0E+00	1.0E+00	1.0E+00	1.2E-09	1.0E+00	1.0E+00	1.0E+00	5.9E-10	1.0E+00	1.0E+00	1.0E+00
Fluoranthene	1.8E-04	1.0E+00	1.0E+00	1.0E+00	2.0E-04	1.0E+00	1.0E+00	1.0E+00	9.7E-05	1.0E+00	1.0E+00	1.0E+00
Naphthalene	1.5E-04	1.0E+00	1.0E+00	1.0E+00	1.6E-04	1.0E+00	1.0E+00	1.0E+00	7.8E-05	1.0E+00	1.0E+00	1.0E+00
Phenol	1.7E-08	1.0E+00	1.0E+00	1.0E+00	1.6E-08	1.0E+00	1.0E+00	1.0E+00	7.8E-09	1.0E+00	1.0E+00	1.0E+00

[a] Bioaccumlation factors (BAFs) for plants are from either chemical-specific regression models with a significant model fit, where BAF = $\exp[B_o+B_1(\ln C_{soil})]/C_{soil,}$ or are a median value from empirical data; both of which are presented in BJC (1998), or when no chemical-specific uptake data were available, a default value of 1.0 was applied (as recommended in DTSC, 2000).

[b] BAFs for soil invertebrates are from either chemical-specific regression models with a significant model fit, where BAF = $\exp[B_o+B_1(\ln C_{soil})]/C_{soil}$, or are a median value from empirical data, both of which are presented in Sample et al. (1998a), or when no chemical-specific uptake data were available, a default value of 1.0 was applied (as recommended in DTSC, 2000).

[c] BAFs for small mammals are from either chemical-specific regression models with a significant model fit, where BAF = $\exp[B_o+B_1 (\ln C_{soil})]/C_{soil}$, or are a median value from empirical data; both of which are presented in Sample et al. (1998b), or when no chemical-specific uptake data were available, a default value of 1.0 was applied (as recommended in DTSC, 2000).

Table B-6a. Derived ecological soil screening levels (ESSLs) applicable to the chemicals of potential ecological concern (CPECs) with respect to each representative receptor of ecological interest (RREI) in the habitat nearest the EWTF and used to select a minimum ESSL for generating an ecological hazard quotient (EHQ).

	EWTF	Calculated as Mammal ESSL for insectivorous reptile (Side-blotched lizard) [mg/kgsoil][a]	ESSL for omnivorous sm mammal (Deer mouse) [mg/kg_{soil}]	ESSL for granivorous sm mammal (Ground squirrel) [mg/kg_{soil}]	ESSL for herbivorous sm mammal (Pocket gopher) [mg/kg_{soil}]	ESSL for herbivorous lg mammal (Black-tailed [Mule] deer) [mg/kg_{soil}]	ESSL for carnivorous mammal (Kit fox) [mg/kg_{soil}]	ESSL for omnivorous avian (Savannah Sparrow) [mg/kg_{soil})	ESSL for carnivorous avian (Burrowing Owl) [mg/kg_{soil}]	Calculated as Avian ESSL for insectivorous reptile[a] (Side-blotched lizard) [mg/kg_{soil}]	ESSL for soil invertebrate[b] (e.g., earthworm) [mg/kg_{soil}]
	PCDFs										
1	1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	1.51E-03	2.06E-05	1.36E-04	7.27E-05	2.76E-03	3.57E-04	9.5E-04	9.8E-03	5.3E-02	5
2	1-4, 7-9 HpCDF (1,2,3,4,7,8,9-HpCDF)	1.96E-03	2.43E-05	1.36E-04	7.27E-05	2.76E-03	3.57E-04	1.2E-03	1.2E-02	6.9E-02	5
3	1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	1.64E-04	2.18E-06	1.36E-05	7.27E-06	2.76E-04	3.57E-05	1.0E-04	1.0E-03	5.8E-03	5
4	1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	1.89E-04	2.38E-06	1.36E-05	7.27E-06	2.76E-04	3.57E-05	1.2E-04	1.2E-03	6.7E-03	5
5	1-9 OCDF (OCDF)	1.47E-01	2.02E-03	1.36E-02	7.27E-03	2.76E-01	3.57E-02	9.2E-02	9.5E-01	5.2E+00	5
	Explosives										
14	2,4-Dinitrotoluene	2.60E+01	1.27E+00	2.72E+00	1.95E+00	4.90E+02	4.10E+00	Not Available[c]	Not Available[c]	Not Available[c]	Not Available[c]
15	2,6-Dinitrotoluene	5.20E+01	2.55E+00	5.43E+00	3.90E+00	9.80E+02	8.20E+00	Not Available[c]	Not Available[c]	Not Available[c]	Not Available[c]
16	RDX	1.04E+03	4.27E+01	1.36E+02	7.27E+01	1.85E+04	2.05E+02	Not Available[c]	Not Available[c]	Not Available[c]	Not Available[c]
	Metals										
6	Aluminum	1.52E+02	2.26E+01	3.54E+02	1.50E+02	1.37E+05	7.52E+01	5.5E+02	3.1E+03	2.8E+03	Not Available[c]
7	Antimony	4.64E+00	6.81E-01	9.90E+00	4.28E+00	3.25E+03	1.21E+00	Not Available[c]	Not Available[c]	Not Available[c]	Not Available[c]
8	Barium	4.07E+03	4.78E+02	3.25E+03	1.62E+03	1.31E+05	1.96E+03	9.5E+01	5.7E+02	5.1E+02	330
9	Cadmium	3.37E-01	4.43E-02	3.57E-01	1.93E-01	1.17E+00	6.19E-01	5.1E-03	5.0E-02	5.9E-03	140
10	Chromium	1.53E+05	1.61E+04	1.82E+05	8.33E+04	4.53E+07	4.11E+04	Not Available[c]	Not Available[c]	Not Available[c]	Not Available[c]
11	Copper	4.24E+02	3.08E+01	1.20E+02	6.12E+01	1.61E+04	7.59E+01	1.8E+01	6.9E+01	1.1E+02	32
12	Lead	1.83E+02	1.43E+01	8.22E+01	3.98E+01	1.56E+04	3.07E+01	2.3E-02	8.5E-02	3.9E-01	1700
13	Zinc	1.39E+01	2.18E+00	3.59E+01	1.95E+01	2.08E+03	7.44E+00	1.5E+00	9.1E+00	8.1E+00	199
	SVOCs										
17	2-Chlorophenol	5.21E+02	2.14E+01	6.79E+01	3.64E+01	9.23E+03	1.03E+02	3.5E+00	2.2E+01	8.9E+01	Not Available[c]
18	Diphenylamine	3.25E+02	1.59E+01	3.40E+01	2.44E+01	6.12E+03	5.13E+01	Not toxic[d]	Not toxic[d]	Not Available[c]	Not Available[c]
19	Fluoranthene	4.91E+03	2.67E+02	8.49E+02	4.55E+02	9.95E+04	1.28E+03	Not Available[c]	Not Available[c]	Not Available[c]	38
20	Naphthalene	3.93E+03	2.14E+02	6.79E+02	3.64E+02	9.10E+04	1.03E+03	Not Available[c]	Not Available[c]	Not Available[c]	Not Available[c]
21	Phenol	6.25E+03	2.56E+02	8.15E+02	4.36E+02	1.11E+05	1.23E+03	3.5E+00	2.2E+01	8.9E+01	30

[a] The ecological soil screening level (ESSL) for the reptile of ecological interest was computed along with both mammalian and avian RREI categories to determine the lowest value for comparison in selecting a chemical-specific minimum ESSL.

[b] ESSLs for soil invertebrates are from DTSC (2005) for TCDD (assuming it is same for TCDF and its congeners); from U.S. EPA (2005a-d) for Sb, Cd, Ba, and Pb; from U.S. EPA (1999) for Cu and Zn; from Sverdrup et al. (2002) for fluoranthene; and from Sample et al. (1996) for phenol.

[c] ESSL applicable to avian species (or for Side-blotched Lizard, as avian species) or for the soil invertebrate for this chemical could not be computed because derivation depends on data that are not available.

[d] Considered to be practically non-toxic (U.S. EPA, 1998) to avian organisms.

Table B-6b. Derived ecological soil screening levels (ESSLs) applicable to the chemicals of potential ecological concern (CPECs) with respect to each representative receptor of ecological interest (RREI) in the habitat at the Ranch site, which is the receptor location furthest from the EWTF, and used to select a minimum ESSL for generating an ecological hazard quotient (EHQ).

	Ranch	Calculated as Mammal ESSL for insectivorous reptile[a] (Side-blotched lizard) [mg/kgsoil][a]	ESSL for omnivorous sm mammal (Deer mouse) [mg/kg_{soil}]	ESSL for granivorous sm mammal (Ground squirrel) [mg/kg_{soil}]	ESSL for herbivorous sm mammal (Pocket gopher) [mg/kg_{soil}]	ESSL for herbivorous lg mammal (Black-tailed Mule deer) [mg/kg_{soil}]	ESSL for carnivorous mammal (Kit fox) [mg/kg_{soil}]	ESSL for omnivorous avian (Savannah Sparrow) [mg/kg_{soil}]	ESSL for carnivorous avian (Burrowing Owl) [mg/kg_{soil}]	Calculated as Avian ESSL for insectivorous reptile[a] (Side-blotched lizard) [mg/kg_{soil}]	ESSL for soil invertebrate[b] (e.g., earthworm) [mg/kg_{soil}]
	PCDDs/PCDFs										
1	1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	3.93E-03	3.48E-05	1.36E-04	7.27E-05	2.76E-03	3.57E-04	2.1E-03	2.0E-02	1.4E-02	5
2	1-4, 7-9 HpCDF (1,2,3,4,7,8,9-HpCDF)	5.04E-03	3.84E-05	1.36E-04	7.27E-05	2.76E-03	3.57E-04	2.5E-03	2.3E-02	1.8E-02	5
3	1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	4.27E-04	3.60E-06	1.36E-05	7.27E-06	2.76E-04	3.57E-05	2.2E-04	2.1E-03	1.5E-03	5
4	1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	4.89E-04	3.80E-06	1.36E-05	7.27E-06	2.76E-04	3.57E-05	2.5E-04	2.2E-03	1.7E-03	5
5	1-9 OCDF (OCDF)	3.82E-01	3.44E-03	1.36E-02	7.27E-03	2.76E-01	3.57E-02	2.1E-01	1.9E+00	1.4E+00	5
	Metals										
6	Aluminum	1.52E+02	2.26E+01	3.54E+02	1.50E+02	1.37E+05	7.52E+01	5.5E+02	3.1E+03	2.8E+03	Not Available[c]
7	Antimony	4.64E+00	6.81E-01	9.90E+00	4.28E+00	3.25E+03	1.21E+00	Not Available[c]	Not Available[c]	Not Available[c]	Not Available[c]
8	Barium	4.07E+03	4.78E+02	3.25E+03	1.62E+03	1.31E+05	1.96E+03	9.5E+01	5.7E+02	5.1E+02	330
9	Cadmium	1.21E-01	9.81E-03	3.87E-02	2.11E-02	1.24E-01	6.24E-02	1.5E-03	1.2E-02	2.1E-03	140
10	Chromium	1.53E+05	1.61E+04	1.82E+05	8.33E+04	4.53E+07	2.30E+04	Not Available[c]	Not Available[c]	Not Available[c]	Not Available[c]
11	Copper	1.01E+01	1.09E+00	5.92E+00	3.22E+00	6.63E+02	2.63E+00	4.5E-01	2.1E+00	2.7E+00	32
12	Lead	7.05E+01	3.46E+00	1.20E+01	6.45E+00	1.62E+03	5.31E+00	6.4E-03	1.8E-02	1.5E-01	1700
13	Zinc	4.77E-01	8.24E-02	4.01E+00	2.19E+00	2.30E+02	7.27E-02	5.2E-02	1.4E-01	2.8E-01	199
	Explosives										
14	2,4-Dinitrotoluene	2.60E+01	1.27E+00	2.72E+00	1.95E+00	4.90E+02	4.10E+00	Not Available[c]	Not Available[c]	Not Available[c]	Not Available[c]
15	2,6-Dinitrotoluene	5.20E+01	2.55E+00	5.43E+00	3.90E+00	9.80E+02	8.20E+00	Not Available[c]	Not Available[c]	Not Available[c]	Not Available[c]
16	RDX	1.04E+03	4.27E+01	1.36E+02	7.27E+01	1.85E+04	2.05E+02	Not Available[c]	Not Available[c]	Not Available[c]	Not Available[c]
	SVOCs										
17	2-Chlorophenol	5.21E+02	2.14E+01	6.79E+01	3.64E+01	9.23E+03	1.03E+02	Not Available[c]	Not Available[c]	Not Available[c]	Not Available[c]
18	Diphenylamine	3.25E+02	1.59E+01	3.40E+01	2.44E+01	6.12E+03	5.13E+01	Not toxic[c]	Not toxic[c]	Not Available[c]	Not Available[c]
19	Fluoranthene	4.91E+03	2.67E+02	8.49E+02	4.55E+02	9.95E+04	1.28E+03	Not Available[c]	Not Available[c]	Not Available[c]	38
20	Naphthalene	3.93E+03	2.14E+02	6.79E+02	3.64E+02	9.10E+04	1.03E+03	Not Available[c]	Not Available[c]	Not Available[c]	Not Available[c]
21	Phenol	6.25E+03	2.56E+02	8.15E+02	4.36E+02	1.11E+05	1.23E+03	Not Available[c]	Not Available[c]	Not Available[c]	30

[a] The ecological soil screening level (ESSL) for the reptile of ecological interest was computed along with both mammalian and avian RREI categories to determine the lowest value for comparison in selecting a chemical-specific minimum ESSL.

[b] ESSLs for soil invertebrates are from DTSC (2005) for TCDD (assuming it is same for TCDF and its congeners); from U.S. EPA (2005a-d) for Sb, Cd, Ba, and Pb; from U.S. EPA (1999) for Cu and Zn; from Sverdrup et al. (2002) for fluoranthene; and from Sample et al. (1996) for phenol.

[c] ESSL applicable to avian species (or for Side-blotched Lizard, as avian species) or for the soil invertebrate for this chemical could not be computed because derivation depends on data that are not available.

[d] Considered to be practically non-toxic (U.S. EPA, 1998) to avian organisms.

Table B-7. Minimum ecological soil screening levels (ESSLs) for the chemicals of potential ecological concern (CPECs), and the organism corresponding to it, for all six receptor locations at which soil concentrations over a 6-in (15-cm) depth were predicted from atmospheric dispersion and deposition modeling.

	Chemicals of potential ecological concern	EWTF[a]		Bldg 812		Bldg. 895		East Pasture		Carnegie		Ranch[a]	
	PCDDs/PCDFs												
1	1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	2.06E-05	Mammal	2.54E-05	Mammal	2.56E-05	Mammal	3.31E-05	Mammal	3.29E-05	Mammal	3.48E-05	Mammal
2	1-4, 7-9 HpCDF (1,2,3,4,7,8,9-HpCDF)	2.43E-05	Mammal	2.93E-05	Mammal	2.95E-05	Mammal	3.69E-05	Mammal	3.66E-05	Mammal	3.84E-05	Mammal
3	1-4,7,8 HxCDF (1,2,3,4,7,8-HxCDF)	2.18E-06	Mammal	2.67E-06	Mammal	2.69E-06	Mammal	3.44E-06	Mammal	3.41E-06	Mammal	3.60E-06	Mammal
4	1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	2.38E-06	Mammal	2.88E-06	Mammal	2.90E-06	Mammal	3.64E-06	Mammal	3.61E-06	Mammal	3.80E-06	Mammal
5	1-9 OCDF (OCDF)	2.02E-03	Mammal	2.50E-03	Mammal	2.52E-03	Mammal	3.27E-03	Mammal	3.24E-03	Mammal	3.44E-03	Mammal
	Explosives												
14	2,4-Dinitrotoluene	1.27E+00	Mammal	1.29E+00	Mammal	1.27E+00	Mammal	1.27E+00	Mammal	1.27E+00	Mammal	1.27E+00	Mammal
15	2,6-Dinitrotoluene	2.55E+00	Mammal	2.55E+00	Mammal	2.55E+00	Mammal	2.55E+00	Mammal	2.55E+00	Mammal	2.55E+00	Mammal
16	RDX	4.27E+01	Mammal	4.27E+01	Mammal	4.27E+01	Mammal	4.27E+01	Mammal	4.27E+01	Mammal	4.27E+01	Mammal
	Metals												
6	Aluminum	2.26E+01	Mammal	2.26E+01	Mammal	2.26E+01	Mammal	2.26E+01	Mammal	2.26E+01	Mammal	2.26E+01	Mammal
7	Antimony	6.81E-01	Mammal	6.81E-01	Mammal	6.81E-01	Mammal	6.81E-01	Mammal	6.81E-01	Mammal	6.81E-01	Mammal
8	Barium	9.53E+01	Bird	9.53E+01	Bird	9.53E+01	Bird	9.53E+01	Bird	9.53E+01	Bird	9.53E+01	Bird
9	Cadmium	5.06E-03	Bird	3.17E-03	Bird	3.29E-03	Bird	1.74E-03	Bird	1.75E-03	Bird	1.49E-03	Bird
10	Chromium	1.61E+04	Mammal	1.61E+04	Mammal	1.61E+04	Mammal	1.61E+04	Mammal	1.61E+04	Mammal	1.61E+04	Mammal
11	Copper	1.84E+01	Bird	4.71E+00	Bird	4.81E+00	Bird	7.31E-01	Bird	7.26E-01	Bird	4.53E-01	Bird
12	Lead	2.28E-02	Bird	1.49E-02	Bird	1.48E-02	Bird	7.76E-03	Bird	7.72E-03	Bird	6.44E-03	Bird
13	Zinc	1.47E+00	Bird	4.10E-01	Bird	4.40E-01	Bird	7.59E-02	Bird	7.94E-02	Bird	5.21E-02	Bird
	SVOCs												
17	2-Chlorophenol	2.14E+01	Mammal	2.13E+01	Mammal	2.14E+01	Mammal	2.14E+01	Mammal	2.14E+01	Mammal	2.14E+01	Mammal
18	Diphenylamine	1.59E+01	Mammal	1.60E+01	Mammal	1.59E+01	Mammal	1.59E+01	Mammal	1.59E+01	Mammal	1.59E+01	Mammal
19	Fluoranthene	3.80E+01	Invertebrate	3.80E+02	Invertebrate	3.80E+01	Invertebrate	3.80E+01	Invertebrate	3.80E+01	Invertebrate	3.80E+01	Invertebrate
20	Naphthalene	2.14E+02	Mammal	2.14E+02	Mammal	2.14E+02	Mammal	2.14E+02	Mammal	2.14E+02	Mammal	2.14E+02	Mammal
21	Phenol	3.54E+00	Bird	3.54E+00	Bird	3.54E+00	Bird	3.54E+00	Bird	3.54E+00	Bird	3.54E+00	Bird

[a] Minimum ESSLs for EWTF and for the Ranch sites can be obtained from examination of Tables B-6a and B-6b.

Table B-8. Soil concentrations over 6-in (15-cm) soil depth predicted at six receptor locations from atmospheric dispersion and deposition modeling (mg/kg).

Chemical	Carnegie	Ranch	Bldg 812 Adult	Bldg 895 ECP	East Pasture	EWTF
PCDDs/PCDFs						
1,2,3,4,6,7,8-Heptachlorodibenzofuran	2.2E-07	1.0E-07	3.6E-06	3.4E-06	2.0E-07	2.4E-05
1,2,3,4,7,8,9-Heptachlorodibenzofuran	5.1E-08	2.4E-08	8.4E-07	7.8E-07	4.6E-08	5.6E-06
1,2,3,4,7,8-Hexachlorodibenzofuran	1.4E-07	6.4E-08	2.2E-06	2.1E-06	1.2E-07	1.5E-05
1,2,3,6,7,8-Hexachlorodibenzofuran	6.1E-08	2.9E-08	1.0E-06	9.4E-07	5.5E-08	6.7E-06
1,2,3,4,6,7,8,9-Octachlorodibenzofuran	2.6E-07	1.2E-07	4.2E-06	4.0E-06	2.3E-07	2.8E-05
Explosives						
2,4-Dinitrotoluene	1.1E-10	5.5E-11	2.0E-09	1.9E-09	1.2E-10	1.6E-08
2,6-Dinitrotoluene	9.4E-12	4.5E-12	1.7E-10	1.6E-10	9.8E-12	1.3E-09
PETN (same as RDX)[a]	6.0E-03	3.4E-03	4.7E-02	6.6E-02	5.7E-03	3.4E-01
RDX [a]	7.9E-02	4.5E-02	6.2E-01	8.7E-01	7.5E-02	4.4E+00
Metals						
Aluminum	9.1E-01	4.6E-01	1.3E+01	1.3E+01	8.4E-01	8.6E+01
Antimony	1.0E-05	5.6E-06	1.1E-04	1.3E-04	1.0E-05	8.4E-04
Barium	1.3E-01	7.0E-02	1.4E+00	1.6E+00	1.2E-01	1.0E+01
Cadmium	6.1E-04	3.4E-04	6.7E-03	7.8E-03	6.0E-04	5.0E-02
Chromium	1.2E-03	6.5E-04	1.1E-02	1.4E-02	1.1E-03	8.4E-02
Copper	2.7E-01	1.4E-01	3.8E+00	3.9E+00	2.7E-01	2.9E+01
Lead	7.2E-02	3.6E-02	1.2E+00	1.1E+00	7.4E-02	8.9E+00
Zinc	2.1E-02	1.1E-02	2.5E-01	2.8E-01	2.0E-02	1.7E+00
SVOCs						
2-Chlorophenol	4.7E-05	2.3E-05	8.3E-04	7.8E-04	4.9E-05	6.5E-03
Diphenylamine	1.2E-09	5.9E-10	2.2E-08	2.0E-08	1.3E-09	1.7E-07
Fluoranthene	2.0E-04	9.7E-05	3.3E-03	3.1E-03	1.8E-04	2.2E-02
Naphthalene[b]	2.2E-08	1.1E-08	3.9E-07	3.6E-07	2.3E-08	3.0E-06
Naphthalene surrogate[b]	1.6E-04	7.8E-05	2.7E-03	2.5E-03	1.5E-04	1.8E-02
Phenol	1.6E-08	7.8E-09	2.9E-07	2.7E-07	1.7E-08	2.2E-06

[a] Soil concentrations for PETN and RDX are summed for purposes of analysis and assessment.

[b] Soil concentration for naphthalene and naphthalene surrogate are summed for purposes of analysis and assessment.

Table B-9. Ecological hazard quotients (EHQs) for chemicals of potential concern (CPECs) at different receptor locations. Each EHQ is derived from the lowest ESSL for all organisms evaluated for the receptor location.

Chemical	Receptor Location					
	EHQ (EWTF/ESSL)	EHQ (Bldg 812/ESSL)	EHQ (Bldg 895/ESSL)	EHQ (EstPst/ESSL)	EHQ (Crnge/ESSL)	EHQ (Ranch/ESSL)
PCDDs/PCDFs						
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	*1.16E+00*	1.42E-01	1.31E-01	5.99E-03	6.67E-03	3.00E-03
1-4, 7-9 HpCDF (1,2,3,4,7,8,9-HpCDF)	2.30E-01	2.86E-02	2.65E-02	1.25E-03	1.39E-03	6.31E-04
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	*6.80E+00*	8.33E-01	7.72E-01	3.57E-02	3.97E-02	1.79E-02
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	*2.82E+00*	3.49E-01	3.24E-01	1.52E-02	1.69E-02	7.67E-03
1-9 OCDF (OCDF)	1.40E-02	1.70E-03	1.57E-03	7.14E-05	7.95E-05	3.57E-05
Energetics & other thermally-labile compounds						
2,4-Dinitrotoluene	1.22E-08	1.57E-09	1.47E-09	9.20E-11	8.85E-11	4.28E-11
2,6-Dinitrotoluene	5.10E-10	6.55E-11	6.14E-11	3.83E-12	3.69E-12	1.78E-12
RDX	1.12E-01	1.55E-02	2.20E-02	1.90E-03	1.98E-03	1.14E-03
Metals						
Aluminum	*3.83E+00*	5.61E-01	5.69E-01	3.73E-02	4.01E-02	2.03E-02
Antimony	1.23E-03	1.64E-04	1.93E-04	1.48E-05	1.51E-05	8.27E-06
Barium	1.09E-01	1.46E-02	1.71E-02	1.31E-03	1.33E-03	7.30E-04
Cadmium	*9.87E+00*	*2.10E+00*	*2.38E+00*	3.45E-01	3.50E-01	2.25E-01
Chromium	5.21E-06	7.04E-07	8.79E-07	7.01E-08	7.21E-08	4.03E-08
Copper	*1.60E+00*	8.11E-01	8.19E-01	3.70E-01	3.69E-01	3.06E-01
Lead	*3.92E+02*	*7.83E+01*	*7.67E+01*	*9.51E+00*	*9.39E+00*	*5.61E+00*
Zinc	*1.16E+00*	6.05E-01	6.27E-01	2.61E-01	2.67E-01	2.17E-01
SVOCs						
2-Chlorophenol	3.03E-04	3.90E-05	3.65E-05	2.28E-06	2.19E-06	1.06E-06
Diphenylamine	1.06E-08	1.36E-09	1.27E-09	7.95E-11	7.65E-11	3.70E-11
Fluoranthene	5.86E-04	8.80E-05	8.22E-05	4.85E-06	5.36E-06	2.55E-06
Naphthalene	8.35E-05	1.25E-05	1.17E-05	6.91E-07	7.63E-07	3.63E-07
Phenol	6.28E-07	8.06E-08	7.56E-08	4.72E-09	4.54E-09	2.20E-09

Note: EHQ values greater than 1 appear in italics (e.g., see EHQ values for Pb).

Table B-10a. Ecological hazard quotients (EHQs) specifically for the San Joaquin Kit Fox at the six receptor locations for which soil concentrations were predicted from modeling.[a]

Chemicals	EWTF	Bldg 812	Bldg 895	East Pasture	Carnegie	Ranch
	EWTF/ESSL for Kit Fox	Bldg 812/ESSL for Kit Fox	Bldg 895/ ESSL for Kit Fox	EstPast/ ESSL for Kit Fox	Carnge/ESSL for Kit Fox	Ranch/ ESSL for Kit Fox
PCDDs/PCDFs						
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	6.7E-02	1.0E-02	9.4E-03	5.6E-04	6.1E-04	2.9E-04
1-4, 7-9 HpCDF (1,2,3,4,7,8,9-HpCDF)	1.6E-02	2.3E-03	2.2E-03	1.3E-04	1.4E-04	6.8E-05
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	4.1E-01	6.2E-02	5.8E-02	3.4E-03	3.8E-03	1.8E-03
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	1.9E-01	2.8E-02	2.6E-02	1.6E-03	1.7E-03	8.2E-04
1-9 OCDF (OCDF)	7.9E-04	1.2E-04	1.1E-04	6.5E-06	7.2E-06	3.4E-06
Energetics & other thermally labile compounds						
2,4-Dinitrotoluene	3.8E-09	4.9E-10	4.6E-10	2.9E-11	2.7E-11	1.3E-11
2,6-Dinitrotoluene	1.6E-10	2.0E-11	1.9E-11	1.2E-12	1.1E-12	5.5E-13
RDX	2.3E-02	3.2E-03	4.6E-03	3.9E-04	4.1E-04	2.4E-04
Metals						
Aluminum	1.2E+00	1.7E-01	1.7E-01	1.1E-02	1.2E-02	6.1E-03
Antimony	6.9E-04	9.2E-05	1.1E-04	8.3E-06	8.5E-06	4.7E-06
Barium	5.3E-03	7.1E-04	8.3E-04	6.3E-05	6.5E-05	3.5E-05
Cadmium	8.1E-02	2.5E-02	2.8E-02	7.2E-03	7.3E-03	5.4E-03
Chromium	2.0E-06	3.3E-07	4.1E-07	4.5E-08	4.6E-08	2.8E-08
Copper	3.9E-01	1.2E-01	1.2E-01	5.9E-02	5.9E-02	5.3E-02
Lead	2.9E-01	5.7E-02	5.6E-02	9.9E-03	9.8E-03	6.8E-03

Chemicals	EWTF	Bldg 812	Bldg 895	East Pasture	Carnegie	Ranch
	EWTF/ESSL for Kit Fox	Bldg 812/ESSL for Kit Fox	Bldg 895/ ESSL for Kit Fox	EstPast/ ESSL for Kit Fox	Carnge/ESSL for Kit Fox	Ranch/ ESSL for Kit Fox
Zinc	2.3E-01	2.0E-01	2.0E-01	1.6E-01	1.6E-01	1.6E-01
SVOCs						
2-Chlorophenol	6.3E-05	8.1E-06	7.6E-06	4.7E-07	4.6E-07	2.2E-07
Diphenylamine	3.3E-09	4.2E-10	4.0E-10	2.5E-11	2.4E-11	1.1E-11
Fluoranthene	1.7E-05	2.6E-06	2.4E-06	1.4E-07	1.6E-07	7.6E-08
Naphthalene	1.7E-05	2.6E-06	2.4E-06	1.4E-07	1.6E-07	7.6E-08
Phenol	1.8E-09	2.3E-10	2.2E-10	1.4E-11	1.3E-11	6.3E-12

[a] The San Joaquin Kit Fox (*Vulpes macrotis mutica*) and the Burrowing Owl (*Athene cunicularia)* are of particular interest because these organisms are of particular concern in the habitat of Site 300.

Table B-10b. Ecological hazard quotients (EHQs) specifically for the Burrowing Owl at the six receptor locations for which soil concentrations were predicted from modeling.[a]

Chemicals	EWTF	Bldg 812	Bldg 895	East Pasture	Carnegie	Ranch
	EWTF/ESSL for Burrowing Owl	Bldg 812/ ESSL for Burrowing Owl	Bldg 895/ESSL for Burrowing Owl	EstPast/ ESSL for Burrowing Owl	Carnge/ ESSL for Burrowing Owl	Ranch/ ESSL for Burrowing Owl
PCDDs/PCDFs						
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	2.5E-04	2.8E-04	2.6E-04	1.1E-05	1.2E-05	5.3E-06
1-4, 7-9 HpCDF (1,2,3,4,7,8,9-HpCDF)	4.6E-05	5.5E-05	5.0E-05	2.2E-06	2.4E-06	1.1E-06
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	1.4E-03	1.6E-03	1.5E-03	6.4E-05	7.1E-05	3.1E-05
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	5.7E-04	6.7E-04	6.2E-04	2.7E-05	3.0E-05	1.3E-05
1-9 OCDF (OCDF)	3.0E-06	3.4E-06	3.1E-06	1.3E-07	1.5E-07	6.4E-08
Energetics & other thermally labile compounds						
2,4-Dinitrotoluene	Not Available[b]					
2,6-Dinitrotoluene	Not Available[b]					
RDX	Not Available[b]					
Metals						
Aluminum	2.8E-02	4.1E-03	4.2E-03	2.7E-04	3.0E-04	1.5E-04
Antimony	Not Available[b]					
Barium	1.8E-02	2.4E-03	2.8E-03	2.2E-04	2.2E-04	1.2E-04
Cadmium	1.00E+00	2.25E-01	2.53E-01	4.23E-02	4.28E-02	2.88E-02
Chromium	Not Available[b]					
Copper	4.2E-01	1.5E-01	1.5E-01	7.5E-02	7.5E-02	6.5E-02
Lead	1.05E+02	2.00E+01	1.96E+01	3.08E+00	3.05E+00	2.03E+00
Zinc	1.9E-01	1.3E-01	1.3E-01	8.5E-02	8.6E-02	7.9E-02

Chemicals	EWTF	Bldg 812	Bldg 895	East Pasture	Carnegie	Ranch
	EWTF/ESSL for Burrowing Owl	Bldg 812/ ESSL for Burrowing Owl	Bldg 895/ESSL for Burrowing Owl	EstPast/ ESSL for Burrowing Owl	Carnge/ ESSL for Burrowing Owl	Ranch/ ESSL for Burrowing Owl
SVOCs						
2-Chlorophenol	Not Available[b]					
Diphenylamine	Not Available[b]					
Fluoranthene	Not Available[b]					
Naphthalene	Not Available[b]					
Phenol	1.0E-07	1.3E-08	1.2E-08	7.7E-10	7.4E-10	3.6E-10

[a] The Burrowing Owl (*Athene cunicularia)* as well as the San Joaquin Kit Fox (*Vulpes macrotis mutica*) are of particular interest because these organisms are of particular concern in the habitat of Site 300.

[b] ESSL applicable to avian species for this chemical could not be computed because derivation depends on data that are not available.

Appendix C. Ecological and Biological Assessment in Support of Renewal of Permit for the Explosive Waste Treatment Facility (EWTF) at Site 300

Preface

The following material on the ecology and biological assessments of Site 300 has been excerpted from Appendix E of the *Final Site-Wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory and Supplemental Stockpile Stewardship and Management Programmatic Environmental Impact Statement* (DOE/EIS-348) published in March 2005 by Lawrence Livermore National Laboratory and the U.S. Department of Energy. Note that references and data, including data in tables, pertaining solely to the Livermore Site have been deleted, and the excerpted pages renumbered.

Appendix E: Ecology and Biological Assessment

This appendix contains two major sections. Section E.1 is a discussion of the ecological characteristics at the . . . Site 300, referred to collectively as the study sites and presents information on the flora and fauna in the upland areas . . . This section focuses largely on the biological features of Site 300, because this approximately 7,000-acre site is largely undeveloped and represents the most biologically diverse area under study. . .

Section E.2, a biological assessment, complies with the U.S. Department of Energy (DOE) guidelines requiring that a biological assessment be prepared in conjunction with a site-wide environmental impact statement (SWEIS). Prepared pursuant to Section 7(c) of the *Endangered Species Act* and to the *California Endangered Species Act*, this biological assessment includes a description of existing biological conditions; the status of threatened and endangered species and other species of concern at the study sites; the impacts, if any, of operations on these species; a determination if effects would occur to species of concern; and mitigation measures where appropriate . . .

E.1 Ecology

E.1.1 Flora

The flora and vegetation at . . . Site 300 have been described in several extensive surveys (BioSystems 1986a, 1986b, Jones and Stokes 1997, 2002a).

E.1.1.1 *Methods*

A plant species list for Site 300 was generated during the 1986 rare plant surveys, which were conducted on foot beginning on March 30, 1986, and continuing at biweekly intervals through mid-May 1986 (BioSystems 1986b). Sampling to typify vegetation composition was conducted in 1986 using a rapid descriptive technique generally termed as “the relevé method.” More details on the relevé methodology may be found in the 1986 survey report (BioSystems 1986a, LLNL 1992a).

More recent plant species lists for Site 300 were generated from on-foot surveys conducted in 1997 and 2002, using California Department of Fish and Game (CDFG) guidelines to sample vegetation along meandering transects that paralleled roads and fire breaks. The 1997 survey was conducted between April 30 and May 12 and on September 23. The 2002 survey was conducted between March 27 and April 3 (Jones and Stokes 2002a).

E.1.1.2 *Results*

Flora

In 1997, 281 plant species were identified at Site 300; an additional 84 plant species were identified in 2002 (Jones and Stokes 2002a). A checklist of 406 plant species is provided in Attachment 2 combining the results of these 2 surveys with an earlier survey done in 1986 (BioSystems 1986b). . . . Table E.1.1.2–1 provides the results of the 1986 survey by analyzing the constancy and importance of plant species. Constancy is the percentage of all relevés (descriptive technique for sampling vegetation) in which a given species is encountered. Importance values are the sum of constancy and mean cover. As such, the importance value is a parameter that represents the frequency at which a species is observed added to the percent of groundcover of this particular species (BioSystems 1986a, LLNL 1992a).

The 1986 survey found that the nonnative grass species, *Avena barbata,* was the most frequently encountered plant at Site 300. Other frequently encountered species were *Bromus hordeaceus (B. mollis), B. diandrus, Erodium cicutarium, B. madritensis rubens*, and *Vulpia myuros*, all nonnative annuals introduced from Europe (Robbins 1940). Collectively, these six species are dominant in annual grasslands over much of lowland California (Heady 1977, BioSystems 1986a). The most commonly encountered plants at Site 300 are provided in Table E.1.1.2–1.

TABLE E.1.1.2–1.—*Constancy, Cover, and Importance Values for the More Important Plant Species at Site 300 from the 1986 Survey*

Species	Constancy	Cover		Importance Value
		Mean	Standard Error	
Avena barbata	87.62	36.66	2.17	124.28
Bromus hordeaceus	73.85	7.27	0.72	81.12
Bromus diandrus	62.84	11.73	1.25	74.57
Erodium cicutarium	65.60	3.62	0.58	69.21
Bromus madritensis rubens	61.47	6.17	0.68	67.64
Vulpia myuros	55.96	5.66	0.68	61.62
Poa secunda	38.53	7.98	1.33	46.52
Trifolium willdenovii	43.12	2.44	0.44	45.56
Orthocarpus exerta	39.91	0.89	0.39	40.80
Lotus wrangellianus	38.07	0.87	0.18	38.94
Amsinckia intermedia	36.70	1.26	0.26	37.95
Gutierrezia bracteata	27.52	1.43	0.31	28.95
Brassica geniculata	27.52	0.93	0.23	28.45
Sanicula bipinnata	26.61	0.23	0.07	26.83
Grindelia camporum	25.69	1.04	0.27	26.73
Vulpia microstachys	23.85	1.71	0.31	25.56
Trifolium gracilentum	22.94	1.33	0.37	24.26
Triteleia laxa	22.02	0.57	0.17	22.58
Herniaria cinerea	20.64	0.35	0.13	20.99
Lupinus bicolor	19.73	0.41	0.17	20.14
Artemisia californica	17.89	1.69	0.38	19.58
Astragalus didymocarpus	18.81	0.69	0.22	19.49
Holocarpha obconica	18.81	0.59	0.37	19.40
Clarkia purpurea	18.81	0.12	0.03	18.93
Achillea millefolium	16.97	0.47	0.12	17.44
Amsinckia testillata	15.14	0.13	0.04	15.27
Galium aparine	14.68	0.26	0.07	14.94
Elymus triticoides	9.63	3.25	0.96	12.88
Eriogonum fasciculatum	11.93	0.88	0.25	12.80
AIlium serra	12.39	0.08	0.03	12.46
Matricaria matricarioides	11.93	0.35	0.19	12.28
Marah fabaceus	11.47	0.10	0.03	11.56

TABLE E.1.1.2–1.—*Constancy, Cover, and Importance Values for the More Important Plant Species at Site 300 from the 1986 Survey (continued)*

Species	Constancy	Cover		Importance Value
		Mean	Standard Error	
Crassula connata	11.47	0.09	0.05	11.55
Nassella pulchra	10.55	0.70	0.23	11.25
Stellaria nitens	11.01	0.09	0.05	11.10
Delphinum hesperium	10.55	0.10	0.04	10.65
Dichelostemma capitata	10.58	0.03	0.01	10.57
Deinandra kelloggii	10.09	0.47	0.30	10.56
Claytonia perfoliata	10.09	0.32	0.13	10.41
Carduus pychnocephalus	10.09	0.23	0.12	10.33
Lupinus succulentus	10.09	0.17	0.05	10.27
Sonchus oleraceus	10.09	0.04	0.02	10.13
Senecio vulgaris	10.09	0.01	0.00	10.11
Eschscholzia californica	9.63	0.23	0.11	9.86
Collinsia heterophylla	9.17	0.26	0.12	9.43
Eriogonum nudum	9.17	0.21	0.08	9.38
Lupinus microcarpus densiflorus lacteus	9.17	0.14	0.04	9.31
Chlorogalum pomeridianum	8.72	0.15	0.06	8.86
Sonchus aspera	8.72	0.03	0.02	8.75
Pterostegia drymerioides	8.72	0.04	0.02	8.75
Guillenia lasiophyllus	8.72	0.03	0.01	8.75
Croton setigerus	8.72	0.03	0.01	8.74
Lasthenia californica	8.26	0.28	0.16	8.53
Eriogonum angulosum	7.80	0.11	0.05	7.91
Delphinium gypsophilum	7.34	0.32	0.17	7.65
Gilia tricolor	7.34	0.10	0.05	7.44
Juniperus californicus	6.88	0.47	0.28	7.35
Polypogon interruptus	6.42	0.70	0.36	7.13
Monolophia major	6.88	0.24	0.13	7.12
Erodium botrys	6.88	0.10	0.05	6.98
Silene antirrhinam	6.88	0.10	0.04	6.98
Brassfca nigra	6.88	0.08	0.05	6.96
Bromus madritensis	6.42	0.42	0.16	6.84
Melica California nevadensis	6.42	0.29	0.13	6.71
Centaurea melatensis	6.42	0.22	0.13	6.64

TABLE E.1.1.2–1.—*Constancy, Cover, and Importance Values for the More Important Plant Species at Site 300 from the 1986 Survey (continued)*

Species	Constancy	Cover		Importance Value
		Mean	Standard Error	
Trifolium oliganthum	6.42	0.13	0.05	6.55
Stylocfine gnaphalioides	6.42	0.07	0.03	6.49
Typha latifolia	5.05	1.26	0.48	6.30
Microseris lindleyi	5.96	0.01	0.01	5.98
Elymus elymoides	5.51	0.34	0.14	5.84
Salvia mellifera	5.05	0.68	0.26	5.72
Mimulus guttatus	5.51	0.20	0.12	5.70
Microseris douglasii	5.51	0.15	0.08	5.66
Linanthus bicolor	5.51	0.16	0.09	5.66
Claytonia parviflora	5.51	0.05	0.03	5.56
Quercus douglasii	5.05	0.50	0.20	5.55
Logfia gallica	5.51	0.04	0.02	5.55
Calochortus invenustus	5.51	0.02	0.01	5.52
Hordeum murinum leporinum	5.05	0.12	0.06	5.16
Amsinckia menziesii	5.05	0.03	0.02	5.08
Delphinium patens	5.05	0.03	0.02	5.08
Stylocline filaginea	5.05	0.03	0.01	5.07
Microsteris gracilis	5.05	0.02	0.01	5.07
Achyrachoena mollis	4.59	0.22	0.21	4.81
Silene gaffica	4.59	0.08	0.05	4.67
Schismus arabicus	4.59	0.07	0.03	4.65

Source: BioSystems 1986a.

The proportion and relative importance of native versus introduced species in the vegetation on Site 300 are similar to patterns documented in other cismontane annual grassland communities, where a handful of introduced species dominate and native species are less common (Heady 1958, Pitt 1975, Talbot et al. 1939).

Poa secunda (scabrella) was the most important native grass identified, occurring on nearly 39 percent of all relevés with an average cover of about 8 percent. Other important native species included the annual herbs *Trifolium tridentatum, Orthocarpus purpurascens, Lotus subpinnatus,* and *Amsinckia intermedia* (BioSystems 1986b).

Community Type Classification

In 1986, a survey delineated 14 plant community types at Site 300 that were combined to form five major types: (1) coastal sage scrub, (2) oak woodland, (3) introduced grasslands, (4) native grasslands, and (5) seeps and springs. In addition to those recognized, six relevés could not be placed in the classification scheme. Two were from the vernal pool and the remaining four were in other unique habitats; i.e., in a clay scald, a *Quercus lobata* stand, an unusual landslide deposit dominated by *Grindelia camporum*, and a *Melica californica* sward, for which no replicate samples could be obtained.

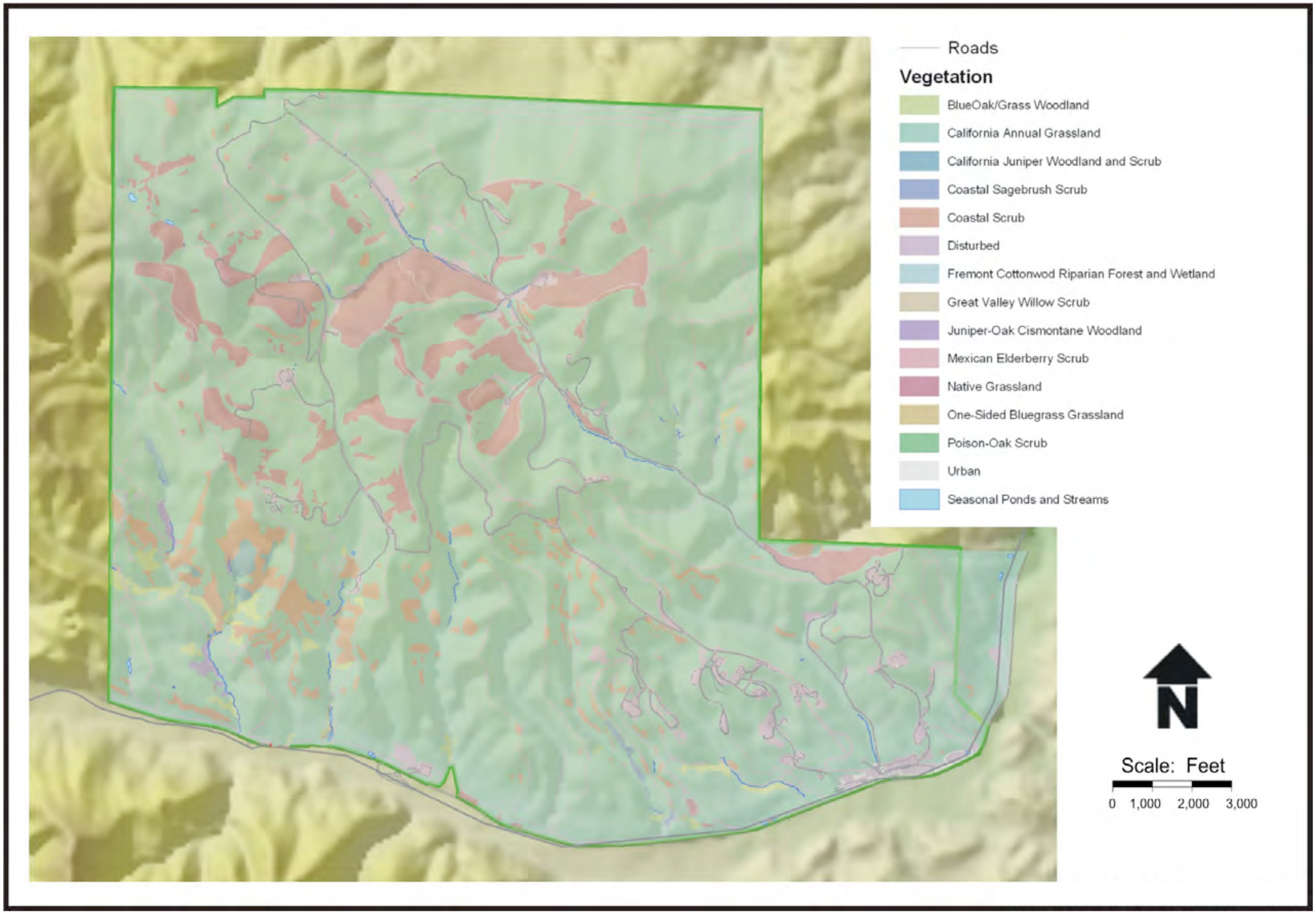
An alternative plant community classification and map have been recently completed. Community types used by Jones and Stokes generally follow the List of California Terrestrial Natural Communities recognized by the California Natural Diversity Data Base (CNDDB). The community types provided in the newer classification are numerically coded and are hierarchical. For example, the general category of Coastal Scrub is coded 32.000.00. California Sagebrush Scrub, a type of Coastal Scrub, is coded 32.010.00 (Jones and Stokes 2002a).

Maps showing the plant habitat types were prepared in 1992 and 2002, based on data collected from the 1986, 1997, and 2002 surveys (LLNL 1992a, Jones and Stokes 2002a). Figure E.1.1.2–1 provides a map of these plant communities at Site 300. A comparison of the two classifications is provided in Table E.1.1.2–2.

TABLE E.1.1.2–2.—*Comparison of Two Classifications Systems of Plant Community Types at Site 300*

Jones & Stokes (2002a) (Natural Community Code/Community Name)	BioSystems (1986)
30.000.00 Scrub and chaparral	
32.000.00 Coastal scrub	Coastal sage scrub
37.000.00 Undifferentiated chaparral scrubs	N/A
40.000.00 Grass and herb dominated communities	
41.000.00 Native grassland	Cismontane native grassland
41.180.00 One-sided bluegrass	Cismontane native grassland
42.000.00 Nonnative grassland	Cismontane annual grassland
44.100.00 Northern vernal pools	Vernal pools
45.700.00 Freshwater seeps	Freshwater seep
50.000.00 Bog and marsh	
52.130.00 Cattail wetland	Freshwater seep
60.000.00 Riparian and bottomland habitat	
61.000.00 Riparian forest and woodland	Northern riparian woodland
63.000.00 Low to high elevation riparian forests and woodlands	N/A
70.000.00 Broad leafed upland tree dominated	
71.000.00 Oak woodlands and forests	Blue oak woodland
80.000.00 Coniferous upland forest and woodland	
89.000.00 Juniper woodlands	Cismontane annual grassland

Sources: BioSystems 1986a, Jones and Stokes 2002a.
N/A = not applicable.



Source: Jones and Stokes 2002a.

FIGURE E.1.1.2–1.—*Plant Community Types Observed at Site 300 in 2002*

Coastal Sage Scrub Community (32.000.00)

Coastal scrub is a shrub-dominated community occurring in the Coast Ranges within the area where the climate has a maritime influence. Although the BioSystems report recognized three types of coastal scrub at Site 300, its vegetation map did not differentiate between the types. In the present vegetation map, most of the areas designated as Coastal Scrub are dominated by a combination of species including California matchweed (*Gutierrezia californica*), *Artemesia californica, Salvia mellifera*, and *Eriogonum fasiculatum*. This general community type also includes stands dominated by other species, such as bush lupine (*Lupinus albifrons*), for which there is currently no equivalent CNDDB community type (Jones and Stokes 2002a).

The coastal scrub general community type occurs in the southwestern part of Site 300 (Figure E.1.1.2–1) and was estimated to cover approximately 108 acres (BioSystems 1986a, LLNL 1992a).

The newer classification further divided the coastal scrub general community into two specific community types: California sagebrush scrub (32.010.00) and California sagebrush-black sage scrub (32.120.00). California sagebrush scrub is a category of coastal scrub with California sagebrush (*Artemisia californica*) the dominant species. California sagebrush-black sage scrub is a category of coastal scrub with California sagebrush and black sage (*Salvia mellifera*) both being dominant species (Jones and Stokes 2002a).

Poison-Oak Scrub (37.000.00)

Poison-oak scrub is a scrub community dominated by poison oak (*Toxicodendron diversilobum*) and occurs in only two locations at Site 300. BioSystems neither classified this habitat type nor is it currently included in the CNDDB classification (Jones and Stokes 2002a).

Native Grassland (41.000.00)

Native grassland is a community dominated by native grasses, primarily one-sided bluegrass (*Poa secunda*) and needlegrass (*Nassella pulchra* and *N. cernua*). This community type is equivalent to BioSystems' Cismontane Native Grassland habitat type. Because many areas of native grassland are managed by controlled burns, the 2002 survey team was unable to assign more specific categories within this general community type (Jones and Stokes 2002a).

The native grass-dominated communities on Site 300 represent a unique resource. The plant species composition of this community type suggests two patterns of variation that may illuminate the structure of pristine California grasslands: (1) most investigators such as Heady (1977) and Barry (1972) agree with Clements (1920) that *Nassella* (*Stipa) pulchra* should dominate native grassland communities, as it often does on very sandy soils (Hull and Muller 1977); however, as discussed by Bartolome and Gemmil (1981), this conclusion may not be accurate. Dominance by *Poa secunda (P. scabrella)* of Site 300 native grasslands specifically contradicts the notion that *Stipa* would dominate California grasslands in the absence of grazing and introduced annuals; and (2) the role of native forbs in native grassland communities has not received much study (Heady 1977). Data from Site 300 suggest that both native annual and perennial forbs can assume an important role under the conditions of frequent burning and no grazing and thus may once have been important dominants or codominants of California grassland communities (BioSystems 1986a).

Stands of native grasslands on Site 300 cover approximately 723 acres and are confined mainly to the northern half of the site (Figure E.1.1.2–1) (BioSystems 1986a). Occurrence of native grass-dominated vegetation correlates with annual prescribed burning.

California Annual Grassland (42.040.00)

California annual grassland is a community dominated by annual grasses that were introduced from Mediterranean Europe during the Spanish colonial era. BioSystems mapped two habitat types corresponding to this map unit, xeric cismontane annual grassland and mesic cismontane annual grassland. The 2002 survey team did not attempt to differentiate xeric and mesic grassland map units because of the drought conditions and because many of these areas had been burned (Jones and Stokes 2002a).

California annual grassland is the largest community type at Site 300, covering approximately 5,647 acres. The most important species are *Avena barbata*, *Bromus diandrus*, *B. hordeaceus (B. mollis)*, and *B. madritensis rubens* (BioSystems 1986a).

Northern Vernal Pool (44.100.00)

Vernal pools at Site 300 are not typical and do not correspond to any of the vernal pool categories in the CNDDB classification. Therefore, they were assigned to the general category of northern vernal pool. Unlike typical vernal pools containing species endemic to vernal pool habitat, the three vernal pools at Site 300 have vegetation composed mostly of wetland generalists that are often found in, but not restricted to, vernal pools. Species observed included stipitate-popcorn flower (*Plagiobothrys stipitatus*), annual hair grass (*Deschampsia danthonioides*), cleistogamous spike-primrose (*Epilobium cleistogamum*), and creeping spikerush (*Eleocharis macrostachya*) (Jones and Stokes 2002a, 2002c).

Freshwater Seep (45.700.00)

Vegetation in the Site 300 freshwater seeps is generally dominated by herbaceous perennial hydrophytes, although riparian scrub is also associated with seeps at several locations. Where perennial soil moisture is present, the dominant species is usually narrow-leaved cattail (*T. angustifolia)*, although broad-leaved cattail (*T. latifolia*) is also present. Other common species in the seeps include creeping wild rye (*Leymus triticoides*), hoary nettle (*Urtica dioica*), saltgrass (*Distichlis spicata)*, Baltic rush (*Juncus balticus*), white hedgenettle (*Stachys albens*), and annual rabbit's-foot grass (*Polypogon monspeliensis*). Woody vegetation is associated with freshwater seeps in some areas. Mulefat (*Baccharis salicifolius*) is present at scattered locations in seeps that occur along the bottoms of drainages (Jones and Stokes 2002c). Freshwater seep corresponds to BioSystems' seeps and springs habitat type (Jones and Stokes 2002a).

Cattail Wetland (52.130.00)

The BioSystems report included cattail wetland in the seeps and springs habitat type. This community is dominated by cattails (*Typha latifolia* and *T. angustifolia*) (Jones and Stokes 2002a).

Seasonal Pond

Seasonal pond designates areas that are seasonally inundated, but that do not have native wetland or vernal pool vegetation. The vegetation is sparse and consists of weedy wetland or ruderal species. Seasonal pond does not have a corresponding CNDDB classification, and the BioSystems report did not identify this habitat (Jones and Stokes 2002a).

Mexican Elderberry Scrub (63.410.00)

Mexican elderberry scrub is a general category of scrub dominated by Mexican elderberry (*Sambucus mexicanus*). The BioSystems report mapped this area as northern riparian woodland at Site 300. This vegetation unit does not correspond closely to any of the CNDDB community types (Jones and Stokes 2002a).

Mulefat Scrub (63.510.00)

Sections of stream channel dominated by mulefat (*Baccharis salicifolius*) were classified as mulefat scrub. The BioSystems report included this vegetation unit with seeps and springs (Jones and Stokes 2002a).

Great Valley Willow Scrub (63.140.00)

Sections of stream channel along Elk Ravine dominated by willows (*Salix* species) were classified as Great Valley willow scrub. This community is an open to dense shrubby streamside thicket dominated by willows, occurring along the major rivers and tributaries throughout the Great Valley watershed. The BioSystems report did not include this habitat type (Jones and Stokes 2002a).

Blue Oak/Grass Woodland (71.020.05)

Blue oak/grass woodland corresponds, in part, to the blue oak woodland of the BioSystems report. The dominant species is blue oak (*Quercus douglasii*), with an understory dominated by annual grasses (Jones and Stokes 2002a).

Valley Oak Forests and Woodlands (71.040.00)

Valley oak forests and woodlands are dense to open tree-dominated communities in which valley oak (*Quercus lobata*) is a dominant species. Fremont cottonwood and willows are also present in the woody overstory in this map unit at Site 300. The BioSystems report discussed, but did not map, valley oaks at Site 300 (Jones and Stokes 2002a).

California Juniper Woodland and Scrub (89.100.00)

California juniper woodland and scrub is an open woody plant community dominated by California juniper (*Juniperus californicus*) with a shrubby understory of coastal scrub species. The BioSystems report did not differentiate this habitat type from coastal sage scrub (Jones and Stokes 2002a).

Juniper-Oak Cismontane Woodland (89.100.01)

Juniper-oak cismontane woodland is an open woody plant community dominated by California juniper and blue oak. The BioSystems report did not differentiate this habitat type from blue oak woodland (Jones and Stokes 2002a).

Disturbed

Areas that are paved, occupied by buildings, or otherwise cleared of vegetation were classified as Disturbed. Disturbed areas do not have a corresponding CNDDB classification. In the BioSystems report, this habitat type was only mapped for developed site facilities and was not applied to other areas, such as fire breaks (Jones and Stokes 2002a).

Urban Habitat

Areas landscaped with ornamental trees and shrubs were classified as urban habitat. Urban habitat does not have a corresponding CNDDB classification. In the BioSystems report, this habitat type was not differentiated from disturbed areas (Jones and Stokes 2002a).

E.1.1.3 *Impacts of Current Operations*

Disturbances to vegetation on Site 300 from current operations are much less than the impacts of land use practices on private lands nearby, where upland and riparian plant communities have been altered by grazing and other agricultural activities. Impacts at Site 300, however, do include the direct loss of vegetation by construction of facilities such as testing sites, firing tables, closed landfills, wastewater facilities, maintenance buildings, security facilities, fences, and roads. These disturbed areas, totaling less than 5 percent of total site acreage, are almost devoid of vegetation. Facilities in the southern half of the site have disturbed mostly introduced grassland plant communities. The generally small facilities in the northern half of the site have not significantly disturbed large areas of land even when adjacent to native grassland habitats.

Other operational practices on Site 300 include the exclusion of grazing and other agricultural practices; construction and maintenance of fire roads and breaks; vegetation management using prescribed burning, herbicides, and disking for fire control; weed control along roads, power poles, and security fence perimeters; and minor construction in or adjacent to existing facilities (BioSystems 1986a, Jones and Stokes 2001).

Lack of Livestock Grazing

Baseline comparisons of the flora on Site 300 with that of neighboring, grazed parcels show a greater complement of native grasses and herbs on Site 300, because no livestock grazing has been permitted since 1953. Slopes and substrates show less instability and erosion, probably the result of a more stable plant cover and the retention of soil-binding native plant species (BioSystems 1986a).

Disking and Applying Herbicides to Contain Fires

Most of the property has not been disked or dry-farmed since it was acquired. The limited disking for fire control has had a minor impact on the overall vegetation of Site 300. Infrequently, a narrow swath of land is disked along the northern, and part of the northeastern and eastern boundaries of the site. This perimeter disking, when done, is performed in May, providing added protection during prescribed burning against the possible escape of fire to offsite properties. The disked areas favor establishment and maintenance of introduced grasses and moderate cover of tarweeds (*Holocarpha obconica*, *Hemizonia kelloggii*, *H. lobbii*) (BioSystems 1986a). Although disking remains an option, depending on seasonal conditions, prescribed burning is preferred for wildfire control (LLNL 2003ah). For general weed and fire control, herbicides such as Krovar®, Oust®, and Roundup Pro® are applied in the fall and winter to the road shoulders, around buildings, and around power poles in the firing areas. In the General Services Area (GSA) and around landscaped areas, road shoulders, and power poles, herbicides such as Roundup Pro®, Ronstar®, and Pendulum®, are applied in the fall and winter months, avoiding areas where sensitive plant species exist. Environmental Restoration Division test wells are sprayed whenever necessary with Roundup Pro® (LLNL 2003ah). Herbicides have favored the introduction and maintenance of ruderal type vegetation in these areas (Frenkel 1970).

Prescribed Burn

Prescribed burning is conducted annually as a means of wildfire control. Site 300 began a burning program in the northeastern half of the site in the 1950s and has continued the program annually since 1960. The prescribed burn area includes approximately 2,000 acres, which is divided into 24 plots. Burning typically begins at the end of May and lasts several weeks, though this schedule depends on the length of the growing season and amount of rainfall (LLNL 1992a, 2003).

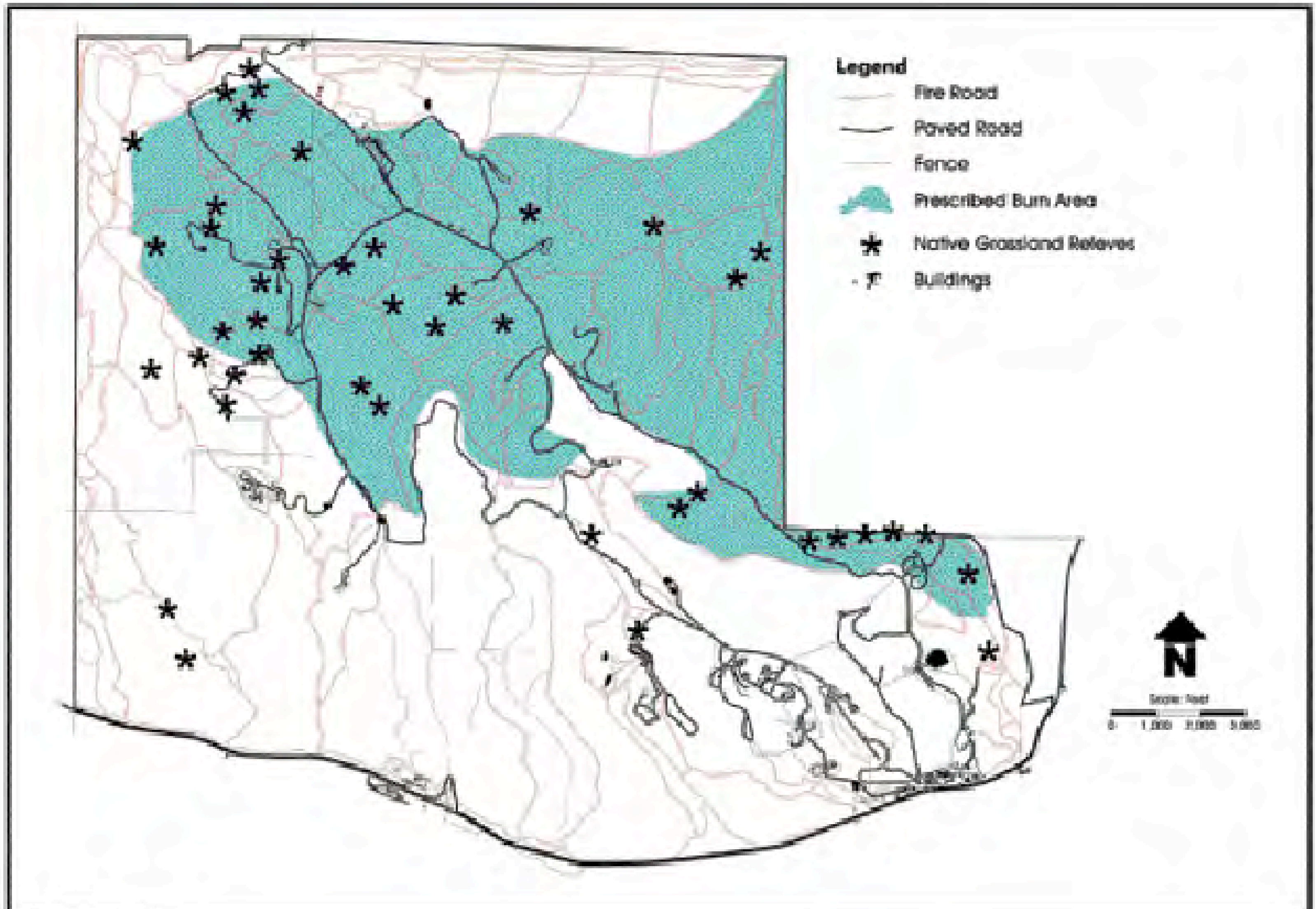
Fire limits the development of coastal sage scrub vegetation in burn areas on Site 300 to rocky sites and influences the composition and distribution of native grasslands. Restriction of coastal sage scrub to rocky sites is associated with reduced dry grass fuel levels and increased patchiness of all fuels. Although vegetation in rocky areas is subject to local fires, the rocks offer some protection and the vegetation may not be burned in every fire. Shrubs that would otherwise be eliminated then increase in importance. Native grassland communities on Site 300 occur almost exclusively in areas with annual prescribed burning (BioSystems 1986a).

Dyer (2002) notes that prescribed burns can play an important role in establishing and restoring native grassland communities in California. Barry (1972) indicated that frequent fire is required to establish and maintain grasslands dominated by native grasses in lowland California. This conclusion is borne out by grassland vegetation found at Site 300. Figure E.1.1.3–1 shows the distribution of native grassland vegetation in relation to the limits of prescribed fires in 1986, with a high correspondence between them. Not all plant communities within the perimeter of annual prescribed fire on Site 300 are native grass-dominated, but the lack of introduced grasses on some habitats strongly correlates with the pattern and frequency of fires (BioSystems 1986a). A comprehensive inventory of native grasslands has not been conducted for California. Notably, Barry (1972) did not mention the presence of native grasslands in the vicinity of Site 300. An estimated 723 acres of native grassland communities occur on Site 300. Using the evaluation criteria established by Barry (1972), Site 300 could be judged one of the largest native grasslands of this kind currently known in California.

Lawrence Livermore National Laboratory (LLNL) biologists have been investigating the effect of prescribed burns on the distribution of *Amsinckia grandiflora* and *Blepharizonia plumosa*, while also developing techniques to restore native perennial grasslands. Birds may be responsible for high levels of granivory in burned, open plots of *Amsinckia grandiflora.* Fire germination experiments suggest that fire may stimulate germination of *Blepharizonia plumosa* ray seeds and older seeds, but inhibit germination of recent-year disc seeds. One of the goals of ongoing research is to demonstrate that burn frequency affects the spread of *P. secunda* (LLNL 2002dj).

The diamond-petaled poppy (*Eschscholzia rhombipetala)*, a plant thought to be extinct until rediscovered in 1993 and thus on the California Native Plant Society (CNPS) 1A List, is present at two locations at Site 300. A small population consisting of 10 individual plants was identified in 1997 in the southwest corner of the site, and a second larger population of 300 individuals was identified in 2002 in the central western part of Site 300. Both populations are not in locations where they are being adversely affected by site operations. The diamond-petaled poppy is not listed by the U.S. Fish and Wildlife Service (USFWS) or CDFG. However, USFWS has designated the diamond-petaled poppy as a target for long-term conservation, and its extreme rarity suggests that it should be considered for listing as endangered (Jones and Stokes 2002a). LLNL biologists have been monitoring the status of these populations and evaluating proposed activity impacts for potential impacts to this species. The latest population studies are provided in *Rare Plant Restoration and Monitoring at Lawrence Livermore National Laboratory Site 300 Project Progress Report, Fiscal Year 2000, October 1999–September 2000* (LLNL 2002dj) and *Population Characteristics of Eschscholzia Rhombipetala, Lawrence Livermore National Laboratory, Livermore, CA* (LLNL 2003ap).

The big tarplant (*Blepharizonia plumosa)*, listed on the CNPS Rare Plant 1B List, is widespread and common at Site 300. This was observed at 26 localities on Site 300 in 1997, with the largest stand occupying more than 84 acres. The number of individual big tarplants present at Site 300 in 1997 was estimated to be 145,468. The big tarplant was observed at a number of locations at Site 300 in 1997, with most found in the northern half of the site. The abundance of big tarplant on Site 300 and its common occurrence in disturbed places suggest that site management practices have not adversely affected the populations at Site 300. The controlled burning does not appear to have an adverse long-term effect on the populations, as high plant densities were observed in 1997 in areas that are burned annually (Jones and Stokes 2002a). LLNL biologists have conducted an extended monitoring program to monitor the status of the big tarplant at Site 300 and evaluate the impact of prescribed burns and other disturbances on the ecology of this species.



Source: BioSystems 1986a.

FIGURE E.1.1.3–1.—*Distribution of Native Grassland Plant Communities in Relation to Prescribed Burns at Site 300 in 1986*

The round-leaved filaree (*Erodium macrophyllum)*, listed on the CNPS Rare Plant 2 List, was identified at one location at Site 300. Round-leaved filaree is not listed by USFWS or CDFG. List 2 species also meet the definition of rare or endangered species under Section 15380(d) of CNPS the *California Environmental Quality Act* guidelines, but they are more common outside of California. The Site 300 population of round-leaved filaree is located in the central western portion of Site 300, approximately 525 feet northeast of the larger diamond-petaled poppy population. The population consists of about 200 individuals in an area of about 3.5 acres. All but two of the plants were observed in fire trails (Jones and Stokes 2002a).

The presence of round-leaved filaree primarily in the fire trails suggests that this disturbance has provided a benefit to the population at Site 300. The nature of this benefit is not clear, but it could range from uncovering buried, dormant seeds to providing a microsite free from competing nonnative grasses (Jones and Stokes 2002a). The round-leaved filaree was included in the 2002 - 2003 rare plant monitoring program to obtain more information on its ecological requirements.

The gypsum-loving larkspur (*Delphinium gypsophilum* ssp. *gypsophilum*), listed on the CNPS Rare Plant 4 List, occurs at six locations with most being on upper slopes in perennial grassland at Site 300. Gypsum-loving larkspur is not listed by USFWS or CDFG. It was placed on List 4 by the CNPS. List 4 species are not considered to be rare or endangered but are uncommon enough to warrant monitoring. However, local public ordinances or resource agencies may define List 4 species as important biological resources, setting a threshold of significance that encompasses impacts on these species. It does not appear that the gypsum-loving larkspur would be adversely affected if fire roads are maintained in their present positions through the existing population(s) and if no new fire roads were constructed through them (Jones and Stokes 2002a).

The California androsace, or California rock jasmine (*Androsace elongata* ssp. *acuta*), a CNPS Rare Plant 4 List species, is widespread and common at Site 300. California androsace is not listed by USFWS or CDFG. The occurrences of California androsace on Site 300 appear to have been relatively unaffected by construction of Site 300 facilities and fire trails, because this species occurs on rock outcrops and relatively steep slopes. Burns are not likely to have a substantial adverse effect on the occurrences, because the plants bloom and set seed in early spring before most fires occur, and because the low vegetation cover where the plants occur would support only a low-intensity fire that would be unlikely to destroy the seed bank (Jones and Stokes 2002a).

Stinkbells (*Fritillaria agrestis*), a CNPS Rare Plant 4 List species, are found at several locations at Site 300. This species is not listed by USFWS or CDFG. The stinkbells occurrences at Site 300 are in a remote location that has not been affected by construction of Site 300 facilities. A fire trail cuts through the habitat and may have removed a portion of the largest stand. The stands are outside of the area that receives regular burns. However, burns would not likely have a substantial adverse effect on the occurrences because the plants bloom and set seed in early spring, before most fires occur, and because the lower vegetation cover where the plants occur would support only a low-intensity fire that would be unlikely to destroy the seed bank (Jones and Stokes 2002a).

The hogwallow starfish (*Hesperevax caulescens)*, a CNPS Rare Plant 4 List species, is found at one location west of Building 851 at Site 300. The location of Building 851 and other structures at Site 300 discussed in Appendix E are shown on maps in Appendix A of this LLNL SW/SPEIS. This species is not listed by USFWS or CDFG. The hogwallow starfish occurrence at Site 300 is at a remote location that does not appear to have been affected by construction of Site 300 facilities. A fire trail cuts through the habitat and is likely to have removed portion of the population. Burns are not likely to have a substantial adverse effect on the occurrence because the plants bloom and set seed in early spring, before most fires occur, and because the low vegetation cover where the plants occur would support only a low-intensity fire that would be unlikely to destroy the seed bank (Jones and Stokes 2002a).

With more attention being focused on the control of invasive plant species, research is evaluating the effect of prescribed burns in managing certain invasive plants. A series of prescribed burns, when annual grasses are dry but before *Centaurea solstitialis* (yellow starthistle) flowers open, have been used to prevent yellow starthistle seed production elsewhere in the Coast Range annual grasslands of California. Fire was used to burn the dry annual grass vegetation and seeds, and it scorched the yellow starthistle flowers enough to prevent seed development. After the third annual burn, perennial grass (purple needlegrass) was increased three-fold, when compared to unburned sites, and yellow starthistle was reduced 96 percent (Lass et al. 1999). This research suggests that annual burns at Site 300 could help reduce spread of certain invasive species on the property.

E.1.2 Fauna

A number of baseline faunal studies were prepared for . . . Site 300 in 1986, 1991, 2001, and 2002 (BioSystems 1986a, DOE 1982a, ESA 1990, LLNL 1992a, UC 1987). These surveys assessed the status of threatened or endangered wildlife species, as well as the presence of other amphibians, reptiles, and mammals without special status. Additional information on special status species may be found in the biological assessment (Section E.2). Many species of breeding birds were noted in the 1991 surveys because most of the fieldwork occurred during the nesting season. Observations of additional migrant and wintering species were recorded during surveys conducted in other seasons.

In 2002, specific surveys were conducted to determine the current status at Site 300 of the California linderiella fairy shrimp, the valley elderberry longhorn beetle, amphibians, reptiles, small mammals, mesocarnivores, bats, breeding raptors, and tricolored blackbirds (Arnold 2002, Bloom 2002, Condor Country Consulting 2002, CSUS 2003, Jones and Stokes 2002b, LLNL 2002di, LLNL 2003ab, LLNL 2003by, Swaim 2002a, Swaim 2002b).

E.1.2.1 *Methods*

Species of wildlife observed during fieldwork were recorded when possible. In addition, during threatened and endangered surveys, sensitive species surveys, and wetlands surveys, notes were kept on species of amphibians, reptiles, birds, and mammals observed. Notes on all wildlife species observed were also kept during night spotlighting, scent station maintenance, and small mammal trapping. More specific information on the field methodologies used is provided in the individual survey reports (Arnold 2002, Bloom 2002, Condor Country Consulting 2002, Jones and Stokes 2001, Jones and Stokes 2002b, LLNL 2002di, LLNL 2003ab, LLNL 2003by).

E.1.2.2 *Results*

Branchiopods

The California linderiella fairy shrimp (*Linderiella occidentalis*), a Federal species of concern, occurs at Site 300. During a 2001–2002 wet season survey, this branchiopod species was found in a vernal pool (FS-04) in the northwest part of the site. Another branchiopod, the California clam shrimp (*Cyzicus californicus*), which is not on Federal or California special status species lists, was also found in this vernal pool (Condor Country Consulting 2002).

Insects

The recent valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) survey at Site 300 is the only insect investigation that has been performed at LLNL (Arnold 2002). The results of this survey are provided in Section E.2.

Amphibians and Reptiles

. . . Five amphibian and 19 reptiles species, including 3 subspecies of the whipsnake, were observed at Site 300 in 1986 (BioSystems 1986c), 1991, and 2002 (Swaim 2002a) (Table E.1.2.2–1). Ponds occur along the perimeter of Site 300, and some of the onsite drainages contain aquatic vegetation supported by underground springs and seeps. Two species of salamanders were observed at Site 300: the California slender salamander (*Batrachoseps attenuatus*) and the California tiger salamander (*Ambystoma californiense*) (BioSystems 1986c). However, the California slender salamander was not observed in the 2002 survey (LLNL 2003ab). The western toad (*Bufo boreas*), Pacific treefrog (*Hyla regilla*), red-legged frog (*Rana aurora draytonii*), and western spade foot toad (*Spea hammondii*) are species known to occur onsite (LLNL 2003ab).

Conditions are far more favorable for reptiles than amphibians at Site 300. Grassland provides ideal habitat for racers (*Coluber constrictor*) and gopher snakes (*Pituophis melanoleucus*). Rock sites provide suitable habitat for such species as the western fence lizard (*Sceloporus occidentalis*), western skink (*Eumeces skiltonianus*), common kingsnake (*Lampropeltis getulus*), and the western rattlesnake (*Crotalus viridis*). The western rattlesnake species has been observed to be widespread and abundant in all habitats on Site 300. Seeps and springs provide excellent habitat for the northern alligator lizard (*Gerrhonotus coeruleus*). Side-blotched lizards (*Uta stansburiana*) and California horned lizards (*Phrynosoma coronatum frontale*) frequent areas with more open vegetation and sandy soils. Snakes found at Site 300 include the glossy snake (*Arizona elegans*), long-nosed snake (*Rhinocheilus lecontei*), and San Joaquin whipsnake (*Masticophis flagellum ruddocki*).

The California red-legged frog, a federally listed threatened species and state species of special concern, was recorded at Site 300 in 1991. In a 2001 survey, the California red-legged frog and California tiger salamander (a federally listed threatened species) were found at a number of breeding and nonbreeding locations at Site 300 (Jones and Stokes 2001). Details regarding the results of the 2001 survey for these species are provided in Section E.2. The western spadefoot toad is a Federal species of concern and State species of special concern. During wet years, this amphibian has been observed at Song Pond and the Overflow Pond located in the GSA of Site

300 (LLNL 2003ab). A State species of special concern, the California horned lizard, was observed in 1991 and occurs site-wide in sandy soil (LLNL 1992a). The San Joaquin whipsnake (*Masticophis flagellum ruddocki*), silvery legless lizard (*Anniella pulchra pulchra*), and California black-headed snake (*Tantilla planiceps*) were observed at Site 300 during a special status reptile survey in 2002 (Swaim 2002a). The silvery legless lizard and San Joaquin whipsnake are Federal species of concern and State species of special concern.

Birds

In 1991, 75 species of birds were observed at the study sites; this includes 70 species observed at Site 300 . . . (Table E.1.2.2–2). These species were also recorded in 1986 during springtime surveys for threatened and endangered species (BioSystems 1986a, BioSystems 1986b, LLNL 1992a). In 2002, an intensive avian survey and related supporting documentation identified the presence of 90 bird species at Site 300 (LLNL 2003by). Table E.1.2.2–2 shows 120 bird species at Site 300 based on identifications provided from the 1986, 1991, and 2002 surveys (BioSystems 1986b, LLNL 1992a, LLNL 2003by) . . .

Site 300, with its interspersion of several different habitats and its abundance of seeds and insects, supports a variety of birds. The western meadowlark (*Sturnella neglecta*), horned larks (*Eremophila alpestris*), and savannah sparrow (*Passerculus sandwichensis*) were the most common small birds seen throughout the open grassland areas. Vegetation at springs and seeps provides nesting habitat for red-winged blackbirds (*Agelaius phoeniceus*) and tricolored blackbirds (*A. tricolor*). These water sources attract a greater number of birds than normally found in the adjacent grasslands. For example, the mourning dove (*Zenaida macroura*), cliff and barn swallow (*Hirundo pyrrhonota* and *H. rustica*), and California quail (*Callipepla californica*) all require water daily.

The number of tricolored blackbirds can vary greatly among survey years. For example, tricolored blackbirds were observed onsite in 1986 but not in 1991 (LLNL 1992a). However, 835 nests were found in Elk Ravine over 3-day surveys in August and September 2002. Nest location analysis determined that 91.7 percent of nests were located in stinging nettle (*Urtica dioca*), 6.8 percent in cattail (*Typha latifolia*), 1 percent in Russian thistle (*Salsola tragus*), and 0.5 percent in horehound (*Marrubium vulgare*) (LLNL 2002di).

TABLE E.1.2.2–1.—*Amphibians and Reptile Species Observed . . . Site 300 in 1986, 1991, and 2001 Surveys*

Species		Study Site	
Scientific Name	**Common Name**	**Site 300**	**. . .**
Ambystoma californiense	California tiger salamander	X	
Batrachoseps attenuatus	California slender salamander	X	
Bufo boreas	Western toad	X	
Hyla regilla	Pacific treefrog	X	
Rana aurora draytonii	California red-legged frog	X	
Rana catesbeiana	Bullfrog		
Sceloporus occidentalis	Western fence lizard	X	
Sceloporus graciosus	Sagebrush lizard	X	
Uta stansburiana	Side-blotched lizard	X	
Phrynosoma coronatum frontale	California horned lizard	X	
Eumeces skiltonianus	Western skink	X	
Eumeces gilberti	Gilbert's skink	X	
Cnemidophorus tigris	Western whiptail	X	
Gerrhonotus coeruleus	Northern alligator lizard	X	
Coluber constrictor	Racer	X	
Coluber constrictor mormon	Western yellow-bellied racer		
Masticophis lateralis euryxanthus	Alameda whipsnake	X	
Masticophis lateralis lateralis	Chaparral whipsnake	X	
Masticophis flagellum ruddocki	San Joaquin whipsnake	X	
Anniella pulchra pulchra	Silvery legless lizard	X	
Tantilla planiceps	California black-headed snake	X	
Pituophis melanoleucus	Gopher snake	X	
Lampropeltis getulus	Common king snake	X	
Thamnophis sirtalis	Common garter snake	X	
Arizona elegans	Glossy snake	X	
Rhinocheilus lecontei	Long-nosed snake	X	
Crotalus viridis	Western rattlesnake	X	

Sources: BioSystems 1986c, LLNL 1992a, LLNL 2003ab, LLNL 2003bz, Swaim 2002a.

TABLE E.1.2.2–2.—*Bird Species Observed at* . . . *Site 300 in 1986, 2001, and 2002 Surveys*

Species		Study Site	
Scientific Name	**Common Name**	**Site 300**	**. . .**
Bucephala clangula	Common goldeneye	*X*	
Bucephala albeola[a]	Bufflehead	X	
Branta Canadensis	canada goose		
Anas platyrhynchos	Mallard	X	
Anas clypeata[a]	Northern shoveller	*X*	
Anas cuamptera[a]	Cinnamon teal	X	
Aythya collatis	Ring-necked duck		
Sterna forsteri	Forster's tern		
Rallus limicola[b]	Virginia rail	X	
Ardea herodias[b]	Great blue heron		
Ardea alba [a]	Great egret	X	
Egretta thula	Snowy egret		
Butorides striatus[b]	Green-backed heron	X	
Nycticorax nycticorax	Black-crowned night-heron	X	
Phalacrocorax auritus[a]	Double-crested cormorant	X	
Podilymbus podiceps[a]	Pied-billed grebe	X	
Gallinago gallinago[a]	Common snipe	X	
Tringa meanoleuca[a]	Greater yellowlegs	X	
Cathartes aura	Turkey vulture	X	
Elanus leucurus[a]	White-tailed kite	X	
Circus cyaneus	Northern harrier	X	
Buteo jamaicensis	Red-tailed hawk	X	
Buteo lagopus[a]	Rough-legged hawk	X	
Buteo lineatus[a]	Red-shouldered hawk	X	
Buteo regalis	Ferruginous hawk	X	
Buteo swainsoni	Swainson's hawk	X	
Accipiter cooperii	Cooper's hawk	X	
Accipiter striatus	Sharp-shinned hawk	X	
Aquila chrysaetos	Golden eagle	X	
Pandion minimus	Osprey	X	
Fulica american	Coot		

TABLE E.1.2.2–2.—*Bird Species Observed . . . Site 300 in 1986, 2001, and 2002 Surveys (continued)*

Species		Study Site	
Scientific Name	**Common Name**	**Site 300**	**. . .**
Falco sparverius	American kestrel	X	
Falco mexicanus	Prairie falcon	X	
Callipepla californica	California quail	X	
Charadrius vociferous	Killdeer	X	
Columba livia	Rock dove	X	
Zenaida macroura	Mourning dove	X	
Geococcyx californianus	Greater roadrunner	X	
Tyto alba	Barn owl	X	
Bubo virginianus	Great horned owl	X	
Athene cunicularia[c]	Burrowing owl	X	
Asio flammeus	Short-eared owl	X	
Otus kennicottii[a]	Western screech owl	X	
Chordeiles minor	Common nighthawk	X	
Aeronautes saxatalis	White-throated swift	X	
Calypte anna	Anna's hummingbird	X	
Calypte costae	Costa’s hummingbird	X	
Selasphorus rufus	Rufous hummingbird	X	
Selasphorus sasin	Allen's hummingbird	X	
Melanerpes formicivorus	Acorn woodpecker	X	
Colaptes auratus	Northern flicker	X	
Picoides nuttallii	Nutall’s woodpecker	X	
Tyrannus verticalis	Western kingbird	X	
Tyrannus vociferans[a]	Cassin’s kingbird	X	
Myiarchus cinerascens	Ash-throated flycatcher	X	
Contopus sordidulus	Western wood-pewee	X	
Empidonax difficilis	Pacific-slope flycatcher	X	
Empidonax traillii[d]	Willow flycatcher	X	
Sayornis nigricans	Black phoebe	X	
Sayornis saya	Say's phoebe	X	
Eremophila alpestris	Horned lark	X	
Petrochelidon (Hirundo) pyrrhonota	Cliff swallow	X	

TABLE E.1.2.2–2.—*Bird Species Observed . . . Site 300 in 1986, 2001, and 2002 Surveys (continued)*

Species		Study Site	
Scientific Name	**Common Name**	**Site 300**	**. . .**
Hirundo rustica[b]	Barn swallow	X	
Stelgidopterxyx serripennis[a]	Northern rough winged swallow	X	
Tachycineta bicolor[a]	Tree swallow	X	
Aphelocoma coerulescens	Western scrub jay	X	
Corvus brachyrhynchos	American crow	X	
Corvus corax	Common raven	X	
Parus inornatus	Plain titmouse	X	
Parus rufescens	Chestnut-backed chickadee		
Sitta carolensis	White-breasted nuthatch		
Salpinctes obsoletus	Rock wren	X	
Thyothorus ludovicianus[a]	Bewick's wren	X	
Thyothorus aedon[a]	House wren	X	
Turdus migratorius	American robin	X[b]	
Catharus guttatus	Hermit thrush	X	
Catharus ustulatus[a]	Swainson's thrush	X	
Ixoreus naevius[a]	Varied thrush	X	
Sialia currucoides[a]	Mountain bluebird	X	
Sialia mexicana[a]	Western bluebird	X	
Mimus polyglottos	Northern mockingbird	X	
Toxostoma redivivum	California thrasher	X	
Anthus rubescens	American pipit	X	
Himantopus mexicanus	Black-necked stilt		
Lanius ludovicianus	Loggerhead shrike	X	
Sturnus vulgaris	European starling	X	
Vireo huttoni	Hutton's vireo	X	
Dendroica petechia	Yellow warbler	X	
Dendroica coronata	Yellow-rumped warbler	X	
Dendroica nigrescens[a]	Black-throated gray warbler	X	
Geothlypis trichas[a]	Common yellowthroat	X	
Oporornis tolmiei	MacGillivray's warbler	X	

TABLE E.1.2.2–2.—*Bird Species Observed . . . Site 300 in 1986, 2001, and 2002 Surveys (continued)*

Species		Study Site	
Scientific Name	**Common Name**	**Site 300**	**. . .**
Vermivora bachmanii	Orange-crowned warbler	X	
Wilsonia pusilla	Wilson's warbler	X	
Piranga ludoviciana	Western tanager	X	
Guiraca caerulea[a]	Blue-grosbeak	X	
Passerina amoena	Lazuli bunting	X	
Pheucticus melanocephalus	Black-headed grosbeak	X	
Pipilo crissalis	California towhee	X	
Amphispiza belli[a]	Bell's sage sparrow	X	
Amphispiza bilineata[a]	Black-throated sparrow	X	
Aimophila ruficeps	Rufous-crowned sparrow	X	
Pooecetes grammineus	Vesper sparrow	X	
Chondestes grammacus	Lark sparrow	X	
Passerculus sandwichensis	Savannah sparrow	X	
Passerella iliaca	Fox sparrow	X	
Ammodramus savannarum[a]	Grasshopper sparrow	X	
Junco hyemalis[a]	Oregon junco	X	
Melospiza lincolnii	Lincoln's sparrow	X	
Melospiza melodia	Song sparrow	X	
Zonotrichia atricapilla	Golden-crowned sparrow	X	
Zonotrichia leucophrys	White-crowned sparrow	X	
Agelaius phoeniceus	Red-winged blackbird	X	
Agelaius tricolor	Tricolored blackbird	X	
Sturnella magna (neglecta)	Western meadowlark	X	
Euphagus cyanocephalus	Brewer's blackbird	X	
Molothrus ater	Brown-headed cowbird	X[b]	
Icterus bullockii	Bullock's oriole	X	
Icterus galbula[b]	Northern oriole	X	
Carpodacus mexicanus	House finch	X	
Carpodacus psaltia	Lesser goldfinch	X	
Carduelis tristis	American goldfinch	X	

TABLE E.1.2.2–2.—*Bird Species Observed* . . . *Site 300 in 1986, 2001, and 2002 Surveys (continued)*

Species		Study Site	
Scientific Name	**Common Name**	**Site 300**	**. . .**
Passer domesticus[b]	House sparrow	X	
Psaltriparus minimus[a]	Bushtit	X	
Bombycilla garrulus[a]	Cedar waxwing	X	
Phalaenoptilus nuttallii[a]	Common poorwill	X	
Baeolphus inornatus[a]	Oak titmouse	X	
Meleagris gallopavo[a]	Wild turkey	X	
Phainopepla nitens	Phainopepla	X	
Ceryle alcyon	Belted kingfisher		
Regulus calendula	Ruby-crowned kinglet	X	

Sources: BioSystems 1986a, LLNL 2003by, LLNL 2003bz.
[a] Not recorded in 2002 survey at Site 300 or found in related documentation.
[b] New record in 2002 survey or related documentation.
[c] . . .
[d] The willow flycatcher was observed at Site 300 in 2003 (LLNL 2003cc).

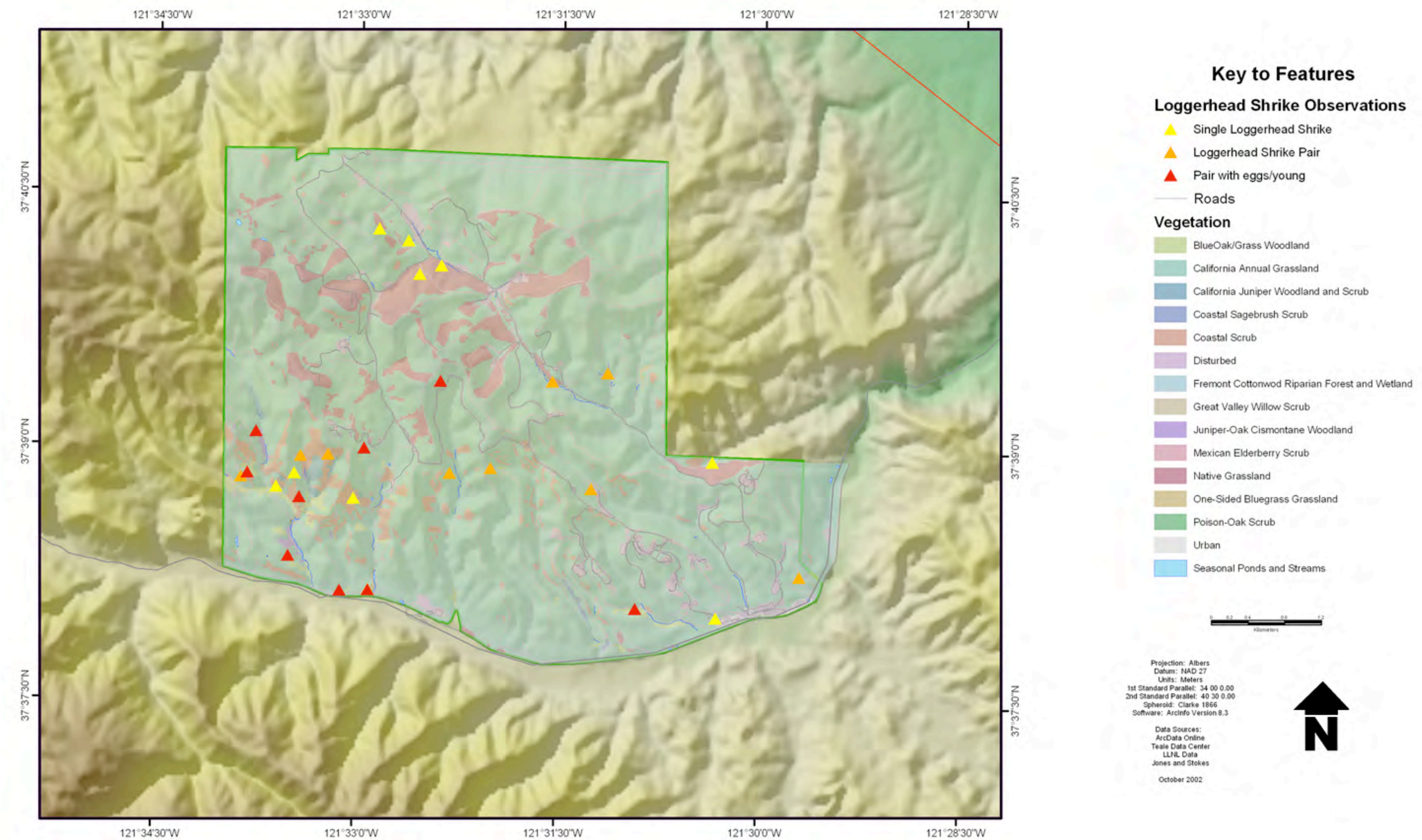
Oak woodlands and a few cottonwoods provide nesting habitat for the western kingbird (*Tyrannus verticalis*), northern oriole (*Icterus galbula*), loggerhead shrike (*Lanius ludovicianus*), and American goldfinch (*Carduelis tristis*). Coastal sage scrub supports the scrub jay (*Aphelocoma coerulescens*), California thrasher (*Toxostoma redivivum*), Bell's sage sparrow (*Amphispiza belli*), Anna's hummingbird (*Calypte anna*), rufous-crowned sparrow (*Aimophila ruficeps*), and white-crowned sparrow (*Zonotrichia leucophrys*). Ecotones of sage scrub and grassland provide ideal habitat for the mourning dove, California quail, lazuli bunting (*Passerino amoena*), and lark sparrow (*Chondestes grammacus*). Rocky outcrops and cliffs provide breeding sites for white-throated swift (*Aeronautes saxatalis*), cliff swallow, Say's phoebe (*Sayornis saya*), and rock wren (*Salpinctes obsoletus*).

Site 300 also supports a population of nesting raptors. A breeding raptor survey, conducted at Site 300 in April and July 2002, identified four species of diurnal raptors and four species of owls. The raptors included the turkey vulture (*Cathartes aura*), red-tailed hawk (*Buteo jamaicensis*), golden eagle (*Aquila chrysaetos*), and American kestrel (*Falco sparverius*), the most frequently observed raptor on Site 300. Owls observed included the barn owl (*Tyto alba*), western screech owl (*Otus kennicottii*), great horned owl (*Bubo virginianus*), and western burrowing owl (*Athene cunicularia*). The survey detected the presence of four active red-tailed hawk, four great horned owl, and three burrowing owl nests, although LLNL biologists have observed as many as 18 nesting pairs of burrowing owls in previous years. One inactive barn owl nest was found on the exterior of the Advanced Test Accelerator (ATA) Building. Also, numerous recently fledged American kestrels and one young western screech owl were observed. Blue oaks and conglomerate cliffs were the most frequently used nest structures. The numbers of breeding pairs and diversity of these birds of prey were relatively low compared to those identified on other large land units in the State of California. A pair of turkey vultures was observed, although no nest was found (Bloom 2002). Although no golden eagle or white-tailed kite nests were found, both species have occasionally nested onsite in the past. The golden eagle nested at Site 300 in 1996, and the white-tailed kite (*Elanus leucurus*) nested in a valley oak at Site 300 in 1997 and 1998 (LLNL 1997o, Bloom 2002). In addition to these species, the northern harrier (*Circus cyaneus*), and prairie falcon (*Falco mexicanus*) were identified in 1986 and 1991 surveys (BioSystems 1986c, LLNL 1992a). Ferruginous hawks, pergrine falcons, broad-winged hawks, osprey, and Swainson's hawk have also been detected at Site 300 during season surveys. Breeding pairs are not anticipated to occur on the property.

A relatively large population of loggerhead shrikes (*Lanius ludovicianus*) was present at Site 300 in 2002. A total of 18 pairs of loggerhead shrike were identified during the 2002 surveys with 9 of the 18 pairs actively nesting. Six of the nests were in junipers and three were in oaks (Bloom 2002). Figure E.1.2.2–1 shows the nest locations of loggerhead shrike in 2002.

. . . Twenty-four species of birds at Site 300 are either Federal species of concern or State species of special concern. The Swainson's hawk (*Buteo swainsoni*) is listed as threatened by the CDFG. This hawk was observed in 1994 on the southeastern perimeter of Site 300 and on the adjacent CDFG Ecological Reserve. The Swainson's hawk nests within riparian habitats and is often associated with alfalfa crops and other forms of agriculture. This species was observed within close proximity to Site 300, but may forage occasionally within the site boundaries (LLNL 2003by).

The ferruginous hawk (*Buteo regalis)* is a Federal species of concern and State species of special concern. Ferruginous hawks are relatively common in the winter at Site 300, routinely observed in association with open grassland habitats (LLNL 2003by).



Source: Bloom 2002.

FIGURE E.1.2.2–1.—*Loggerhead Shrike Nesting Locations at Site 300 in 2002*

The Cooper's hawk (*Accipiter cooperii)* is a State of California species of special concern. This hawk has been observed associated with cottonwood or willow trees at the Elk Ravine Constant Effort Banding Station and along Corral Hollow Road (LLNL 2003by).

The sharp-shinned hawk (*Accipiter striatus*) is a State species of special concern. This species was detected during the 2002 avian monitoring program at Site 300 (LLNL 2003by).

The golden eagle (*Aquila chrysaetos*) is a State species of special concern. The golden eagle is found at Site 300 and is known to have nested within the site boundaries and dependably nests within close proximity to Site 300 along Corral Hollow Road. This eagle has often been observed foraging on California ground squirrels (*Spermophilus beecheii*) at Site 300.

The northern harrier (*Circus cyaneus)* is a State species of special concern. The northern harrier is relatively common in the winter at Site 300, routinely observed in association with open grassland habitats. Breeding has been documented at Site 300 (LLNL 2003by).

The osprey (*Pandion haliaetus)* is a State species of special concern. A single sub-adult Osprey was observed flying over Corral Hollow in 2000, likely a dispersing juvenile or early migrant (LLNL 2003by).

The white-tailed kite (*Elanus leucurus)* is a State of California fully protected species. The white-tailed kite was not observed in 2002, but is known to breed occasionally at Site 300. This species has been declining noticeably within the Tri-valley region for the past 3 years and also in southern California where long-term monitoring of this species has occurred (LLNL 2003by).

The horned lark (*Eremophila alpestris)* is a State species of special concern. This species is very common at Site 300 and has been detected at many of the variable circular plot point count stations in 2002. No horned larks were banded, implying that this species probably spends little time within riparian habitats at Site 300 (LLNL 2003by).

The grasshopper sparrow (*Ammodramus savannarum)* is a Federal species of concern. This species was observed in localized groups within the northern third of Site 300 (LLNL 2003by).

Bell's sage sparrow (*Amphispiza belli)* is a Federal species of concern. Bell's sage sparrow was only detected west of Building 854 in coastal sage scrub habitat. This species is likely to only be found within the sage scrub community and is a likely breeder for Site 300 (LLNL 2003by).

The prairie falcon (*Falco mexicanus)* is a State species of special concern. A single prairie falcon was observed at the northeast corner of Site 300 in 2000 (LLNL 2003by).

The tricolored blackbird (*Agelaius tricolor)* is a Federal species of concern and State species of special concern. A regionally important breeding colony of tricolored blackbirds is located in Elk Ravine, near Building 812. This species has also been observed foraging within the grasslands of Site 300 in the nonbreeding season. A total of 835 nests were located in 2002 within Elk Ravine (LLNL 2003by).

The loggerhead shrike (*Lanius ludovicianus)* is a Federal species of concern and State species of special concern. This species is common at Site 300 in both the breeding and nonbreeding season. This species is likely distributed in nearly all habitats, including urban areas of Site 300 (LLNL 2003by, Bloom 2002).

The California thrasher (*Toxostoma redivivum)* is a Federal species of concern. Nesting has been observed in coastal sage scrub habitat near Building 858 and observed in coastal sage scrub habitat east of Building 854 (LLNL 2003by).

The oak titmouse (*Baeolphus inornatus*) is a Federal species of concern. Nesting has only been observed in an oak snag in the southwest corner of Site 300, characteristic of its close association with oak habitat (LLNL 2003by).

The yellow warbler (*Dendroica petechia)* is a State species of special concern. It was banded at an Elk Ravine Constant Effort Mist Netting Station and only observed at that location, which is associated with a riparian habitat (LLNL 2003by).

Almost all of the bird species listed in Table E.1.2.2–2 also receive protection under the *Migratory Bird Treaty Act* (16 *United States Code* [U.S.C.] §703 et seq.). This law governs the taking, killing, possessing, transporting, and importation of migratory birds, their eggs, parts and nests. Executive Order 13186, Responsibilities of Federal agencies to Protect Migratory Birds, issued on January 10, 2001, provides additional guidance on the responsibilities of Federal agencies to protect migratory birds on property under their jurisdiction.

Mammals

Twenty-six species of mammals were recorded during threatened and endangered species surveys in 1986 and 1991 (BioSystems 1986c, LLNL 1992a). Additional surveys have been conducted at Site 300 during which four additional species were observed (Jones and Stokes 2002b, CSUS 2003, LLNL 2003bh) . . . All the species were seen at Site 300 . . . (Table E.1.2.2–3). The investigation included conducting ground surveys in open areas, night spotlighting, establishing scent stations, and trapping small mammals.

Productive and diverse grasslands on Site 300 support an abundance of rodents and lagomorphs (rabbits and hares). Conditions are ideal for California ground squirrels (*Spermophilus beecheyi)* especially in the northern portion of Site 300 where the terrain is less rugged. Other common rodents include the house mouse (*Mus musculus*), deer mouse (*Peromyscus maniculatus*), Heermann's kangaroo rat (*Dipodomys heermanni*), valley pocket gopher (*Thomomys bottae*), and, in the higher grass cover, the California vole (*Microtus californicus*) and western harvest mouse (*Reithrodontomys megalotis*). Lagomorphs such as black-tailed hares (*Lepus californicus*) and desert cottontails (*Sylvilagus audubonii*) are also widespread and abundant, with the latter tending to occupy areas with more cover (LLNL 1992a, Jones and Stokes 2002b).

TABLE E.1.2.2–3.—*Mammal Species Observed* . . .
Site 300 in 1986 and 2002 Surveys

Species		Study Site	
Scientific Name	**Common Name**	**Site 300**	**. . .**
Didelphis virginiana	Virginia opossum	X	
Sylvilagus audubonii	Desert cottontail	X	
Lepus californicus	Black-tailed hare	X	
Spermophilus beecheyi	California ground squirrel	X	
Thomomys bottae	Valley pocket gopher	X	
Perognathus californicus	California pocket mouse	X	
Perognathus inornatus	San Joaquin pocket mouse	X	
Dipodomys heermanni	Heermann's kangaroo rat	X	
Reithrodontomys megalotis	Western harvest mouse	X	
Peromyscus maniculatus	Deer mouse	X	
Neotoma lepida	Desert woodrat	X	
Microtus californicus	California vole	X	
Mus musculus	House mouse	X	
Sus scrofa	Feral swine	X	
Canis latrans	Coyote	X	
Vulpes vulpes	Red fox	X	
Urocyon cinereoargenteus	Gray fox	X	
Procyon lotor	Raccoon	X	
Mustela frenata	Long-tailed weasel	X	
Taxidea taxus	Badger	X	
Spilogale gracilis	Western spotted skunk	X	
Mephitis mephitis	Striped skunk	X	
Felis concolor	Mountain lion	X	
Felis domesticus	Feral house cat	X	
Lynx rufus	Bobcat	X	
Tadarida brasiliensis	Mexican free-tailed bat	X	
Antrozous pallidus	Pallid bat	X	
Myotis volans	Long-legged myotis	X	
Myotis yumanensis	Yuma myotis	X	
Odocoileus hemionus	Black tailed deer	X	

Sources: LLNL 1992a, LLNL 2003bh, CSUS 2003, Jones and Stokes 2002b.

Many mammalian predators are supported by the rich prey base. Grassland predators include the long-tailed weasel (*Mustela frenata*), western spotted skunk (*Spilogale gracilis*), striped skunk (*Mephitis mephitis*), coyote (*Canis latrans*), badger (*Taxidea taxus*), and bobcat (*Lynx rufus*). Red foxes (*Vulpes vulpes*), which have been reported from nearby areas to the east and north of the site, have greatly expanded their range in the Central Valley (BioSystems 1986c). They show a preference for more disturbed areas, often denning in roadside culverts, and were observed near

Site 300 in 1991. Sage scrub, wooded, and riparian habitats attract other mammalian predators not normally found in grasslands including bobcat, gray fox (*Urocyon cinereoargenteus*), raccoon (*Procyon lotor*), and mountain lion (*Felis concolor*). Although these habitats are preferred, they are relatively limited on Site 300; consequently, grassland areas are used as well. Only minor areas of riparian vegetation are associated with the seeps and springs that occur along the canyon bottoms. Black-tailed deer (*Odocoileus hemionus*) prefer these habitats, but are frequently seen in the open grasslands (LLNL 1992a).

A mesocarnivore survey was conducted from mid-September through mid-October 2002, involving eight spotlighting sessions. An average of 19.8 miles (range of 14 to 28 miles) was driven for each session. Table E.1.2.2–4 summarizes the spotlighting results for the following three mesocarnivores: badger (*Taxidea taxus*), bobcat (*Lynx rufus*), and coyote (*Canis latrans*). Other species observed included burrowing owl *(Athene cunicularia*), great-homed owl (*Bubo virginianus*), barn owl (*Tyto alba*), lesser nighthawk (*Chordeiles acutipennis*), western meadowlark (*Sturnella neglecta*), red-tailed hawk (*Buteo jamaicensis*), kangaroo rat (genus *Dipodomys*), deer mouse (*Peromyscus maniculatus*), black-tailed hare (*Lepus californicus*), desert cottontail (*Sylvilagus audubonii*), western toad (*Bufo boreas*), California red-legged frog (*Rana aurora draytonii*), feral swine (*Sus scrofa*), and black-tailed deer (*Odocoileus hemionus*) (CSUS 2003).

Table E.1.2.2–4 also includes the results of a camera-monitored scent station survey at 30 locations, with observations made for 14 days at the first 10 locations and for 7 days at the other locations. The camera stations and spotlight sessions were effective in detecting the presence of mesocarnivores. Both methods detected the presence of bobcat, a rather difficult predator to observe. Orloff (BioSystems 1986c) detected gray foxes on Site 300, while no foxes were detected in the 2002 survey. Additionally, raccoon (*Procyon lotor*), long-tailed weasel (*Mustela frenata*), striped skunk (*Mephitis mephitis*), and western spotted skunk (*Spilogale gracilis*) were detected in 1986, but not in 2002 (BioSystems 1986c, CSUS 2003).

TABLE E.1.2.2–4.—*Species and Numbers of Individual Mammals Recorded During Night Spotlighting and Predator Scent-Baited Camera Stations at Site 300 in 2002*

Species	Spotlighting [a]	Camera Stations [b]
Badger	10	1
Black-tailed deer	—	7
Feral swine	—	2
Bobcat	1	1
Coyote	14	3
Hare	—	7

Source: CSUS 2003.
[a] Spotlighting conducted on the nights of September 16, 17, and 30 and October 1, 8, 9, 14, and 15, 2002.
[b] Predator Scent-Baited Camera Stations were operated at 30 locations.

A small mammal survey was conducted May 14 to May 19, June 20 to June 22, and July 30 to August 1, 2002. Trapping was performed in six major communities: coastal scrub, annual grassland, native grassland, riparian, oak savanna, and spring/seep wetland. Additionally, trapping was performed on native grassland and seep communities before and after annual prescribed burns.

A total of 210 small mammals, representing 9 species in 3 families, were captured during 2,689 trap nights at Site 300. Species captured included the valley pocket gopher (*Thomomys bottae*), California pocket mouse (*Perognathus californicus*), San Joaquin pocket mouse (*Perognathus inornatus*), Heermann's kangaroo rat (*Dipodomys heermanni*), western harvest mouse (*Reithrodontomys megalotus*), deer mouse (*Peromyscus maniculatus*), brush mouse (*Peromyscus boylii*), California vole (*Microtus californicus*), dusky-footed woodrat (*Neotoma fuscipes*), and house mouse (*Mus musculus*). No state or federally listed threatened or endangered species were observed during the 2002 small mammal survey. However, the San Joaquin pocket mouse is a Federal species of concern (Jones and Stokes 2002b).

Table E.1.2.2–5 summarizes the total number of individuals of each species captured at each survey site during each trapping period of the small mammal survey. The number of species captured in descending order at Site 300 communities was: riparian (7), coastal scrub and annual grassland (5), native grassland and seep/spring wetland (3), and oak savannah (2). The number of individual mammals captured by community in descending order was riparian (65), coastal scrub (63), annual grassland (28), seep/spring wetland (17) communities, oak savanna (5), and native grassland (4) (Jones and Stokes 2002b).

Surveys were conducted in 1991 at . . . Site 300, for two federally listed species, the San Joaquin kit fox (*Vulpes macrotis mutica*) and the riparian woodrat (*Neotoma fuscipes riparia*), and one Federal species of concern, the San Joaquin pocket mouse (*Perognathus inornatus*); and at Site 300 for two federally listed candidate species, the San Joaquin pocket mouse (*Perognathus inornatus*) and the riparian woodrat (*Neotoma fuscipes riparia*). Of the three species only the San Joaquin pocket mouse was observed; the San Joaquin kit fox and the riparian woodrat were not observed onsite (LLNL 1992a).

Surveys were conducted for the San Joaquin kit fox in 1991, and hundreds of project-specific surveys have been conducted at the site since 1993. No kit fox were recorded at Site 300 in 1991, and none have been detected there in subsequent surveys including one in 2002 (CSUS 2003). However, this species has been observed in close proximity to Site 300 (Orloff et al. 1986, Sproul and Fleet 1993). A comprehensive mitigation and monitoring plan was developed for this species in the *Final Environmental Impact Statement and Environmental Impact Report for Continued Operation of Lawrence Livermore National Laboratory and Sandia National Laboratories* (1992 LLNL EIS/EIR) (LLNL 1992a, Jones and Stokes 2001).

A report is being prepared of a bat survey at Site 300. Preliminary information indicates that the following special status species were observed: Pallid bat (*Antrozous pallidus*), a State species of special concern; the long-legged myotis (*Myotis volans*), a Federal species of concern; and the Yuma myotis (*Myotis yumanensis*), a Federal species of concern (LLNL 2003bh). . . .

TABLE E.1.2.2–5.—*Small Mammal Trapping Results at Site 300 in 2002*

	Vegetative Community and Trapping Period									
	Nonwetland								Seep/Spring Wetland	
	Annual Grassland		Native Grassland		Oak Savannah	Riparian	Coastal Scrub	Grid 1 & Trapline 1	Seep Channel Trapline	Seep Channel Trapline
Species	**6/20-6/22**	**4/17-4/19**	**Post-burn 6/20-6/22**	**Post-burn 7/30-8/1**	**6/20-6/22**	**5/14-5/16**	**5/14-5/16**	**5/17-5/19**	**Post-burn 6/20-6/22**	**Post-burn 7/30-8/1**
Valley pocket gopher		1				1				
California pocket mouse							1			
San Joaquin pocket mouse	2				3					
Heerman's kangaroo rat	4						22			
Western harvest mouse	13					7			4	6
Deer mouse	8	1	4	4	1	7	10	3	3	7
Brush mouse		2				32	10	11		
California vole	1			2		4				
Dusky-footed woodrat						13	20	3		1
House mouse						1				
No. species captured	5	3	1	2	2	7	5	3	2	3
Total captures	28	4	4	6	4	65	63	17	7	14
No. trap-nights	300	300	4	300	300	300	300	300	39	150
Captures/100 trap-nights	9.33	1.33	1.33	2.00	1.33	21.67	21.00	5.67	4.67	9.33

Source: Jones and Stokes 2002b.

E.1.2.3 *Impacts of Current Operations*

Program activities for Site 300 are discussed in Chapter 3 and Appendix A of the LLNL SW/SPEIS. The activities discussed in Section E.1.1 for vegetation would also affect wildlife at Site 300, as would vehicle traffic, fencing of facilities, explosives testing, surface impoundments, and the sewage lagoon.

Prescribed Burn

Prescribed burns may have a positive, neutral, or negative effect on wildlife depending on the species and time of year. Animals living underground, such as ground squirrels, burrowing owls, and pocket mice or animals, such as lizards, that escape into crevices and holes, are unlikely to be directly affected by fast-moving grass fires (BioSystems 1986c). Rodents inhabiting this region are adapted to periodic grass fires, so burning should not have an adverse impact on them. Burns stimulate new vegetative growth and create range conditions that probably support a greater diversity of wildlife than if the area were not burned. These newly burned areas provide excellent foraging habitat for open-country raptors. Annual burning provides a diversity of habitat for ground-nesting bird species, including raptors, but also may result in mortality for the young before they have fledged and habitat reduction for some grassland nesting passerines.

A research proposal has recently been coordinated with the USFWS to evaluate the effects of prescribed burning on the Alameda whipsnake at Site 300 and several other locations (Swaim 2002c). The research proposal received a favorable biological opinion by the USFWS (USFWS 2002a). No Alameda whipsnake mortality due to fire has been observed at Site 300 to date (LLNL 2001c).

Lack of Livestock Grazing

Site 300, which is surrounded on three sides by heavily grazed lands, has not been grazed for almost 50 years. Studies have suggested that grazing may increase habitat stability for rodent species including the California ground squirrel (Balestreri 1981, Laughrin 1970). Other studies have indicated that heavy grazing lowers the density of some rodent species such as kangaroo rats and pocket mice (O'Farrell and McCue 1981, O'Farrell et al. 1980). The exclusion of grazing on Site 300 appears to have resulted in an abundance of several granivorous rodents (e.g., kangaroo rats and pocket mice) that no longer need to compete with livestock for food. Despite the lack of grazing, however, ground squirrel populations have overall remained more plentiful in the flatter, northern half of Site 300. Many herbivorous animals generally prefer perennial grasses to the less nutritious annuals. These perennial grasslands have developed in areas where grazing has been excluded and where annual prescribed burns occur.

The exclusion of livestock grazing may have a mixed effect on the bird population. Ground-nesting species, including raptors, probably benefit from the resultant tall grass. Foraging suitability for other open-country raptors, such as golden eagles, is enhanced by the presence of low cover perennial grasslands; in other areas, foraging suitability is reduced where tall annuals obscure ground visibility. Overall, however, raptor habitat potential is excellent onsite (BioSystems 1986c).

The exclusion of livestock grazing also has a positive impact because springs and associated wetlands that are important to many species of wildlife have not been degraded or destroyed by livestock.

Ground Squirrel Control

Presently, there is no active ground squirrel control program anywhere at Site 300. Control is done, on an as needed basis, around the surface impoundment, using Fumitoxin (aluminum phosphide) fumigant, traps, or zinc phosphide treated grain bait stations (LLNL 2003ah). The impact from the application of these rodenticides is anticipated to be negligible when used in accordance with their U.S. Environmental Protection Agency (EPA) pesticide label instructions.

Disking, Grading Fire Trails, and Applying Herbicides to Contain Fires

Site 300 maintenance staff annually receives training on special status species identification and distribution, and preactivity surveys for the presence of sensitive natural resources are performed prior to disking. The perimeter-disking project proceeds only after consultation with the LLNL wildlife biologist. The Site 300 maintenance staff follows mitigation measures provided by the wildlife biologist to protect sensitive wildlife and habitats such as American badger dens from the potential effects of disking. No known mortality of special status wildlife has occurred as a result of the disking activity during the past 8 years (LLNL 2001c).

Approximately 85 miles of fire trails are graded every spring along existing routes (BioSystems 1986c). Some ground-dwelling species such as California horned lizard and silvery legless lizard may be adversely affected if present during grading operations (Stebbins 2003).

Herbicide applications discussed earlier for vegetation would be anticipated to have minimal impact on wildlife species when used in accordance with their EPA pesticide label instructions. At no time are herbicides sprayed on habitat suitable for the Alameda whipsnake or California red-legged frog. Prior to late-Fall application, ground areas subject to spraying are assessed by a LLNL wildlife biologist. Also, herbicide projects proceed only after consultation with a LLNL wildlife biologist (LLNL 2001c).

Vehicle Traffic

Vehicles traveling along the paved roads and the better fire trails could cause wildlife mortality. This cause of wildlife mortality, however, would be minimal along the dirt roads and fire trails in the more remote and biologically diverse areas.

The nocturnal seasonal migrations of amphibians such as the California tiger salamander and California red-legged frog could result in mortality along roads. But again, impacts should be minimal as nighttime vehicle traffic is sparse and migrations are infrequent.

Fencing of Facilities

The perimeter of Site 300 includes approximately 0.5 mile of chain-link and 13.4 miles of barbed wire fencing (LLNL 2003bi). Large mammals generally cannot enter areas equipped with gates and chain-link fences.

Fencing around the surface impoundments mentioned below only exclude some of the larger species of wildlife. However, fences also provide perches for many species of birds, including burrowing owls and loggerhead shrikes.

Explosives Testing

All three primary outdoor explosives testing facilities at Site 300 are approximately 1 mile from the site's northern border; explosives testing is conducted almost entirely during the day. The explosions are weekly to daily, and wildlife exists near these facilities with relatively minimal impact.

Diurnal raptors that forage directly over the facilities are the species most vulnerable to flying debris and shock overpressure; these include the golden eagle, prairie falcon, northern harrier, black-shouldered kite, ferruginous hawk, and red-tailed hawk. Smaller birds may also be affected.

Explosive Process Water Surface Impoundments and Sewage Oxidation Pond

Visual inspection of the explosive process water surface impoundments revealed few wildlife species existing within the waters. The impoundments are lined with a high density polyethylene liner. A few scattered cattail were observed in one small area; the remainder of the shoreline is devoid of vegetation. Shorebirds have been seen foraging along the edge. The California tiger salamander and western toad are known to use these impoundments, but they are considered suboptimal habitats because they lack submergent and emergent vegetation. Amphibian use of the impoundments would likely be strictly transitory with accompanying minimal impacts.

The highly eutrophic sewage oxidation pond supports many aquatic species, including a nesting pair of mallards. Wading birds such as the green heron have been observed at this location. The California red-legged frog and California tiger salamander have also been observed at the overflow pond (also referred to as the percolation pond) only and not at the oxidation pond. Breeding has been reported for these two amphibian species at a number of locations at Site 300 (Jones and Stokes 2001, LLNL 2003ab).

E.2 BIOLOGICAL ASSESSMENT

This biological assessment addresses the status of threatened, endangered, and other species of concern (referred to as sensitive species) that are known to occur at . . . Site 300. This assessment was prepared pursuant to the *Endangered Species Act* and the *California Endangered Species Act* . . .

The original version of Section E.2.2, Site 300, was prepared as a separate biological assessment by Brook Vinnedge, Steven Avery, and Scott Frazier (Jones and Stokes 2001). Preparation of this part of the biological assessment involved contact with members of the USFWS Sacramento office staff. Contributions to the biological assessment were also made by Karen Swaim (Swaim Biological Consulting) and Jim Woollett (LLNL). There has been minimal change in the biological and operational conditions at Site 300 in the time since the assessment was approved (USFWS 2002b). Therefore, the document has been prepared in essentially the same format as provided in December 2001, to facilitate its review by USFWS. Where needed, this part of the biological assessment provides updates or new information on the mission and operations of Site 300 as described in this LLNL SW/SPEIS from special status plant surveys; valley elderberry longhorn beetle survey results; and from the schedule of Site 300 activities discussed previously.

Federal agencies are required by Section 7 (a)(2) of the *Endangered Species Act* (16 U.S.C. §1536) to ensure that their actions are "not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of the critical habitat of such species…"

The *California Endangered Species Act* (California Fish and Game Code Sections 2050 through 2068) includes provisions intended to protect threatened and endangered species that may be affected by development projects subject to the *California Environmental Quality Act*. The *California Endangered Species Act* states that agencies should not approve projects that would jeopardize the continued existence of threatened or endangered species, or result in the destruction or adverse modification of habitat essential to the continued existence of those species if there are reasonable and prudent alternatives available that would conserve the species or its habitat.

This biological assessment presents the results of surveys conducted for Federal and state endangered and threatened species; Federal candidate plant and animal species; and state species of special concern. These surveys were conducted to determine what impacts, if any, the Proposed Action and the alternatives would have on these species and to ensure compliance with the *United States Endangered Species Act* and *California Endangered Species Act* for activities undertaken at . . . Site 300.

For the LLNL SW/SPEIS, consultation under Section 7 of the *Endangered Species Act* was initiated with the USFWS on October 21, 2002, when a letter was sent to their office in Sacramento, California, requesting a list of endangered, threatened, and other species of concern that may occur or are known to occur at . . . Site 300. A response received on October 28, 2002, provided . . . one for Site 300 (Attachment 1). This list has been used to update the status of listed species at these two LLNL sites (Table E.2–1). Species accounts for Federal and California species with endangered, threatened, or candidate status are provided in Attachment 3 at the end of this appendix.

Data for . . . Site 300 are presented separately, in part, because they are separate geographic and biological locations. Additionally, the USFWS elected to provide separate biological opinions for these sites in the 1992 LLNL EIS/EIR, and separate consultation has been conducted with USFWS since then. Text from biological assessments submitted in 1992, 1997, 2001, and related amendments, has been incorporated into this document with little change to retain the nature of carefully coordinated and implemented agreements during the past decade made between LLNL, DOE, and USFWS regarding species protected by the *Endangered Species Act* (LLNL 1992a, LLNL 1998a, Jones and Stokes 2001). However, the biological assessment includes new information or changes in the regulatory status of species present at . . . Site 300 . . .

TABLE E.2–1.—*Federally and State-Listed Threatened, Endangered, and Other Special Status Plant and Animal Species with Potential to Occur at . . . Site 300 in 2001 and 2002*

			Site	Status	
Common Name	**Scientific Name**	**. . .**	**Site 300**	**Federal Status Code**	**State Status Code**
		Plants			
Big tarplant	*Blepharizonia plumosa*		X	-	CNPS List 1 B
Hogwallow starfish	*Hesperevax caulescens*		X	-	CNPS List 4
Large-flowered fiddleneck	*Amsinckia grandiflora*		X	FE (CH)	CNPS List 1 B
Round-leaved filaree	*Erodium macrophyllum*		X	-	CNPS List 2
Stinkbells	*Fritillaria agrestis*		X	-	CNPS List 4
Diamond-petaled poppy	*Eschscholzia rhombipetala*		X	FSC	CNPS List 1 B
Gypsum rock jasmine	*Androsace elongata* ssp. *acuta*		X	-	CNPS List 4
Gypsum loving larkspur	*Delphinium gypsophilum* ssp. *gypsophilum*		X	-	CNPS List 4
		Invertebrates			
Valley elderberry longhorn beetle	*Desmocerus californicus dimorphus*		X	FT	-
California linderiella fairy shrimp	*Linderiella occidentalis*		X	FSC	-

TABLE E.2–1.—*Federally and State-Listed Threatened, Endangered, and Other Special Status Plant and Animal Species with Potential to Occur at . . . Site 300 in 2001 and 2002 (continued)*

		Site		Status	
Common Name	**Scientific Name**	**. . .**	**Site 300**	**Federal Status Code**	**State Status Code**
Amphibians					
California tiger salamander	*Ambystoma californiense*		X	FT (CH not proposed at LLNL)	CASSC
California red-legged frog	*Rana aurora draytonii*		X	FT (CH proposed)	CASSC
Western spadefoot toad	*Spea hammondii*		X	FSC	CASSC
Reptiles					
Alameda whipsnake	*Masticophis lateralis euryxanthus*		X	FT (CH rescinded)	FT
California horned lizard	*Phrynosoma cornatum frontale*		X	FSC	CASSC
San Joaquin coachwhip (whipsnake)	*Masticophis flagellum ruddocki*		X	FSC	CASSC
Silvery legless lizard	*Anniella pulchra pulchra*		X	FSC	CASSC
Birds					
Cooper's hawk	*Accipiter cooperii*		X	MBTA	CASSC
Sharp-shinned hawk	*Accipiter striatus*		X	MBTA	CASSC
Golden eagle	*Aquila chrysaetos*		X	MBTA	CASSC
Red-tailed hawk	*Buteo jamaicensis*		X	MBTA	-
Rough-legged hawk	*Buteo lagopus*		X	MBTA	-
Red-shouldered hawk	*Buteo lineatus*		X	MBTA	-
Ferruginous hawk	*Buteo regalis*		X	FSC, MBTA	CASSC
Swainson's hawk	*Buteo swainsoni*		X	MBTA	ST, MBTA
Northern harrier	*Circus cyaneus*		X	MBTA	CASSC
White-tailed kite	*Elanus leucurus*		X	MBTA	CASSC
Osprey	*Pandion haliaetus*		X	MBTA	CASSC

TABLE E.2–1.—*Federally and State-Listed Threatened, Endangered, and Other Special Status Plant and Animal Species with Potential to Occur at . . . Site 300 in 2001 and 2002 (continued)*

			Site	Status	
Common Name	**Scientific Name**	**. . .**	**Site 300**	**Federal Status Code**	**State Status Code**
		Birds			
Bushtit	*Psaltriparus minimus*		X	MBTA	-
Horned lark	*Eremophila alpestris*		X	MBTA	CASSC
Northern shoveler	*Anas clypeata*		X	MBTA	-
Cinnamon teal	*Anas cuamptera*		X	MBTA	-
Mallard	*Anas platyryynchos*		X	MBTA	-
Bufflehead	*Blucephala albeola*		X	MBTA	-
Common goldeneye	*Bucephala clangula*		X	MBTA	-
White-throated swift	*Aeronautes saxatalis*		X	MBTA	-
Great egret	*Ardea alba*		X	MBTA	-
Cedar waxwing	*Bombycilla garrulus*		X	MBTA	-
Common poorwill	*Phalaenoptilus nuttallii*		X	MBTA	-
Blue-grosbeak	*Guiraca caerulea*		X	MBTA	-
Lazuli bunting	*Passerina amoena*		X	MBTA	-
Turkey vulture	*Cathartes aura*		X	MBTA	-
Killdeer	*Charadrius vociferus*		X	MBTA	-
Mourning dove	*Zenaida macroura*		X	MBTA	-
Western scrub jay	*Aphelocoma californica*		X	MBTA	-
American crow	*Corvus brachyrhynchos*		X	MBTA	-
Common raven	*Corvus corax*		X	MBTA	-
Greater roadrunner	*Geococcyx californianus*		X	MBTA	-
Bell's sage sparrow	*Amphispiza belli*		X	FSC, MBTA	-
Black-throated sparrow	*Amphispiza bilineata*		X	MBTA	-
Rufous crowned sparrow	*Aimophila ruficeps*		X	MBTA	-

TABLE E.2–1.—*Federally and State-Listed Threatened, Endangered, and Other Special Status Plant and Animal Species with Potential to Occur at . . . Site 300 in 2001 and 2002 (continued)*

		Site		Status	
Common Name	**Scientific Name**	**. . .**	**Site 300**	**Federal Status Code**	**State Status Code**
		Birds			
Grasshopper sparrow	*Ammodramus savannarum*		X	FSC, MBTA	-
Lark sparrow	*Chondestes grammacus*		X	MBTA	-
California towhee	*Carpodacus mexicanus*		X	MBTA	-
Oregon junco	*Junco hyemalis*		X	MBTA	-
Lincoln's sparrow	*Melospiza lincolnii*		X	MBTA	-
Song sparrow	*Melospiza melodia*		X	MBTA	-
Fox sparrow	*Passerella iliaca*		X	MBTA	-
Savannah sparrow	*Passerculus sandwichensis*		X	MBTA	-
Golden-crowned sparrow	*Zonotrichia atricapilla*		X	MBTA	-
White-crowned sparrow	*Zonotrichia leucophrys*		X	MBTA	-
American kestrel	*Falco columbarius*		X	MBTA	-
Prairie falcon	*Falca mexicanus*		X	MBTA	CASSC
House finch	*Carpodacus mexicanus*		X	MBTA	-
Lesser goldfinch	*Carduelis psaltria*		X	MBTA	-
Cliff swallow	*Petrochelidon pyrrhonota*		X	MBTA	-
Northern rough winged swallow	*Stelgidopteryx serripennis*		X	MBTA	-
Tree swallow	*Tachycineta bicolor*		X	MBTA	-
Red-winged blackbird	*Agelaius phoeniceus*		X	MBTA	-
Tricolored blackbird	*Agelaius tricolor*		X	FSC, MBTA	CASSC
Brewer's blackbird	*Euphagus cyanocephalus*		X	MBTA	-
Bullock's oriole	*Icterus bullockii*		X	MBTA	-
Brown-headed cowbird	*Molothrus ater*		X	MBTA	-

TABLE E.2–1.—*Federally and State-Listed Threatened, Endangered, and Other Special Status Plant and Animal Species with Potential to Occur at . . . Site 300 in 2001 and 2002 (continued)*

		Site		Status	
Common Name	**Scientific Name**	**. . .**	**Site 300**	**Federal Status Code**	**State Status Code**
		Birds			
Western meadowlark	*Sturnella magna*		X	MBTA	-
Loggerhead shrike	*Lanius ludovicianus*		X	FSC, MBTA	CASSC
Northern mockingbird	*Mimus polyglottos*		X	MBTA	-
California thrasher	*Toxostoma redivivum*		X	FSC, MBTA	-
California quail	*Callipepla californica*		X	MBTA	-
Oak titmouse	*Baeolphus inornatuss*		X	FSC, MBTA	-
Yellow-rumped warbler	*Dendroica coronata*		X	MBTA	-
Black-throated gray warbler	*Dendroica nigrescens*		X	MBTA	-
Yellow warbler	*Dendroica petechia*		X	MBTA	CASSC
Common yellowthroat	*Geothlypis trichas*		X	MBTA	CASSC
MacGillivary's warbler	*Oporornis tolmiei*		X	MBTA	-
Orange-crowned warbler	*Vermivora bachmanii*		X	MBTA	-
Wilson's warbler	*Wilsonia pusila*		X	MBTA	-
Double-crested cormorant	*Phalacrocorax auritus*		X	MBTA	CASSC
Northern flicker	*Colaptes auratus*		X	MBTA	-
Nuttall's woodpecker	*Picoides nuttallii*		X	FSC, MBTA	-
Pied-billed grebe	*Podilymbus podiceps*		X	MBTA	-
Phainopepla	*Phainopepla nitens*		X	MBTA	-
Ruby-crowned kinglet	*Regulus calendula*		X	MBTA	-
Common snipe	*Gallinago gallinago*		X	MBTA	-
Greater yellowlegs	*Tringa melanoleuca*		X	MBTA	-
Burrowing owl	*Athene cunicularia*		X	FSC, MBTA	CASSC
Short-eared owl	*Asio flammeus*		X	FSC, MBTA	CASSC

TABLE E.2–1.—*Federally and State-Listed Threatened, Endangered, and Other Special Status Plant and Animal Species with Potential to Occur . . . Site 300 in 2001 and 2002 (continued)*

			Site	Status	
Common Name	**Scientific Name**	**. . .**	**Site 300**	**Federal Status Code**	**State Status Code**
		Birds			
Great horned owl	*Bubo virginianus*		X	MBTA	-
Western screech owl	*Otus kennicottii*		X	MBTA	-
Barn owl	*Tyto alba*		X	MBTA	-
Western tanager	*Piranga ludoviciana*		X	MBTA	-
Anna's hummingbird	*Calypte anna*		X	MBTA	-
Costa's hummingbird	*Calypte costae*		X	FSC, MBTA	-
Rufous hummingbird	*Selasphorus rufus*		X	FSC, MBTA	-
Rock wren	*Salpinctes obsoletus*		X	MBTA	-
Bewick's wren	*Thyothorus ludovicianus*		X	MBTA	-
House wren	*Troglodytes aedon*		X	MBTA	-
Hermit thrush	*Catharus guttatus*		X	MBTA	-
Swainson's thrush	*Catharus ustulatus*		X	MBTA	-
Varied thrush	*Ixoreus naevius*		X	MBTA	-
Mountain bluebird	*Sialia currucoides*		X	MBTA	-
Western bluebird	*Sialia mexicana*		X	MBTA	-
American robin	*Turdus migratorius*		X	MBTA	-
Pacific-slope flycatcher	*Empidonax difficillis*		X	MBTA	-
Willow flycatcher	*Empidonax traillii*		X	MBTA	SE
Ash-throated flycatcher	*Myiarchus cinerascens*		X	MBTA	-
Black phoebe	*Sayornis nigricans*		X	MBTA	-
Say's phoebe	*Sayornis saya*		X	MBTA	-
Western kingbird	*Tyrannus verticalis*		X	MBTA	-
Cassin's kingbird	*Tyrannus vociferans*		X	MBTA	-

TABLE E.2–1.—*Federally and State-Listed Threatened, Endangered, and Other Special Status Plant and Animal Species with Potential to Occur . . . Site 300 in 2001 and 2002 (continued)*

			Site	Status	
Common Name	**Scientific Name**	**. . .**	**Site 300**	**Federal Status Code**	**State Status Code**
		Mammals			
Pallid bat	*Antrozous pallidus*		X		CASSC
Long-legged myotis	*Myotis volans*		X	FSC	-
Yuma myotis	*Myotis yumaensis*		X	FSC	-
San Joaquin pocket mouse	*Perognathus inornatus inornatus*		X	FSC	-
San Joaquin kit fox [b]	*Vulpes macrotis mutica*		X	FE	ST

Sources: Jones and Stokes 2001, CDFG 2002a, CDFG 2002b, LLNL 2003ab, LLNL 2003by, LLNL 2003ac.

[a] . . .

[b] Although the San Joaquin kit fox has not been observed in surveys from 1986 to the present, monitoring efforts continue to watch for the presence of this species onsite, due to confirmed sighting near Site 300.

X = Indicates the presence of a species at . . .Site 300.

- = Indicates the absence of a species at . . .Site 300.

FE = Federal-listed endangered (any species which is in danger of extinction throughout all or a significant portion of its range).
FT = Federal-listed threatened (any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range).
FPT = Federal-listed proposed threatened (a proposal to list a species as likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range pending release of a final rule).
CH = Critical habitat (the USFWS may establish critical habitat for threatened or endangered species consisting of a geographic area determined essential for the conservation of the species).
FSC = Federal species of concern for Alameda and San Joaquin Counties. May be endangered or threatened. Not enough biological information has been gathered to support listing at this time (U.S. Fish and Wildlife Service 1-1-03-SP-0162).
CASSC = California species of special concern.
SE = State-listed endangered.
ST = State-listed threatened.
MBTA = *Migratory Bird Treaty Act.*
CNPS List 1A = Plants presumed extinct in California.
CNPS List 1B = Plants rare, threatened, or endangered in California and elsewhere.
CNPS List 2 = Plants rare, threatened, or endangered in California, but more common elsewhere.
CNPS List 3 = Plants about which we need more information – a review list.
CNPS List 4 = Plants of limited distribution – a watch list.

. . . E.2.2 Site 300

E.2.2.1 *Introduction*

Site 300, an NNSA facility, is located in San Joaquin and Alameda counties, California. This part of the biological assessment relates to continuing Site 300 activities under the Proposed Action: grading and maintaining fire trails; storm drainage system maintenance; culvert improvement and installation; prescribed annual burning; proposed termination of surface water releases; construction related projects; decontamination and demolition of facilities; maintenance of facilities, paved roads, and utilities; landscaping and grounds maintenance; herbicide application and disking; invasive species control; ground squirrel control; vehicle traffic; explosive testing; high explosive process water surface impoundments and a sewage oxidation pond. The biological assessment has been prepared to determine the extent that which these Proposed Action activities would affect any of the threatened or endangered species, or their critical habitat listed below. This biological assessment has been prepared in accordance with legal requirements set forth under Section 7 of the *Endangered Species Act* (16 U.S.C. §1536[cj]).

E.2.2.2 *Affected Species*

The species considered in this biological assessment are:

- California red-legged frog (*Rana aurora draytonii*), a federally listed threatened species (61 FR 25813-25833)
- Alameda whipsnake (*Masticophis lateralis euryxanthus*), a federally listed threatened species (62 FR 64306)
- California tiger salamander (*Ambystoma californiense*), a federally listed proposed threatened species (68 FR 28649)

Based on habitat assessments, field surveys, and distribution data, the California red-legged frog, Alameda whipsnake, and California tiger salamander were identified as either having the potential to occur or as occurring at the Site 300 Proposed Action project areas. The areas pertaining to the Proposed Action addressed in this biological assessment include formerly designated critical habitat for the Alameda whipsnake and proposed critical habitat for the California red-legged frog (Figure E.2.2.2–1).

E.2.2.2.1 *Critical Habitat*

E.2.2.2.1.1 Alameda Whipsnake

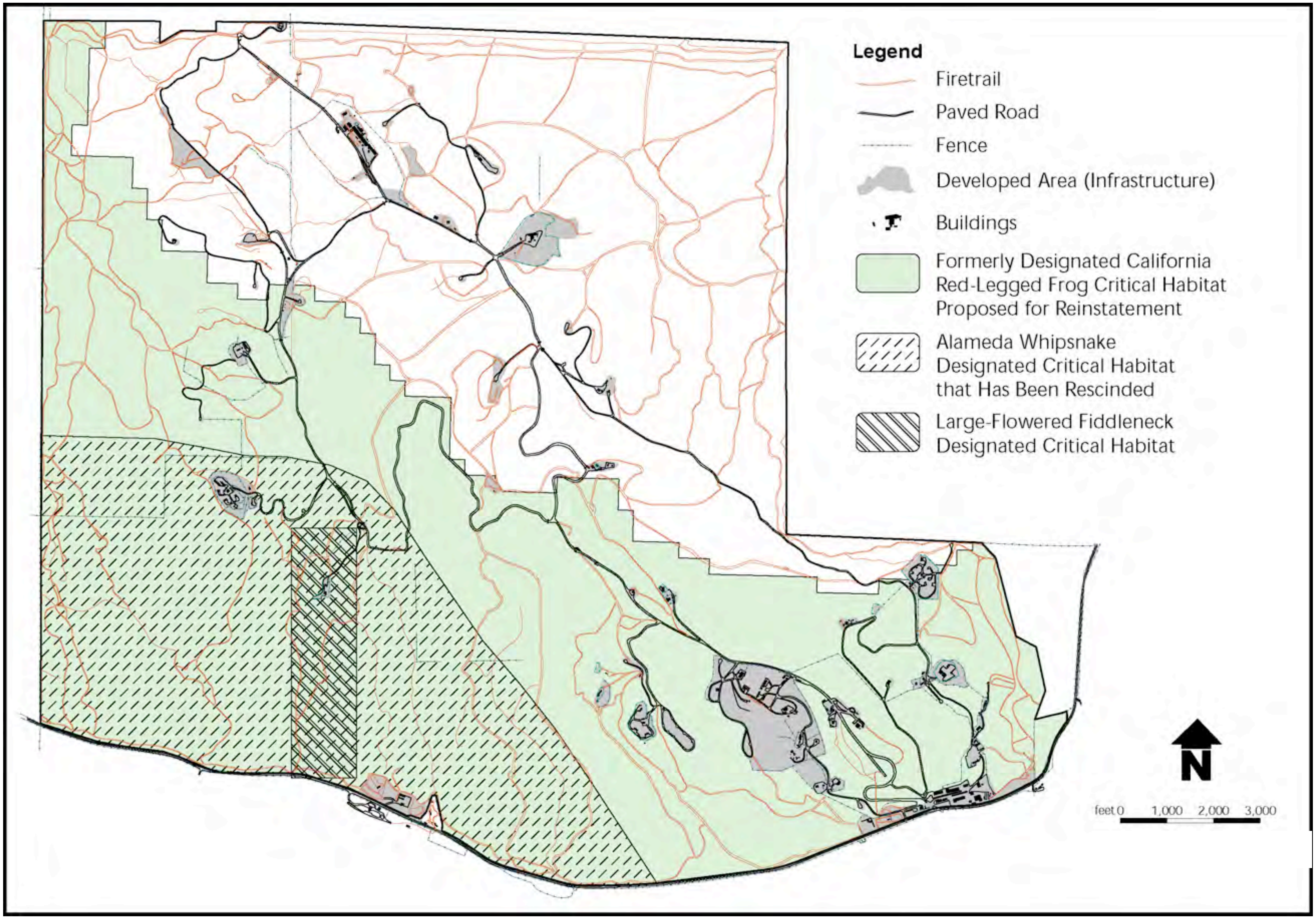
Although critical habitat for the Alameda whipsnake was established by USFWS on October 3, 2000, 400,000 acres of that critical habitat were rescinded by a recent court order (CC Times 2003). Site 300 contains about 1,592 acres of formerly designated Alameda whipsnake critical habitat (Figure E.2.2.2–1). It is possible that during the next few years that critical habitat for this species may be reinstated again at Site 300 when the USFWS publishes a new critical habitat proposal. Primary constituent elements for the Alameda whipsnake include habitats that support scrub communities such as mixed chaparral, chamise-redshank chaparral, coastal scrub, annual grassland, and oak woodlands adjacent to scrub habitats (65 FR 58933). The formerly designated critical habitat within Site 300 contains many of the Alameda whipsnake primary constituent elements, including annual grassland and oak woodland habitats linked to sage scrub habitats and rock outcrops (Jones and Stokes 2001).

E.2.2.2.1.2 California Red-Legged Frog

Although critical habitat for the California red-legged frog was established by the USFWS on March 13, 2001, most of that critical habitat has been rescinded by a court order (USDCDC 2002). Site 300 contains approximately 4,050 acres of formerly designated California red-legged frog critical habitat (60 percent of the Site 300). In April 2004, the USFWS issued a proposed rule to reinstate formerly designated critical habitat for the California red-legged frog at Site 300 (69 FR 19620, 69 FR 32966). Primary constituent elements for the California red-legged frog include both aquatic and upland habitat where suitable breeding and nonbreeding habitat are intermingled throughout the landscape and are interconnected by continuous dispersal habitat (66 FR 14626, March 13, 2001) (Jones and Stokes 2001).

E.2.2.2.1.3 California Tiger Salamander

Proposed critical habitat for the Central population of the California tiger salamander was presented in a proposed rule by the USFWS on August 10, 2004. The primary constituent elements for the California tiger salamander are aquatic and upland areas, including vernal pool complexes, where suitable breeding and nonbreeding habitats are interspersed throughout the landscape, and are interconnected by continuous dispersal habitat (69 FR 48570).



Source: Jones and Stokes 2001.

FIGURE E.2.2.2–1.—*Status of Designated Critical Habitat for Three Species at Site 300*

E.2.2.3 *Unaffected Species*

The large-flowered fiddleneck (*Amsinckia grandiflora*) is federally listed as endangered (50 FR 19374, May 8, 1985) and state-listed as endangered. The large-flowered fiddleneck occurs in two populations (one experimental and one natural) in designated critical habitat near Building 858 (LLNL 2001bb). A small population of this species has also been known to occur in Draney Canyon, near the Site 300 Alameda/San Joaquin county line, but this population has not been observed since 1997. A portion of Site 300 (640 acres) is designated critical habitat for this species; however, there would be no affect on this species or its critical habitat as a result of the Proposed Action activities (refer to Figure E.2.2.2–1). Dr. Tina Carlsen monitors this population of large-flowered fiddleneck at Site 300 (Jones and Stokes 2002a). Any future projects that could affect this species or its critical habitat would be evaluated separately.

The San Joaquin kit fox (*Vulpes macrotis mutica*) is federally listed as endangered and state-listed as threatened. Protocol-level surveys were conducted for this species in 1991, and hundreds of project-specific surveys have been conducted at the site since 1993. No kit fox were recorded at Site 300 in 1991 and none have been detected there in subsequent surveys, including a recent mammal (mesocarnivore) survey in 2002 (CSUS 2003). Available data suggest that Proposed Action projects would not likely affect the San Joaquin kit fox. Although no kit fox were observed in the above-mentioned surveys, LLNL wildlife biologists continue to monitor for the presence of kit foxes at Site 300 due to records of this species in the vicinity of the site. A comprehensive mitigation and monitoring plan was developed for this species in the 1992 LLNL EIS/EIR (LLNL 1992a).

The valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) is federally listed as a threatened species. Protocol level surveys were conducted in 1991 and project-specific surveys have been conducted at Site 300 since 1993. No beetles were detected at Site 300 during any of those surveys. In May of 1997, USFWS issued Site 300 a biological opinion for pruning elderberry shrubs along the edge of a fire trail in the southeast corner of the site for three separate time periods. One pruning occurred in May/June 1997, and no beetles or evidence of beetles were detected (Jones and Stokes 2001). In 2002, four surveys were conducted during April and May at Site 300 for the valley elderberry longhorn beetle and its host, the blue elderberry plant. Elderberry plants were found at six locations at Site 300 and two locations on adjacent land southeast of Site 300 in a CDFG preserve. During these surveys, 10 exit holes, considered to be from valley elderberry longhorn beetles, were found in elderberry plants. Additionally, six adult beetles were observed in a canyon just north of Elk Ravine, with two of the adults clearly exhibiting identifying characteristics of the valley elderberry longhorn beetle (Arnold 2002). No facility construction activities would be allowed to occur within a 300-foot radius of known locations of elderberry bushes without prior consultation with the USFWS. Because of these protective measures, the valley elderberry longhorn beetle would not be adversely affected.

Two seasonal pools at Site 300 were altered prior to 1990 to make them deeper. Protocol-level surveys were conducted at these two sites in 1991; no vernal pool fairy shrimp, vernal pool tadpole shrimp, or longhorn fairy shrimp were identified in the pools. During a 2001–2002 wet season survey, the California fairy shrimp (*Linderiella occidentalis*), a Federal species of concern, was found in a vernal pool (FS-04) in the northwest part of Site 300. Another branchiopod, the California clam shrimp (*Cyzicus californicus*), which is not on Federal or

California special status species lists, was also found in this vernal pool (Jones and Stokes 2001, Condor Country Consulting 2002). However, because the Proposed Action projects would not affect these two seasonal pools, listed shrimp species are not considered in this biological assessment.

The Swainson's hawk (*Buteo swainsoni*) is state-listed as threatened by the CDFG. This hawk was observed in 1994 on the southeastern perimeter of Site 300 and the adjacent CDFG Ecological Reserve. The Swainson's hawk nests within riparian habitats and is often associated with alfalfa crops and other forms of agriculture. This species was observed within close proximity to Site 300, but probably forages occasionally within the site boundaries (LLNL 2003by). The Swainson's hawk is not considered in this biological assessment because Proposed Action projects would not likely affect the occasional foraging activity at Site 300.

The willow flycatcher (*Empidonax traillii*) is state-listed as endangered by the CDFG. This flycatcher was observed for the first time at Site 300 during a constant effort mist netting survey in Elk Ravine in 2003 (LLNL 2003ac). The willow flycatcher was observed in part of Elk Ravine that is not being affected by continuing activities and is not anticipated to be adversely impacted.

E.2.2.4 *Consultations to Date*

- 1990–1991 EIS/EIR (Appendix F) biological assessment consultations.

- Spring 1994: Site 300 biologists informally consulted with USFWS on a proposed sewage pond maintenance project at Site 300 when the California red-legged frog was proposed endangered.

- May 1997: USFWS issued a biological opinion with mitigation measures identified for the valley elderberry longhorn beetle habitat alteration along a Site 300 fire trail.

- 1998 to present: Numerous informal Section 7 consultations with USFWS for project-specific activities that could, as proposed, indirectly affect threatened and endangered species (e.g., the California red-legged frog or the Alameda whipsnake) or their habitat.

- December 20, 2000: Site 300 biologist Jim Woollett met with biologist Curt McCasland of USFWS to discuss the proposed and ongoing project activities for annual maintenance and operational activities within developed areas at Site 300 and within critical habitat areas for the California red-legged frog and the Alameda whipsnake at Site 300. A subsequent telephone conversation on the same topic between Mr. Woollett and Mr. McCasland occurred on January 22, 2001. Formal consultation was not required for these maintenance projects because they will be conducted in developed, industrial areas, which do not contain the species and do not comprise the primary constituent habitat elements for the species.

- March 2, 2001: Site 300 submitted a technical assistance request to USFWS for proposed maintenance and operational activities in the Alameda whipsnake and California red-legged frog critical habitat.

- May 2001: Phone conversation and field meeting with USFWS biologist Don Hankins indicated that formal consultation was required for the proposed project (fire trail maintenance, storm drain system maintenance, culvert improvements and installations, prescribed burning, and termination of cooling tower water releases) that had been included in the technical assistance request.

- September 10, 2001: A species list was received from USFWS. The list includes species potentially occurring at the project site that are listed as threatened, endangered, or proposed for such listing under the *Endangered Species Act*.

- September 20, 2001: LLNL staff met with USFWS biologist Don Hankins to discuss the several continuing operators and their potential effects on the California red-legged frog, California tiger salamander, and the Alameda whipsnake and their habitats. This biological assessment incorporates avoidance and mitigation measures and enhancement opportunities discussed at that meeting.

- December 6, 2001: NNSA submitted the November 2001 biological assessment to USFWS for continuing operations at Site 300.

- May 17, 2002: USFWS issued a biological opinion that continuing operations as described in the biological assessment are not likely to jeopardize the continued existence of the California red-legged frog or the Alameda whipsnake at Site 300 and also are not likely to destroy or adversely modify their designated habitat at this facility (USFWS 2002b).

- October 28, 2002: USFWS provided a species list for . . . Site 300 for the LLNL SW/SPEIS (USFWS 2002d).

E.2.2.5 *Proposed Action Project Activities*

The Proposed Action would comprise 15 Site 300 management activities: (1) grading and maintaining fire trails; (2) ongoing program of maintenance of the storm drainage system; (3) improving and installing culverts; (4) prescribed annual burning; (5) termination of surface-water releases from Buildings 827, 851, and 865; (6) construction related projects; (7) demolition of facilities; (8) maintenance of facilities, paved roads, and utilities; (9) landscaping and grounds maintenance; (10) herbicide application and disking; (11) invasive species control; (12) ground squirrel control; (13) vehicle traffic; (14) explosive testing; and (15) explosive process water surface impoundments and sewage oxidation pond.

The biological opinion (1-1-02-F-0062) for the continuing operations of Site 300 authorized the incidental take of 25 California red-legged frogs and 5 Alameda whipsnakes during fire trail grading, storm drainage system maintenance, culvert improvement and installation activities, prescribed burns, and termination of surface water releases from several buildings (USFWS 2002b). However, the Proposed Action for this LLNL SW/SPEIS includes a number of additional projects noted above. Therefore, NNSA requests that the level of incidental take of California red-legged frogs and Alameda whipsnakes be modified to address all Site 300 operations included in this LLNL SW/SPEIS.

In April 2004, the USFWS issued a proposed rule to reinstate formerly designated critical habitat for the California red-legged frog at Site 300 (69 FR 19620, 69 FR 32966). Additionally, the USFWS may redesignate critical habitat for the Alameda whipsnake during the 10-year period covered by the LLNL SW/SPEIS (USDCDC 2002, USFWS 2003, CC Times 2003). Therefore, NNSA may request a conference on this topic.

This section of the biological assessment discusses the temporal and spatial effects that the proposed project activities at Site 300 may have on federally listed threatened, endangered, proposed, and candidate species and their critical habitats, and outlines mitigation measures that would be specific to those effects. Mitigation measures would be implemented as identified in sections on continuing activities (see also Section E.2.2.5.16).

E.2.2.5.1 *Grading and Maintaining Fire Trails*

An 85-mile system of dirt fire trails currently allows vehicle access to all areas of Site 300 (Figure E.2.2.5.2–1). The purpose of the trails is to curtail onsite and offsite movement of wildfires. Fire trails also provide the only access to remote areas of Site 300 for fire protection and security personnel. Annual fire trail grading has been performed in late April and early May since 1953, when the trails were first cut. Grading is generally very shallow across the surface of the trail.

E.2.2.5.2 *Storm Drainage System Maintenance*

Storm drain systems associated with roadways are periodically cleaned to remove debris. This activity minimizes potential for flooding and subsequent erosion of nearby facilities and support structures. Figure E.2.2.5.2–1 identifies locations where storm drainage system maintenance and general maintenance would occur.

Maintenance of culverts involves hand tools such as shovels, or heavy equipment such as backhoes, and is generally performed during the dry season or when water is not present. Maintenance at these crossings could include the removal of vegetation from existing wetlands and drainages. This activity would be infrequent, however, and generally would be conducted in late summer, when California red-legged frog adults and tadpoles can be verified as no longer present in waterbodies. The following maintenance activities could be involved in keeping watercourses and drainages operational:

- Erosion repairs and preventive measures, including installation or repair of riprap or gabion structures
- Fill and installation of jute netting, or other erosion control fabrics
- Removal of storm debris such as branches, silt, and trash
- Watershed upgrades with additional or relocated inlets

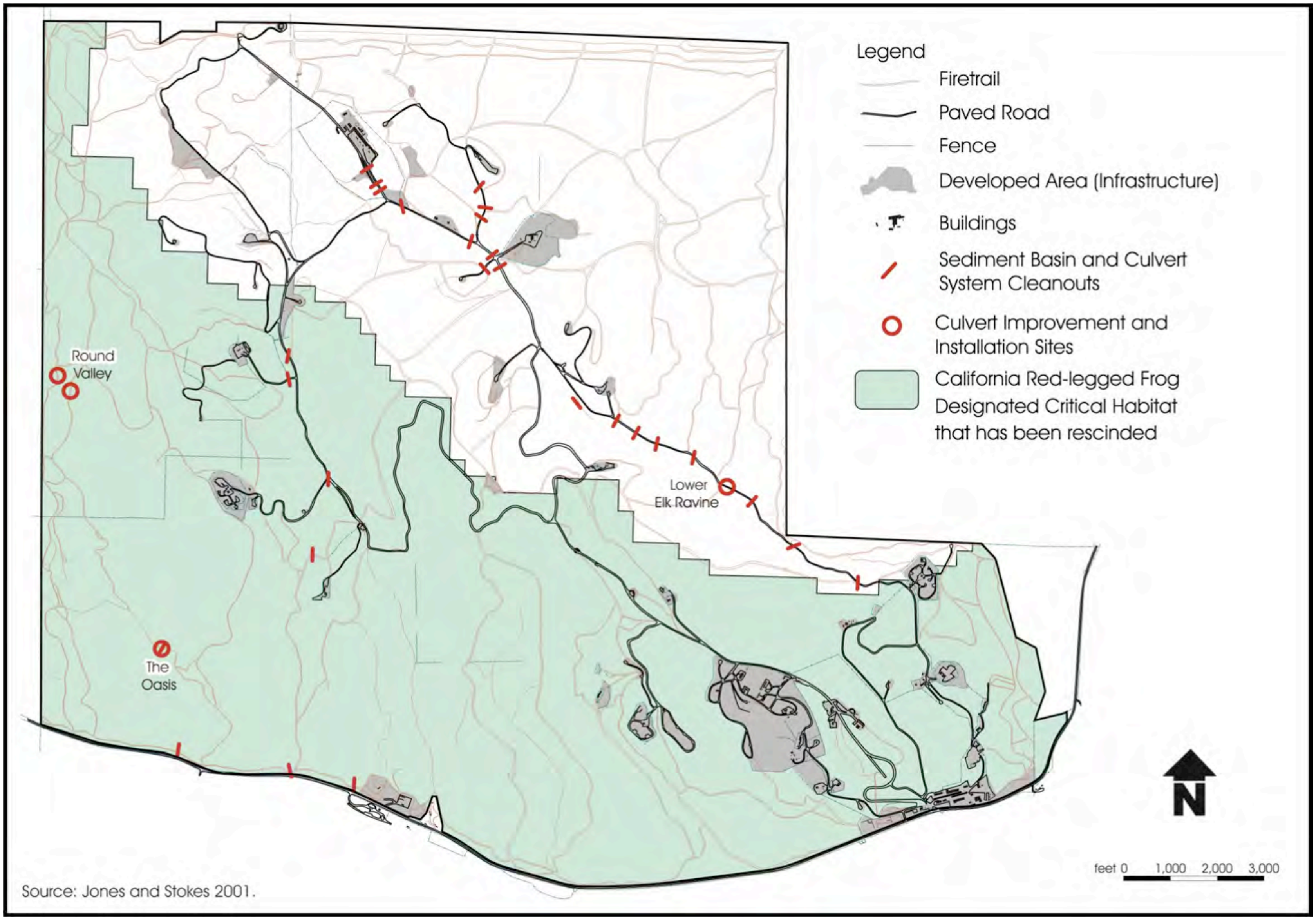


FIGURE E.2.2.5.2–1.—*Culvert Repair and Installation at Site 300*

E.2.2.5.3 *Culvert Improvement and Installation*

Four sites have been identified (Figure E.2.2.5.2–1) where existing culverts should be upgraded or new culverts installed to prevent upland runoff from cutting through fire trails and to reduce sediment load in nearby drainages. NNSA proposes to install new culverts or replace culverts as follows:

- Replace one existing culvert, approximately 18 to 24 inches in diameter, at the Oasis wetland with two culverts, each 24 inches in diameter and 60 feet long, to transport water down the slope. The eroded slope would be replaced with approximately 200 cubic yards of native soil. After the culvert is laid and the slope has been rebuilt, the slope would be stabilized with an erosion-control blanket and an appropriate erosion-control seed mix.

- Install two new culverts at Round Valley, each 36 inches in diameter and 40 feet long.

- Install a new culvert at Lower Elk Ravine, 48 inches in diameter (or smaller) and 40 feet long.

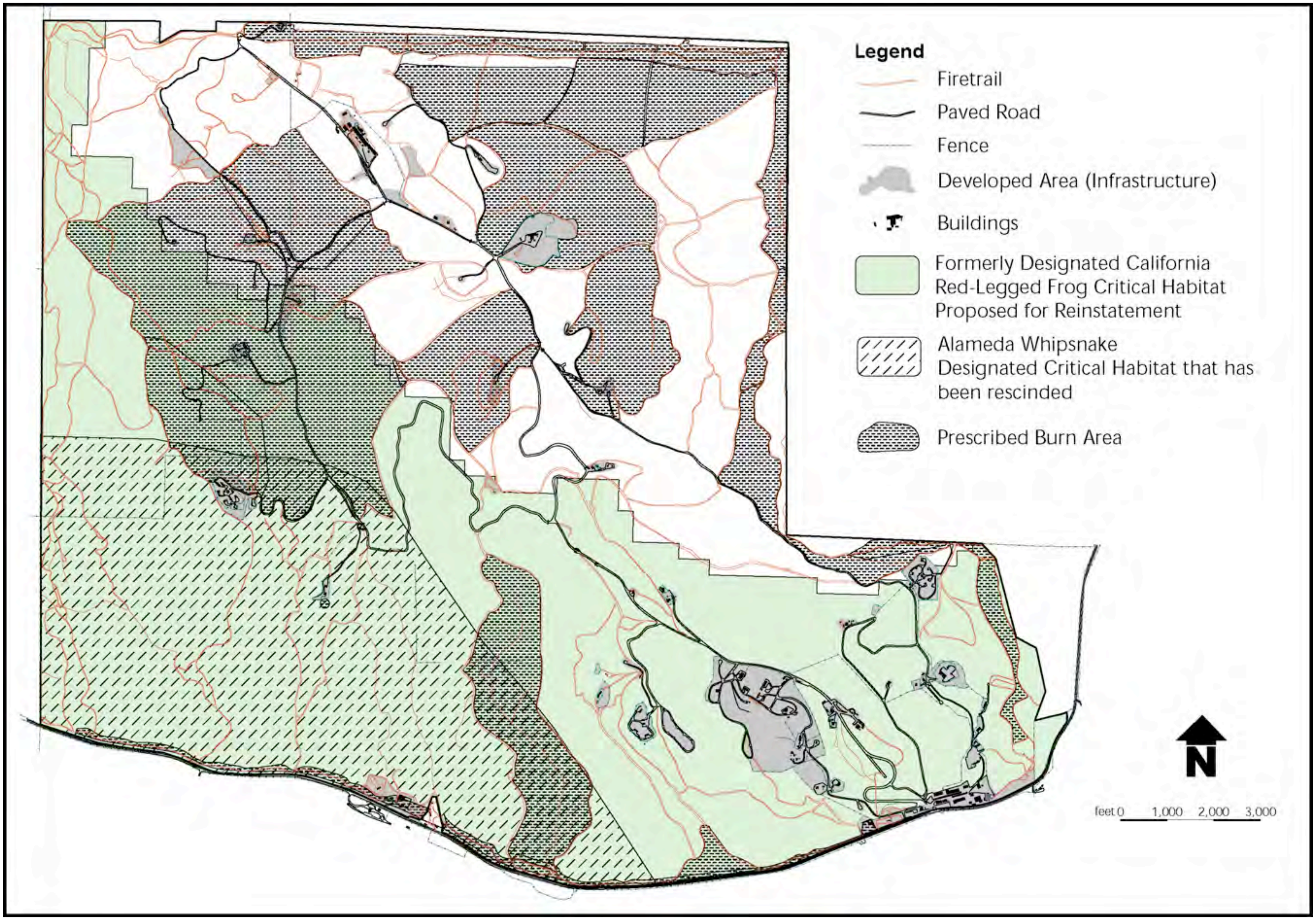
E.2.2.5.4 *Prescribed Annual Burning*

Grassland areas immediately surrounding shot facilities and specific locations on the Site 300 perimeter are burned annually under prescribed conditions (Figure E.2.2.5.4–1). The purpose of the prescribed burns is to prevent wildfires.

This maintenance activity has taken place since the site began operations in 1955. Each year, typically during the last week in May through the first week in July, approximately 2,000 acres are burned (Jones and Stokes 2001, LLNL 2004a). Figure E.2.2.5.4–1 denotes the areas subject to prescribed burning. No riparian, wetland, or sage scrub habitats are affected by the burning activity. These prescribed burns move quickly with relatively low heat due to the frequency of burning and low overall fuel volume. In addition to this burning activity, a small portion in the experimental large-flowered fiddleneck population is annually burned according to a study design approved by USFWS (LLNL 2001bb).

Approximately 620 acres of proposed designated California red-legged frog critical habitat and approximately 385 acres of formerly designated Alameda whipsnake critical habitat fall within a scheduled prescribed burn area at Site 300 (Figure E.2.2.5.4–1) (USFWS 2002b).

There is a confirmed beneficial result of annual burning on native plants such as bunchgrass (BioSystems 1986a); a native bunchgrass prairie habitat occurs at Site 300 almost solely within the prescribed burn areas.



Source: Jones and Stokes 2001.

FIGURE E.2.2.5.4–1.—*Prescribed Burn Areas at Site 300*

E.2.2.5.5 *Termination of Surface Water Releases*

Some buildings at Site 300 have used or continue to use cooling tower systems that circulate water to cool buildings and equipment. A byproduct of the cooling tower systems is a regular release of blowdown water into proximal drainages. These regular water releases have inadvertently created perennial wetlands of various sizes adjacent to the towers (Table E.2.2.5.5–1, Figure E.2.2.5.5–1).

Potable water is supplied to the artificial wetlands at Buildings 827, 851, and 865 since their cooling tower water supply has ceased. In 1996, for example, operations at Building 865 were discontinued and the facility was designated inactive. Potable water was then supplied to the wetland originally created by this cooling tower. Potable water was also supplied to wetlands at Buildings 851 and 827 following a project in 1994 to redirect the cooling tower water to subsurface leach fields to comply with regional water board requirements to eliminate these discharges.

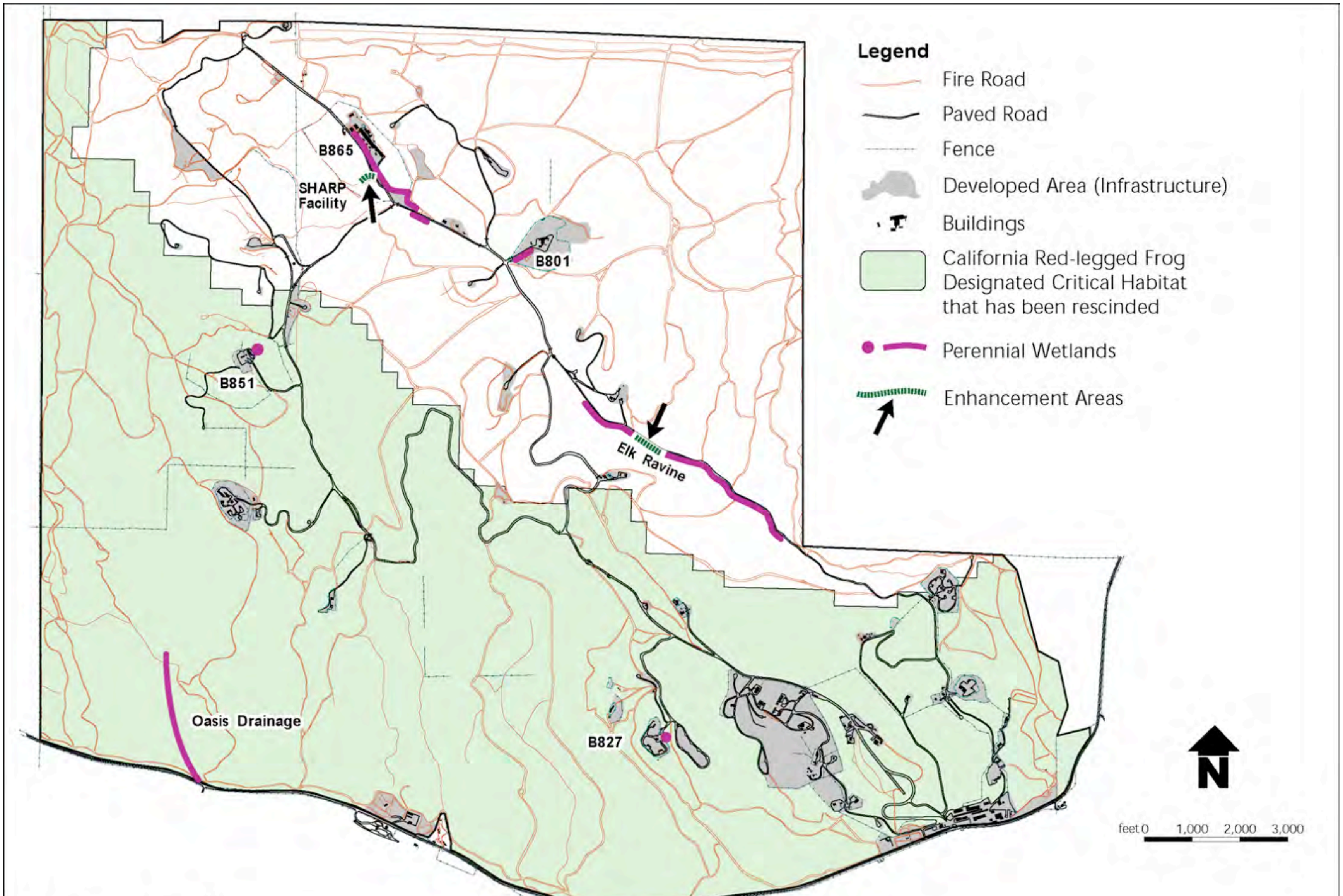
TABLE E.2.2.5.5–1.—*Summary of Wetland Features Associated with Cooling Tower Water Releases*

Cooling Tower Location	Wetland	Wetland Suitable CRLF Area Acres	Breeding Habitat Acres	CRLF or CTS Present
Building 801 (1 pool)	Artificial	0.03	0.001	None detected
Building 827	Artificial	0.03	No pools	None detected
Building 851	Artificial	0.02	No pools	None detected
Building 865 (3 breeding pools)	Artificial	0.55	0.0003	CRLF (breeding)
Total Acreage		**0.62**	**0.004**	

Source: Jones and Stokes 2001.
Note: CTS = California tiger salamander; CRLF = California red-legged frog.

The artificial wetland at Building 801, however, is still fed by cooling tower water. There are no plans to terminate water releases from Building 801; however, maintenance in the drainage channel to remove cattails would be conducted as needed. Water would not be removed from any of the wetlands created by potable water prior to development of the enhancement areas (see Section E.2.2.9.1). Because of the termination of water releases, 0.62 acre of artificial wetlands would be eliminated (Jones and Stokes 2001).

The Building 801 cooling tower has been discharging water into its associated wetland for over 20 years. The pool associated with the wetland was formed within the last year after vegetation was cleared around the culvert. Buildings 827 and 851 have been discharging potable water into the artificially created wetlands for about 7 years. Wetlands associated with Buildings 851 and 827 do not have standing water.



Source: Jones and Stokes 2001.

FIGURE E.2.2.5.5–1.—*Select Locations of Perennial Wetlands and Proposed Enhancement Areas at Site 300*

At Building 865, a 0.55-acre wetland was artificially created over 16 years ago by cooling tower surface water releases. This is the only artificially created wetland that contains California red-legged frogs. There are three California red-legged frog breeding pools associated with this wetland; each pool is approximately 7 feet in diameter, and all are located below outfall culverts.

E.2.2.5.6 *Construction Related Projects*

Under the Proposed Action, the Energetic Materials Processing Center (EMPC) would be constructed at Site 300 (see Figure E.2.2.5.6–1). This planned facility would be comprised of approximately 40,000 square feet and would be located in the southeast quadrant of Site 300. The facility would replace Buildings 805, 806, and 813. The operations of Building 807 would move to this center, but Building 807 would be retained and waste packaging operations from Building 805 would be moved to Building 807. The EMPC would house modern explosives machining, pressing, assembly, inspection, and some radiography. An additional building would provide an inert machine, offices, and shower/change room facilities. Three magazines capable of storing 1,000 pounds of explosives each would also be built (LLNL 2002ap).

Two projects would be constructed if either the Proposed Action or the No Action Alternative were selected. The first would be a wetland enhancement project previously coordinated with the USFWS involving the enhancement and protection of 1.86 acres of wetland after the termination of artificial wetlands near Buildings 801, 827, 851, and 865. This project is discussed in Section E.2.2.5.5 (Jones and Stokes 2001, USFWS 2002b). The second project would involve receipt of water from the Hetch Hetchy water system as a part of the Site 300 Revitalization Project as described in Appendix A of this LLNL SW/SPEIS. Construction aspects of this second project have already been completed.

E.2.2.5.7 *Decontamination and Demolition of Facilities*

Under the Proposed Action, Building 808 at Site 300 would be decontaminated and demolished. After the structure has been demolished, the area would be landscaped for soil retention. This building would be demolished if either the Proposed Action or the No Action Alternative were selected.

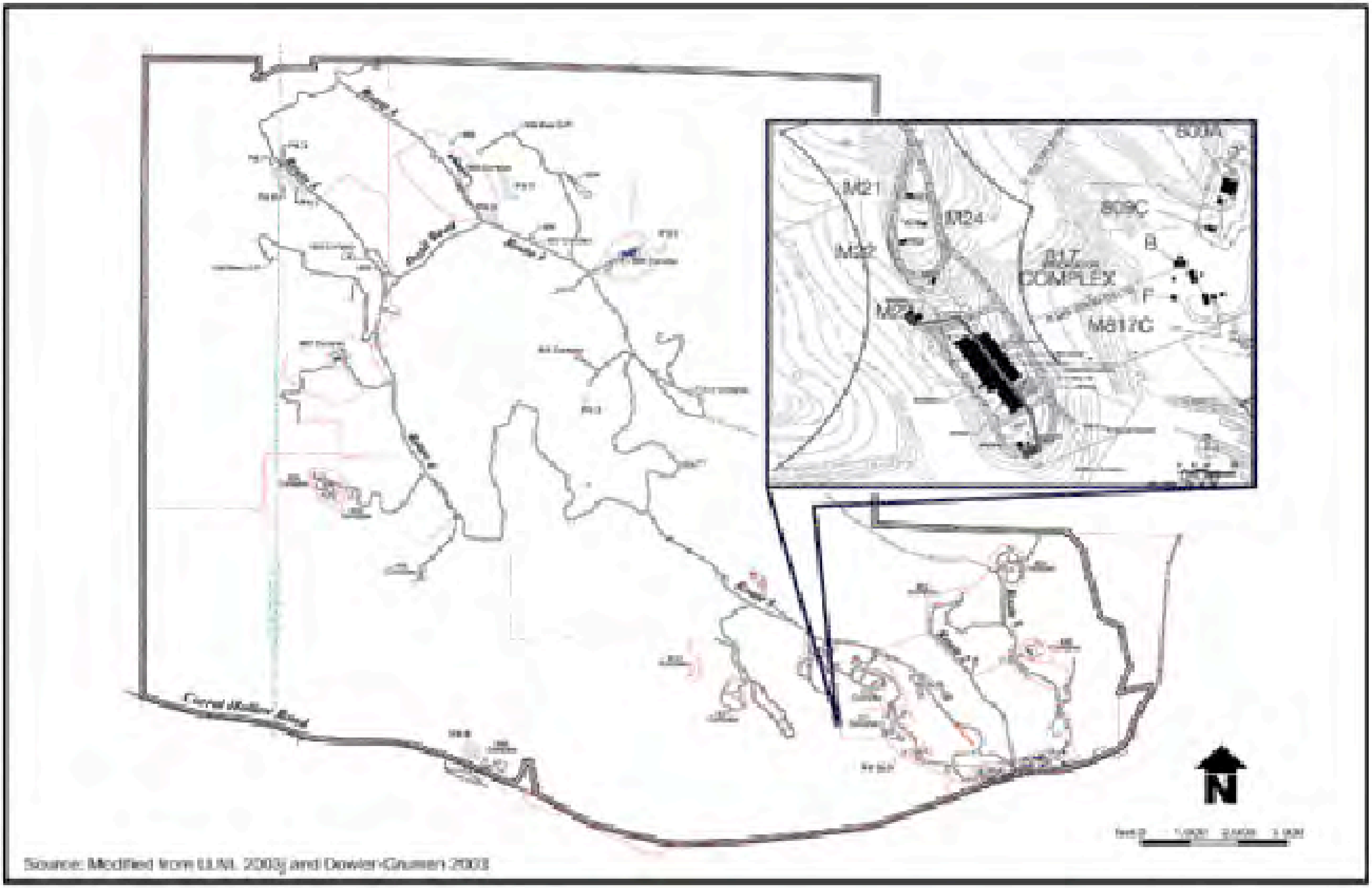


FIGURE E.2.2.5.6–1.— *Proposed Energetics Materials Processing Center at Site 300*

E.2.2.5.8 *Maintenance of Facilities, Paved Roads, and Utilities*

LLNL would continue to maintain facilities, paved roads, and utility systems at Site 300 in support of the site mission. Utilities maintained would include water, electrical, fuel, and sewer systems. These operations would occur primarily within developed areas representing less than 5 percent of the total site acreage.

E.2.2.5.9 *Landscaping and Grounds Maintenance*

LLNL would continue to conduct landscaping and grounds maintenance operations at the Site 300 in support of the site mission. These activities would include mowing lawns; trimming shrubbery; planting and maintaining vegetation at various locations on Site 300; and performing site landscaping. Landscaping and grounds maintenance activities would occur primarily within developed areas representing less than 5 percent of the total site acreage.

E.2.2.5.10 *Herbicide Application and Disking*

For general weed and fire control at Site 300, herbicides such as Krovar®, Oust®, and Roundup Pro® would be applied in the fall and winter to the road shoulders, around buildings, and around power poles in the firing areas. In the remainder of the GSA and around landscaped areas, road shoulders, and around power poles, herbicides such as Roundup Pro®, Ronstar®, and Pendulum®, would be applied in the fall and winter months, avoiding areas where sensitive plant species exist. Area around Environmental Restoration Division test wells would be sprayed for weed control whenever necessary with Roundup Pro® (LLNL 2003ah).

Most of the property has not been disked or dry-farmed since it was acquired. Infrequently, a narrow swath of land would be disked along the northern, and part of the northeastern and eastern boundaries of the site. This perimeter disking, when done, would be performed in May, providing added protection during prescribed burning against the possible escape of fire to offsite properties. Although disking would remain an option (depending on seasonal conditions), prescribed burning would be preferred for wildfire control (LLNL 2003ah).

E.2.2.5.11 *Invasive Species Control*

Field bindweed (*Convolvulus arvensis*), bull thistle (*Cirsium vulgare)*, Italian thistle (*Carduus pycnocephala*), Mediterranean mustard (*Hirschfeldia incana*), milk thistle (*Silybum marianum*), and yellow star-thistle (*Centaurea solstitialis*) are among the invasive plant species present at Site 300 (Jones and Stokes 2002a). A formal invasive species control program has not been established at Site 300. However, annual prescribed burns have been used elsewhere against certain invasive plant species such as yellow starthisle, which is present at Site 300 (see Section E.2.2.5.4) (Lass et al. 1999). Prescribed burns could have an ancillary benefit in controlling this species (Pollak and Kan 1998). Additionally, the design for the enhanced wetlands at the Super High Altitude Research Project (SHARP) Facility would include measures to reduce the establishment of invasive plants (see Section E.2.2.9.2).

The bullfrog, a known predator of the California red-legged frog, has not been observed at Site 300 . . . The feral pig (*Sus scrofa*), a known predator of the California red-legged frog, is occasionally removed from Site 300 and would continue to be removed, as necessary (LLNL 2003ab).

E.2.2.5.12 *Ground Squirrel Control*

Presently, there is no active ground squirrel control program anywhere at Site 300. Control would be done, on an as needed basis, around the explosive process water surface impoundments, using Fumitoxin (aluminum phosphide) fumigant, traps, or zinc phosphide treated grain bait stations (LLNL 2003ah).

E.2.2.5.13 *Vehicle Traffic*

Vehicle traffic at Site 300 is limited primarily to the small staff of workers required to maintain and operate this site. Most of the vehicle traffic would continue to occur during daylight hours, with nighttime vehicle traffic continuing to be being sparse.

E.2.2.5.14 *Explosive Testing*

At Site 300, three primary outdoor explosives testing facilities are approximately 1 mile from the site's northern border. Explosives testing would be conducted almost entirely during the day. The explosions would occur on a daily to weekly basis. A fourth explosives testing facility is now enclosed.

E.2.2.5.15 *Explosive Process Water Surface Impoundments and Sewage Oxidation Pond*

Explosive process water surface impoundments and a sewage oxidation pond are present at Site 300. The impoundments are lined with a high-density polyethylene liner.

E.2.2.5.16 *Schedule of Continuing Activities*

- Fire trail grading would occur annually from approximately April through mid-June, with April and May typical.
- Prescribed burning would occur annually typically from the last week of May through the first week of July, depending on weather conditions.
- Removal of storm debris such as branches and trash from the storm drainage system would be conducted as needed.
- Vegetation and sediment removal around culverts would occur during the dry season, prior to October 15.
- Culvert improvement and installation activities also would occur during the dry season, prior to October 15.
- Termination of water release would occur only when California red-legged frog mitigation sites are established. The preferred time to terminate water release would be at the end of the dry season (late September to early November).

- Construction and demolition projects would be conducted at the times indicated in Chapter 3 under the No Action Alternative, Proposed Action, and Reduced Operation Alternative and Appendix A of the LLNL SW/SPEIS.
- Other recurring operations would be performed as needed.

E.2.2.6 *Potential Effects of the Proposed Action Activities on Threatened and Proposed Threatened Species*

This section describes the potential direct and indirect effects of Proposed Action activities on the California red-legged frog, California tiger salamander, and the Alameda whipsnake. The primary direct-effect mechanisms considered in this biological assessment would include fire trail grading; prescribed burns; storm drainage system maintenance, improvement, and culvert installation; termination of surface water releases; construction related projects; decontamination and demolition of facilities; maintenance of facilities, paved roads, and utilities; landscaping and grounds maintenance; herbicide application and disking; invasive species control; ground squirrel control; vehicle traffic; explosive testing; and operation of high explosive process water ponds and sewage lagoon. Potential indirect effects on listed species would include degradation of water quality and formation of barriers to migration/dispersal. A discussion of the direct and indirect effects for each species follows.

E.2.2.6.1 *California Red-Legged Frog*

E.2.2.6.1.1 Direct Effects

E.2.2.6.1.1.1 Burning and Fire Trail Grading

There would be no direct effect on the California red-legged frog's primary constituent elements or its formerly designated critical habitat as a result of burning or fire trail grading. Approximately 620 acres of formerly designated California red-legged frog critical habitat falls within a prescribed burn area, all of which is upland grassland habitat (USFWS 2002b). In April 2004, the USFWS issued a proposed rule to reinstate formerly designated critical habitat for the California red-legged frog at Site 300 (69 FR 19620, 69 FR 32966). It is unlikely that modification of this habitat would cause the direct mortality of any individual frogs, for four reasons: (1) perennial aquatic habitat where some frogs spend a majority of the year is not burned; (2) prescribed burning would occur typically from May through July, outside the dispersal period, thereby reducing the potential for direct effects on individual California red-legged frog from fire trail grading or burning in upland habitat; (3) most areas are burned annually and the fires do not generate much heat and California red-legged frog, using upland burrows for aestivation, are unlikely to be affected by a low-intensity fire; and (4) the grading of fire trails would occur along existing trails, previously disturbed (Jones and Stokes 2001).

E.2.2.6.1.1.2 Storm Drainage System Maintenance

This activity would occur during the dry season. However, there could be some water remaining in the storm drainage system. Sediment removal would improve frog habitat and thus have a positive effect on the population, but it could also lead to mortality of individual frogs. Therefore, any wet drainages would be inspected by a biologist prior to and during excavation.

E.2.2.6.1.1.3 Culvert Improvement and Installation

These activities at the Oasis, Round Valley, and Lower Elk Ravine locations would have the potential to result in direct mortality of individual frogs. However, because work would be conducted during the dry season, it is unlikely that the replacement and installation of new culverts would directly affect frogs. Mitigation and avoidance measures to further minimize potential for direct effects on the California red-legged frog or its habitat are provided in Section E.2.2.6.1 (Jones and Stokes 2001).

E.2.2.6.1.1.4 Termination of Surface Water Releases

This activity would directly affect the California red-legged frog and its habitat by eliminating the source of water sustaining one wetland where frogs are known to occur (Jones and Stokes 2001).

Affected Site 1: Building 865 Wetland

This artificially created wetland consists of three small pools below culvert outfalls and a 328-foot long wetland. The wetland is choked with cattails (in the foreground of the upper photo in Figure E.2.2.6.1.1.4–1). Pools average 7 feet in diameter; three of the four are known breeding locations for California red-legged frogs. The Site 300 biologist has monitored this pond for 6 years; frogs have been present at the site each year (Jones and Stokes 2001).

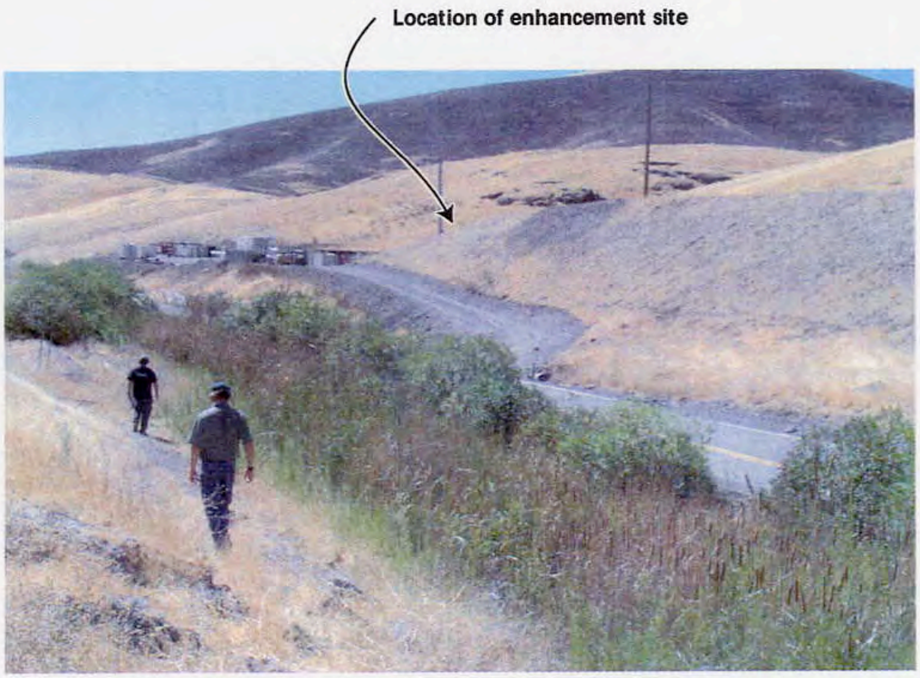
Removal of the artificial water source currently supplied to the Building 865 wetland would affect 0.55 acre of wetland habitat and approximately 0.003 acre of breeding habitat (Jones and Stokes 2001).

Affected Site 2: Building 801 Wetland

This site consists of a small pool and associated wetland. The pool, sparsely vegetated with cattails, is roughly 6.6 feet in diameter with an area of less than 0.001 acre. The wetland, heavily vegetated with cattails, is 0.03 acre in area. Water has been discharged into this wetland for a number of years; however, the pool has only existed since the outfall below the culvert was cleared of vegetation. Although the California red-legged frog does not occur at this site, the pool provides potential breeding habitat for this species. This wetland would continue to be fed by the Building 801 cooling tower; therefore, no net impact would be expected (Jones and Stokes 2001).

Affected Sites 3 and 4: Buildings 851 and 827 Wetlands

The cooling towers at Buildings 851 and 827 have associated wetlands of less than 0.02 acre for both sites. There is no standing water at either of these locations, and neither wetland provides occupied California red-legged frog habitat. The Site 300 biologist has monitored these wetlands consistently for the last 6 years and has never observed a California red-legged frog at either wetland. The termination of water from the two sources would impact low-quality California red-legged frog habitat.



Building 865 Upper Elk Ravine Cooling Tower Wetland (Impact Site)

Sharp Facility Seep (Enhancement Site)

Source: Jones and Stokes 2001.

FIGURE E.2.2.6.1.1.4–1.—*Photographs of Upper Elk Ravine Area (Enhancement and Impact Area)*

E.2.2.6.1.1.5 Construction Related Activities

Under the Proposed Action, construction of the EMPC would result in the disturbance of approximately 40,000 square feet of soil at Site 300. A field reconnaissance of the proposed EMPC site was performed to detect the presence of special status wildlife species and/or their habitats at Site 300. No California red-legged frogs were detected in the proposed construction area (LLNL 2003ag). The construction location would be within the area at Site 300 where the USFWS issued a proposed rule to reinstate formerly designated critical habitat for the California red-legged frog (69 FR 19620, 69 FR 32966).

The proposed EMPC construction would be within the dispersal capability of California red-legged frogs from breeding and nonbreeding areas in the southeastern part of Site 300. Therefore, a pre-activity survey would be conducted prior to the groundbreaking for the EMPC to minimize the potential for incidental take of California red-legged frogs.

E.2.2.6.1.1.6 Decontamination and Demolition of Facilities

It is unlikely that Building 808 decontamination and demolition activities would result in direct mortality of the California red-legged frog unless individuals of this species are present at the project site. However, this facility is located in an upland area that is not typically frequented by California red-legged frogs. The proposed decontamination and demolition would likely have minimal adverse effect on this species. The decontamination and demolition of Building 808 at Site 300 would eliminate approximately 1,500 square feet of developed space after this structure has been demolished and then landscaped for soil retention.

E.2.2.6.1.1.7 Maintenance of Facilities, Paved Roads, and Utilities

The routine maintenance of facilities, paved roads, and utilities at Site 300 would probably not result in direct mortality of California red-legged frogs, because the maintenance of facilities, paved roads, and utilities would be primarily in upland areas, which would pose minimal risk to California red-legged frogs. Additionally, these maintenance activities would be conducted during the daylight hours when this species is not typically active.

E.2.2.6.1.1.8 Landscaping and Grounds Maintenance

Landscaping and grounds maintenance activities at Site 300 would probably not result in direct mortality of California red-legged frogs, because these activities would avoid known wetland breeding areas and associated nonbreeding areas. Additionally, these activities would be conducted during the daylight hours when this species is not typically active.

E.2.2.6.1.1.9 Herbicide Application and Disking

Herbicide application at the Site 300 would be performed primarily to eliminate vegetation along security fences and on the perimeter of some facilities. Preactivity surveys for the presence of sensitive natural resources would be performed prior to disking, and Site 300 maintenance staff would receive training annually on special status species identification and distribution. The Site 300 maintenance staff would follow mitigation measures established by wildlife biologist to protect sensitive wildlife and habitats (e.g., American badger dens) from the potential effects of disking. No known mortality of special status wildlife has occurred as a result of the disking activity during the past 8 years. The perimeter-disking project would proceed only after consultation with a LLNL wildlife biologist (LLNL 2001c).

Herbicides would not be applied to aquatic habitat suitable for California red-legged frog breeding. Prior to late-fall application, ground areas subject to spraying would be assessed by a LLNL wildlife biologist. Also, herbicide projects would proceed only after consultation with the wildlife biologist (LLNL 2001c). California red-legged frog populations were lower in areas downwind from areas where agricultural pesticides are applied (Davidson et al. 2001). Herbicide applications would pose minimal risk provided the formulations are applied in accordance with EPA pesticide label instructions; under conditions with little or no wind to avoid herbicide drift; only to the extent necessary; and in accordance with the additional LLNL safeguards.

E.2.2.6.1.1.10 Invasive Species Control

The occasional removal of feral pigs, a known predator and cause of habitat degradation, would have a beneficial effect on California red-legged frogs. No bullfrogs have been observed at Site 300, so bullfrog control measures have not been required.

E.2.2.6.1.1.11 Ground Squirrel Control

The occasional control of ground squirrels with Fumitoxin (aluminum phosphide) fumigant, traps, or zinc phosphide treated grain bait stations would probably not result in direct mortality of California red-legged frogs, unless conducted in frog habitat. The impact from the application of these rodenticides would be negligible when used in accordance with their EPA pesticide label instructions.

E.2.2.6.1.1.12 Vehicle Traffic

Vehicle traffic at Site 300 could result in mortality of California red-legged frogs found on roads or fire trails. However, the risk is considered low because vehicle traffic at Site 300 would be limited; the majority of traffic would occur during the daylight hours when this species is not typically active; most of the California red-legged frog breeding and nonbreeding areas are in less accessible parts of the site and migrations of this species are infrequent. A large population of California red-legged frogs is in the ATA Building drainage ditches, which are adjacent to a road. There would be some potential for frog-vehicle interaction here, although it would be low because most traffic occurs during the day.

E.2.2.6.1.1.13 Explosive Testing

Explosives testing would probably not result in direct mortality of California red-legged frogs. Additionally, the explosives testing areas are not occur in prime habitat for the California red-legged frog (BioSystems 1986c). Further, explosives testing would be primarily conducted during the daylight hours when this species is not typically active.

E.2.2.6.1.1.14 Explosive Process Water Surface Impoundments and Sewage Oxidation Pond

The California red-legged frog has been observed only at the overflow pond (also referred to as the percolation pond) and not at the sewage oxidation pond (Jones and Stokes 2001, LLNL 2003ab). These ponds provide suboptimal habitat and would not likely adversely affect the California red-legged frog population at Site 300.

E.2.2.6.1.2 Indirect Effects

E.2.2.6.1.2.1 Storm Drainage System Maintenance

Storm drainage system maintenance activities would indirectly benefit the California red-legged frog habitat. Previous drainage maintenance activities at Site 300 involved periodic removal of sediment in catch basins and below culverts. These activities resulted in the creation of deep pools suitable for breeding by the California red-legged frog. The continuation of this maintenance activity would maintain this additional breeding habitat.

Because the Proposed Action activities would not be expected to pose a barrier to movement of frogs during the wet season, no indirect impact to California red-legged frog would be expected (Jones and Stokes 2001).

E.2.2.6.1.2.2 Erosion

Grading of fire trails disturbs sediment that could indirectly affect the California red-legged frog by reducing habitat suitability. During a Site 300 survey in 2002, natural erosion from a fire trail crossing and inadequately designed culvert was noted to have degraded the adjacent aquatic habitat (Wetland 12 in Appendix F of this LLNL SW/SPEIS) and in Lower Draney Canyon. Wetlands in this area no longer have adequate depth to support breeding by the California red-legged frog, although breeding was noted in this area in 1999 (LLNL 2003ab). Erosion from another fire trail is shown in Figure E.2.2.6.1.2.1–1.

Source: LLNL 2003ad.

FIGURE E.2.2.6.1.2.1–1.—*Erosion in Elk Ravine above Building 812*

E.2.2.6.1.3 Mitigation and Avoidance Measures

To protect the California red-legged frog and its habitat, the following avoidance and mitigation measures would be implemented at Site 300 during maintenance activities (Jones and Stokes 2001):

- The loss of breeding habitat for the California red-legged frog at Building 865 would be offset by plans to enhance California red-legged frog habitat onsite (see Section E.2.2.9).
- All storm drainage system maintenance would be performed during the dry season, or when water is not present in the work area. In the four areas scheduled for culvert improvement or installation, a preactivity survey would be conducted within 24 hours of construction. A qualified biologist would be present during construction to examine potential burrow sites within the work zone to determine if they are occupied by the California red-legged frog.
- Prior to fire trail grading, prescribed burning, storm drainage system maintenance, and culvert improvement and installation activities, a qualified biologist would provide worker awareness training to all project personnel. This training would include recognition of California red-legged frog and its habitat.

- Construction personnel and equipment would be confined to designated work areas and approved access roads.
- If the California red-legged frog were encountered during preactivity surveys or during project activities, all work would cease until the frog is removed and relocated or the frog would be temporarily held in a wetted container. Frog collection would be performed by a USFWS-approved biologist.
- Any incidental take would be immediately reported to USFWS at (916) 414-6600.

E.2.2.6.2 *Alameda Whipsnake*

E.2.2.6.2.1 Direct Effects

E.2.2.6.2.1.1 Firetrail Grading

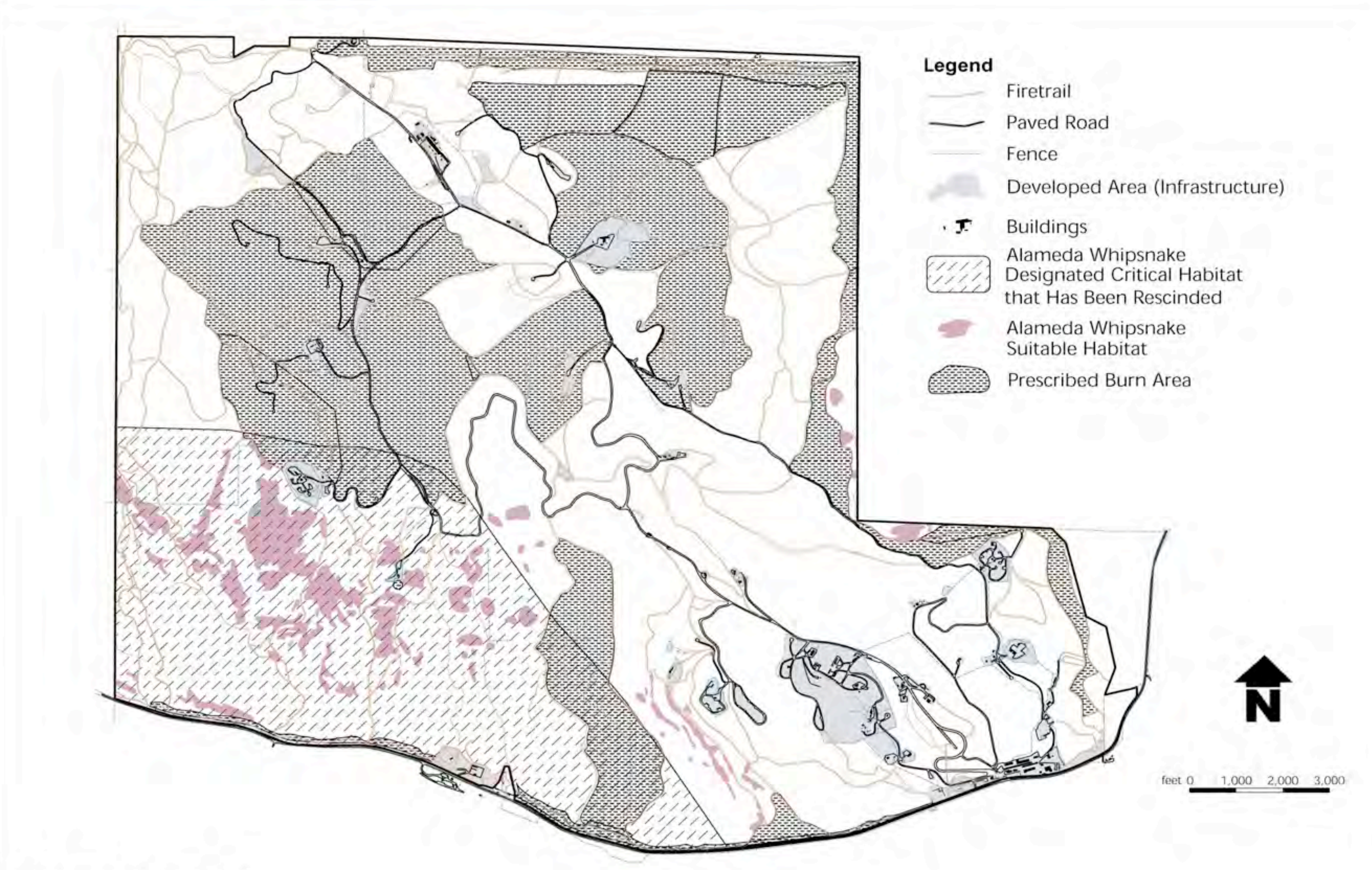
This activity could result in direct mortality of individual snakes from grading equipment during grading. Mitigation measures have been identified to minimize potential for direct impact of this activity on this species (see Section E.2.2.6.2.3) (Jones and Stokes 2001).

E.2.2.6.2.1.2 Storm Drainage System Maintenance, Culvert Improvement/Installation, and Termination of Surface Water Releases

Because these activities would not occur within the Alameda whipsnake habitat, they would not directly affect the Alameda whipsnake or its critical habitat. In addition, there would be no direct effects on the Alameda whipsnake from termination of water supply to the artificially created wetlands at Buildings 865, 801, 851, and 827.

E.2.2.6.2.1.3 Prescribed Burns

Prescribed burns would be anticipated to occur within 400 feet of the nearest edge of sage scrub, the primary constituent habitat elements of the Alameda whipsnake (Figure E.2.2.6.2.1.3–1). At four other locations (along the east boundary), small isolated patches of sage scrub would be close to the burn area boundary, but separated from it by a fire trail. No known fires have encroached on these areas within the past 46 years. Because Alameda whipsnakes are known to use grassland habitat within 400 feet of sage scrub and rock outcrops at Site 300, there would only be a small potential for direct mortality as a result of prescribed burns. No Alameda whipsnake mortality has been observed at Site 300 after a prescribed burn (LLNL 2001a). In addition, because the Alameda whipsnake inhabits fire-dependent communities, the species has probably acquired behavioral adaptations that minimize potential for mortality from fire (Jones and Stokes 2001). A research proposal has been coordinated with the USFWS to investigate, in greater depth, the effects of prescribed burning on the Alameda whipsnake at Site 300 and several other locations (Swaim 2002c). The USFWS has also issued a biological opinion on this project (USFWS 2002a).



Source: Jones and Stokes 2001.

FIGURE E.2.2.6.2.1.3–1.—*Formerly Designated Critical Habitat and Suitable Habitat for the Alameda Whipsnake at Site 300*

E.2.2.6.2.1.4 Construction Related Activities

Under the Proposed Action, construction of the EMPC would result in the disturbance of approximately 40,000 square feet of soil at Site 300. A field reconnaissance of the proposed EMPC site was performed to detect the presence of special status wildlife species and/or their habitats at Site 300. No Alameda whipsnakes were detected in the proposed construction area (LLNL 2003ag). The proposed EMPC site would be some distance from coastal scrub habitat where the Alameda whipsnake has been observed, so it is unlikely that this project would affect this species. The proposed EMPC site is not located in formerly designated critical habitat for the Alameda whipsnake.

E.2.2.6.2.1.5 Decontamination and Demolition of Facilities

It is unlikely that Building 808 decontamination and demolition activities would result in direct mortality of the Alameda whipsnake, because this facility is not located in an area with suitable habitat for this species (see Figure E.2.2.6.2.1.3–1). Therefore, proposed decontamination and demolition would likely have minimal effect on this species. The decontamination and demolition of Building 808 at Site 300 would eliminate approximately 1,500 square feet of developed space after this structure has been demolished and then landscaped for soil retention.

E.2.2.6.2.1.6 Maintenance of Facilities, Paved Roads, and Utilities

The routine maintenance of facilities, paved roads, and utilities at Site 300 would probably not result in direct mortality of the Alameda whipsnake, although a potential for direct impact exists in the southwest portion of the site where suitable habitat for this species exists. Mitigation measures have been identified to minimize the potential for direct effects on the Alameda whipsnake (see Section E.2.2.6.2.3)

E.2.2.6.2.1.7 Landscaping and Grounds Maintenance

Landscaping and grounds maintenance activities at Site 300 would probably not result in direct mortality of the Alameda whipsnake, although a potential for direct impact exists in the southwest portion of the site where suitable habitat for this species exists. Mitigation measures have been identified to minimize the potential for direct effects on the Alameda whipsnake.

E.2.2.6.2.1.8 Herbicide Application and Disking

Herbicide application at the Site 300 would be performed primarily to eliminate vegetation along security fences and on the perimeter of some facilities. Preactivity surveys for the presence of sensitive natural resources would be performed prior to disking, and Site 300 maintenance staff would receive annual training on special status species identification and distribution. The Site 300 maintenance staff would follow mitigation measures established by wildlife biologists to protect sensitive wildlife and habitats from the potential effects of disking. No known mortality of special status wildlife has occurred as a result of the disking activity during the past 8 years. The perimeter-disking project would proceed only after consultation with a LLNL wildlife biologist (LLNL 2001c).

Herbicide formulations would pose minimal risk when applied in accordance with their EPA pesticide labels and under conditions with little or no wind so as to avoid herbicide drift. Herbicides would not be sprayed on habitat suitable for the Alameda whipsnake. Prior to late-Fall application, ground areas subject to spraying would be assessed by LLNL wildlife biologist. Also, herbicide projects would proceed only after consultation with a wildlife biologist (LLNL 2001c).

E.2.2.6.2.1.9 Invasive Species Control

The control of certain invasive plant species during prescribed burns would probably not result in direct mortality of Alameda whipsnakes, as discussed in Section E.2.2.6.2.1.3, Prescribed Burns. The occasional removal of feral pigs, a known predator and cause of habitat degradation has a beneficial effect on Alameda whipsnakes.

E.2.2.6.2.1.10 Ground Squirrel Control

The occasional control of ground squirrels with Fumitoxin (aluminum phosphide) fumigant, traps, or zinc phosphide treated grain bait stations would probably not result in direct mortality of the Alameda whipsnake. The impact from the application of these rodenticides would be anticipated to be negligible when used in accordance with their EPA pesticide label instructions.

E.2.2.6.2.1.11 Vehicle Traffic

Vehicle traffic at Site 300 could result in direct mortality of the Alameda whipsnake. However, the risk is considered low because vehicle traffic at Site 300 would be limited and most of the suitable habitat for the Alameda whipsnake is in less accessible parts of the site.

E.2.2.6.2.1.12 Explosive Testing

Explosives testing would probably not result in direct mortality of the Alameda whipsnake, because the test areas are not in areas with suitable habitat for the Alameda whipsnake.

E.2.2.6.2.1.13 Explosive Process Water Surface Impoundments and Sewage Oxidation Pond

Operation of the explosive process water surface impoundments and sewage oxidation pond would probably not result in direct mortality of the Alameda whipsnake, because they are not located in areas with suitable habitat for this species.

E.2.2.6.2.2 Indirect Effects

Prescribed burning would temporarily alter approximately 385 acres of grassland habitat within the formerly designated critical habitat (USFWS 2002b). No suitable coastal sage scrub habitat for the Alameda whipsnake would be affected. Burning would not take place in any of the coastal sage scrub or rock outcrops or in any grassland closer than 400 feet from primary constituent habitat elements for this species.

There would be no indirect effects on the Alameda whipsnake as a result of termination of surface water releases to the artificially created wetlands or from activities associated with storm drainage system maintenance and culvert improvement/installation. Fire trail grading would not indirectly affect the Alameda whipsnake or whipsnake habitat by creating any barriers to dispersal.

E.2.2.6.2.3 Mitigation and Avoidance Measures

In order to protect the Alameda whipsnake and its habitat during annual burning and grading activities, Site 300 would implement the following mitigation and avoidance measures (Jones and Stokes 2001):

- Prior to fire trail grading and prescribed burning, a qualified biologist would provide worker awareness training to all project personnel; this training would include recognition of the Alameda whipsnake and its habitat.
- If the Alameda whipsnake were encountered during grading, work would cease until the snake is removed and relocated by a USFWS-approved biologist.
- If the Alameda whipsnake were encountered during any project activity, work would cease until the snake is removed and relocated by a USFWS-approved biologist.
- Any incidental take of this species would be immediately reported to USFWS at (916) 414-6600.

E.2.2.6.3 *California Tiger Salamander*

E.2.2.6.3.1 Direct Effects

E.2.2.6.3.1.1 Burning and Fire Trail Grading

Grading of fire trails would be unlikely to result in the direct mortality of individual California tiger salamanders, because this activity would occur during the summer, after individual salamanders have dispersed from breeding pools into upland refugia. Fire trails would be graded along previously disturbed existing trails. Song Pond, a known breeding pool for California tiger salamanders, falls within a prescribed burn area. However, burns would occur during May–July when the California tiger salamander would be below ground, thereby reducing the likelihood of direct effects this activity could have on the California tiger salamander. In addition, because these burns would occur annually and fuel load would be low, impacts associated with this activity would be reduced (Jones and Stokes 2001).

E.2.2.6.3.1.2 Storm Drainage System Maintenance

Storm drainage system maintenance could result in the direct mortality of the California tiger salamander because these activities could occur in perennial drainages. However, because maintenance activities would be conducted in late summer or fall, it is unlikely that the California tiger salamander would occur within the Proposed Action project areas. Mitigation measures described for the California red-legged frog would further reduce potential to directly affect the California tiger salamander (Jones and Stokes 2001).

E.2.2.6.3.1.3 Culvert Improvement and Installation

These activities could result in the direct mortality of the California tiger salamander, because they could occur in areas of ponded water. However, because improvement and installation work would be conducted after the breeding season, it is unlikely that the California tiger salamander would occur within the Proposed Action project areas. Mitigation measures have been identified to further minimize potential for direct effects on the California tiger salamander or its habitat (Jones and Stokes 2001).

E.2.2.6.3.1.4 Termination of Surface Water Releases

The termination of water from Buildings 865, 851, and 827 would not directly affect the California tiger salamander; these artificial wetlands have been monitored by the Site 300 biologist for 6 years and the California tiger salamander has never been identified at these sites.

E.2.2.6.3.1.5 Construction Related Activities

Under the Proposed Action, construction of the EMPC would result in the disturbance of approximately 40,000 square feet of soil at Site 300. A field reconnaissance of the proposed EMPC site was performed to detect the presence of special status wildlife species and/or their habitats at Site 300. No California tiger salamanders were detected in the proposed construction area (LLNL 2003ah). The proposed EMPC construction would be within the dispersal capability of California tiger salamanders from areas in the southeastern part of Site 300 where this species has been observed. Therefore, a pre-activity survey would be conducted prior to the groundbreaking for the EMPC to avoid injury to California tiger salamanders.

E.2.2.6.3.1.6 Decontamination and Demolition of Facilities

It is unlikely that Building 808 decontamination and demolition activities would result in direct mortality of the California tiger salamander unless individuals of this species are present at the project site. However, this facility is in an upland area that is not typically frequented by California tiger salamanders. The proposed decontamination and demolition would likely have minimal adverse effect on this species. The decontamination and demolition of Building 808 at Site 300 would eliminate approximately 1,500 square feet of developed space after this structure has been demolished and then landscaped for soil retention.

E.2.2.6.3.1.7 Maintenance of Facilities, Paved Roads, and Utilities

The routine maintenance of facilities, paved roads, and utilities at Site 300 would probably not result in direct mortality of California tiger salamanders, because the maintenance of facilities, paved roads, and utilities would be primarily in upland areas, which would pose minimal risk to California tiger salamanders. Additionally, these maintenance activities would be conducted during the daylight hours when this species is not typically active.

E.2.2.6.3.1.8 Landscaping and Grounds Maintenance

Landscaping and grounds maintenance activities at Site 300 would probably not result in direct mortality of California tiger salamanders, because these activities avoid known wetland areas inhabited by this species. Additionally, these activities would be conducted during the daylight hours when this species is not typically active.

E.2.2.6.3.1.9 Herbicide Application and Disking

Herbicide application at Site 300 would be performed primarily to eliminate vegetation along security fences and on the perimeter of some facilities. Preactivity surveys for the presence of sensitive natural resources would be performed prior to disking, and Site 300 maintenance staff would receive annual training on special status species identification and distribution. The Site 300 maintenance staff would follow mitigation measures established by a wildlife biologist to protect sensitive wildlife and habitats (e.g., American badger dens) from the potential effects of disking. No known mortality of special status wildlife has occurred as a result of the disking activity during the past 8 years. The perimeter-disking project would proceed only after consultation with a LLNL wildlife biologist (LLNL 2001c).

Herbicides would not be applied on aquatic habitat suitable for California tiger salamander breeding. Prior to late-fall application, ground areas subject to spraying would be assessed by LLNL wildlife biologists. Also, herbicide projects proceed only after consultation with a LLNL wildlife biologist (LLNL 2001c). Herbicide applications should pose minimal risk to the California tiger salamander provided the formulations are applied in accordance with EPA pesticide label instructions; under conditions with little or no wind to avoid herbicide drift; only to the extent necessary; and in accordance with LLNL safeguards.

E.2.2.6.3.1.10 Invasive Species Control

The occasional removal of feral pigs, a known predator and cause of habitat degradation, would have a beneficial effect on California tiger salamanders. No bullfrogs have been observed at Site 300, so bullfrog control measures have not been required.

E.2.2.6.3.1.11 Ground Squirrel Control

The occasional control of ground squirrels with Fumitoxin (aluminum phosphide) fumigant, traps, or zinc phosphide treated grain bait stations would probably not result in direct mortality of California tiger salamanders unless conducted in California tiger salamander habitat. The impact from the application of these rodenticides would be negligible when they are used in accordance with their EPA pesticide label instructions.

E.2.2.6.3.1.12 Vehicle Traffic

Vehicle traffic at Site 300 could to result in mortality of California tiger salamanders found on roads or fire trails. However, the risk is considered low because vehicle traffic at Site 300 would be limited . . . ; the majority of traffic would occur during the daylight hours when this species is not typically active; and migrations of this species are infrequent.

E.2.2.6.3.1.13 Explosive Testing

Explosives testing would probably not result in mortality of California tiger salamanders as the explosives testing areas are not in prime habitat for the California tiger salamander (BioSystems

1986c). Further, explosives testing would be primarily conducted during the daylight hours when this species is not typically active.

E.2.2.6.3.1.14 Explosive Process Water Surface Impoundments and Sewage Oxidation Pond

The California tiger salamander has been observed at the overflow pond (also referred to as the percolation pond) only, and not at the sewage oxidation pond. This species has also been observed at the explosives process water surface impoundments (Jones and Stokes 2001, LLNL 2003ab). These ponds provide suboptimal habitat and would not likely adversely affect the California tiger salamander population at Site 300.

E.2.2.6.3.2 Indirect Effects

Fire trail grading would disturb sediment that could result in an indirect negative impact on the California tiger salamander by reducing habitat suitability. Storm drainage system maintenance would create deep pools, enhancing the California tiger salamander breeding habitat. There would be no indirect effect on this species as a result of prescribed burning, and the prescribed burning would not likely pose a barrier to movement of salamanders during the wet season (Jones and Stokes 2001).

E.2.2.6.3.3 Mitigation and Avoidance Measures

To protect the California tiger salamander and its habitat, Site 300 would implement the same avoidance and mitigation measures discussed for the California red-legged frog (Jones and Stokes 2001).

E.2.2.7 *Interrelated Actions*

Interrelated actions are part of a larger action and dependent upon the larger action for their justification. The Proposed Action operations would not be part of a larger project or plan, although a research project has been coordinated with the USFWS to evaluate the effects of prescribed burns on the Alameda whipsnake at several locations, including Site 300, as discussed in Section E.2.2.6.2.1.3, Prescribed Burns (Swaim 2002c). The USFWS has already issued a separate biological opinion on this research project that is including Site 300 as one of its study locations (USFWS 2002d). There would be no interrelated effects on listed species within the project area with the exception of the Alameda whipsnake investigation.

E.2.2.8 *Cumulative Effects*

The Proposed Action activities at Site 300 would not result in cumulative effects. Typically, cumulative effects under the *Endangered Species Act* would include all future actions "reasonably certain to occur" within the action area. There are no known additional future activities planned at Site 300 that would contribute to cumulative effects on listed species covered in this biological assessment (Jones and Stokes 2001). The incremental effect of the Proposed Action on biological resources within the area would be positive, particularly in the long term, when taken in the context of continuing conversion of wildlife habitat for agricultural, residential, commercial, and industrial use in the vicinity of Site 300.

E.2.2.9 *Conservation and Mitigation*

One of the Proposed Action projects would remove a maximum of 0.62 acre of wetland habitat, of which the California red-legged frog occupies only 0.55 acre (Table E.2.2.5.5–1). Of the 0.55 acre, 0.003 acre of occupied California red-legged frog breeding habitat would be affected. Approximately 0.07 acre of unoccupied wetland habitat would also be affected (wetlands at Buildings 801, 827, and 851). NNSA proposes to mitigate for the 0.62-acre artificial wetland removed by protecting and enhancing selected areas, and increasing breeding opportunities for the California red-legged frog and the California tiger salamander in areas where breeding habitat is limited or nonexistent. These designated areas would be managed and protected for the California red-legged frog and the California tiger salamander. A minimum of 1.86 acres of wetland habitat would be enhanced and protected for the California red-legged frog and the California tiger salamander. Three mitigation sites for potential enhancement are described in detail below.

E.2.2.9.1 *Potential Enhancement Sites*

E.2.2.9.1.1 Oasis Canyon Wetland

The Oasis Canyon wetland, comprising 1.16 acres (see Figure A-l in Appendix A), originates at an abandoned inclined mine shaft seep. In 2001, this wetland was observed to have high-quality breeding and nonbreeding habitat that would be managed (e.g., invasive species control) and protected as a natural drainage in perpetuity for the California red-legged frog (Jones and Stokes 2001). However, no breeding was noted in 2002 at this location due to sedimentation (LLNL 2003ab).

E.2.2.9.1.2 Mid Elk Ravine

Mid Elk Ravine, comprising approximately 1.6 acres, is a perennial drainage vegetated with mature willows, oaks, and cattails. LLNL biologists have conducted frog surveys in this drainage since 1996. Nonbreeding California red-legged frogs have been observed in the drainage, but no breeding frogs have been detected in this drainage during surveys. The drainage lacks pooled water areas of sufficient depth to provide suitable breeding habitat.

Enhancement of this drainage by creating one or more ponds in selected areas would increase suitable habitat for breeding frogs in an area where such habitat is limited. The site would allow breeding ponds of about 0.15 acre.

E.2.2.9.1.3 SHARP Facility Seep

A perennial 0.08-acre seep located in the upper Elk Ravine watershed is one of the proposed enhancement areas for the California red-legged frog and the California tiger salamander. The seep is approximately 328 feet west of Building 865 and is currently surrounded by the remains of a concrete structure. Due to close proximity to the Building 865 wetland (occupied by the California red-legged frog), the SHARP Facility seep could provide an important breeding site for the California red-legged frog. Figure E.2.2.6.1.1.4–1 shows the SHARP Facility enhancement area. At peak capacity, the enhancement area would sustain a pond up to 0.07 acre in area with a maximum depth of approximately 4 to 6 feet. The proposed enhancement of this seep would be conducted prior to the termination of the supplied water to the Building 865 wetland.

E.2.2.9.2 *Creation of Breeding Habitat*

The proposed preservation and management activities are intended to compensate primarily for impacts on 0.55 acre of artificial wetland, part of which provides dispersal and foraging habitat for the California red-legged frog and the California tiger salamander. The first component of these mitigation actions would involve the establishment of a 1.86-acre mitigation area consisting of existing riparian and wetland resources that provide equal or greater habitat value than the affected wetlands. NNSA would permanently set aside this area for the protection and management of the California red-legged frog.

The second component would involve the creation of a minimum of 0.01 acre of breeding habitat at two distinct locations in Site 300. The main goal of this approach is to compensate for impacts on artificial breeding pools by creating pools of equal or greater habitat quality. The two components of the proposed California red-legged frog and the California tiger salamander mitigation actions are summarized in Table E.2.2.5.5–1 and described in detail in the following sections.

Biologists and hydrologists selected two locations in the Elk Ravine watershed for the creation of breeding ponds and associated semipermanent marshes. The two sites will be referred to as the SHARP Facility and Mid Elk Ravine mitigation sites. They were selected largely because the topography and hydrologic conditions at both sites are highly suitable for pond and marsh creation. A general description of existing environmental conditions at each site and a general description of the proposed mitigation approach and associated construction methods are provided below (Jones and Stokes 2001).

E.2.2.9.2.1 The SHARP Facility

The SHARP Facility is located near the headwaters of Elk Ravine on the opposite side of the road from Building 865 (Figure E.2.2.6.1.1.4–1). The seep and surrounding area consist of the lower half of a small, ephemeral drainage trending east-west. This drainage way was altered during the early 1990s when the facility was constructed (Jones and Stokes 2001).

During the late 1990s, a perennial groundwater seep developed, which now surfaces along the northwestern embankment. This seep is associated with subsurface drainage from the west side of Site 300 and, therefore, was sampled for tritium contamination. Low concentrations of tritium, below drinking water standards, have been detected in this water. The exact rate of flow from the seep is unknown, but was estimated to range from 0.25 to 1 gallon per minute during August 2001. This estimate is expected to be representative of flow rates during the summer months, but flow rates may vary considerably throughout the year. Water emanating from the seep flows in a thin stream along the northern embankment of the drainageway, where it currently supports a small community of cattails, willows, nettles, and other riparian and wetland vegetation. Water from the seep and the surrounding watershed exits the site through a culvert that drains into upper Elk Ravine, just downstream from Building 865. California red-legged frogs have been found using this area; however, the habitat does not contain the proper characteristics for California red-legged frog breeding (Jones and Stokes 2001).

The SHARP Facility drains approximately 25 acres of steep annual grasslands that are underlain almost entirely by the moderately coarse- and medium-textured Entisols of the Wisflat, San Timoteo, and Arburua series. These soils are, in turn, underlain by weathered sandstone and siltstone at depths ranging from 10 to 31 inches. Mean annual precipitation at Site 300 is approximately 10 to 11 inches, with 90 percent of the precipitation occurring as rainfall between November and April. Mean annual reference evapotranspiration for the nearby town of Tracy is 4 inches per month, ranging from a low of 0.7 inch per month in December to a high of 7.9 inches per month in July. The seep does not currently support a breeding population of California red-legged frogs or California tiger salamanders due to the lack of pooled water areas (Jones and Stokes 2001).

The general mitigation approach, construction method, and maintenance procedures for the SHARP Facility breeding pond were addressed in a recent biological assessment and related biological opinion (Jones and Stokes 2001, USFWS 2002b).

E.2.2.9.2.2 Mid Elk Ravine Site

The Mid Elk Ravine site, located immediately south of Building Complex 812, consists of a 200-foot reach of the main channel of Elk Ravine and a section of moderate-to-steep slopes that abut the channel on either side. Most of Elk Ravine is intermittent drainageway, but a perennial seep located approximately 1,200 feet upstream of the site provides a constant, low-volume flow of water, estimated to range from 5 to 10 gallons per minute. This estimate is probably representative of the average flow rate during the summer months, but the rate may vary considerably throughout the year. The seep supports a continuous stand of riparian and wetland vegetation extending several thousand feet downstream from its source.

The subject reach of the Elk Ravine channel is 3 to 7 feet wide and 3 to 8 feet deep, with a gradient of approximately 3 to 5 percent. The channel supports a thick stand of cattails and fewer numbers of associated hydrophytic species. The bed of the channel consists primarily of fine sands, silts, and clays trapped by the cattails. The soil survey of San Joaquin County indicates that the hill slope that bounds the western side of the channel is occupied by soils of the Alo and Vaqueros series, while the hill slope that bounds the eastern side of the project reach is underlain by soils of the Wisflat, Arburua, and San Timoteo series. As described above, the soils of the Wisflat, Arburua, and San Timoteo series are shallow, medium-textured Entisols underlain by sandstone and siltstone bedrock at depths ranging from 10 to 30 inches. Soils of the Alo and Vaqueros series are moderately deep, Vertisols (i.e., expansive clay soils) underlain by shale at depths of 30 inches to more than 6 feet.

The subject reach of Elk Ravine drains a 1,470-acre watershed that consists almost entirely of steep annual grasslands underlain by soils of the Wisflat, Arburua, San Timoteo, Alo, and Vaqueros series. Impervious surfaces, such as roads, buildings, parking lots, and staging areas comprise an estimated 0.5 percent of the watershed. Precipitation and evapotranspiration characteristics for the Mid Elk Ravine site are identical to those described above for the SHARP Facility (Jones and Stokes 2001).

The general mitigation approach, construction method, and maintenance procedures for the Mid Elk Ravine breeding habitat site were addressed in a recent biological assessment and related biological opinion (Jones and Stokes 2001, USFWS 2002b).

E.2.2.10 *Compensation and Set-Asides*

E.2.2.10.1 *Alameda Whipsnake*

Mitigation measures for impacts on the Alameda whipsnakes would include participation in a 5-year study on the effects of burning on this species. Site 300 has agreed to support and participate in a study proposed by the USFWS Recovery Program on the potential effects of prescribed burns on the Alameda whipsnake (Jones and Stokes 2001).

E.2.2.10.2 *California Red-Legged Frog*

Mitigation for impacts on California red-legged frog habitat would include monitoring the enhancement areas annually for 5 years and semi-annually for the next 5 years to determine whether the ponds are functioning as intended and to determine whether invasive bullfrogs have colonized the enhancement sites. Monitoring would involve spring surveys for the California red-legged frog. If bullfrogs were discovered at the site, the Site 300 biologist would make the necessary effort to remove adults and larvae.

A 5-year report would be prepared and submitted to USFWS. This report would document the results of annual surveys in enhancement areas and evaluate the success of the proposed mitigation plan (Jones and Stokes 2001).

E.2.2.11 *Contingency Plan*

If, after 10 years, the proposed enhancement pond mitigation action were not effective, the Site 300 biologist would discuss the results with USFWS.

E.2.2.12 *Conference*

As noted in Section E.2.2.5.5, a preliminary survey was conducted for the proposed EMPC in March 2003 without detecting any protected or sensitive species. NNSA would like to request a conference with the USFWS to discuss: (a) any plans that the USFWS may have to redesignate critical habitat for the California red-legged frog in the vicinity of the proposed EMPC site at Site 300; and (b) any measures required to address the California tiger salamander at Site 300 associated with the recent elevation of the status of this species from proposed threatened to threatened (69 FR 47212).

E.2.2.13 *Conclusion and Determination*

With implementation of proposed avoidance, conservation, and mitigation measures, the Proposed Action activities may affect (but are not likely to adversely affect) the Alameda whipsnake, California tiger salamander, and California red-legged frog.

Fire trail grading may indirectly affect the California red-legged frog and California tiger salamander; however, mitigation measures would minimize the potential impact. The Alameda whipsnake may be affected by this activity; however, pre-activity surveys would minimize the potential for incidental take.

Storm drainage system maintenance is likely to provide a long-term, indirect benefit to California red-legged frog and California tiger salamander habitat by creating pools and enhancing breeding habitat. Direct effects would be minimized through implementation of pre-activity surveys. This activity would have no effect on the Alameda whipsnake.

Culvert improvement and installation may affect (but are not likely to adversely affect) the California red-legged frog and California tiger salamander. Direct effects would be mitigated through the implementation of avoidance and mitigation measures. There would be no effect on the Alameda whipsnake as a result of this activity.

The proposed burning of grassland in formerly designated Alameda whipsnake critical habitat may affect (but is not likely to adversely affect) the Alameda whipsnake. The impacts on the Alameda whipsnake associated with annual prescribed burning in grassland habitat are unknown. Future conservation of this species would be fostered through a research project conducted by NNSA that would address this impact.

The termination of surface water release may affect the California red-legged frog. NNSA would mitigate for the loss of 0.62 acre of artificial wetlands through the permanent protection and enhancement of a minimum of 1.86 acres of natural wetland habitat. This habitat would be managed and protected for the continued recovery of the California red-legged frog.

Construction-related projects such as the proposed EMPC at Site 300 may affect (but are not likely to adversely affect) the California red-legged frog and California tiger salamander. These species were not observed during a field reconnaissance of the proposed construction site in an upland location. Direct effects would be minimized through implementation of a pre-construction survey. There would be no effect on the Alameda whipsnake.

Demolition of facilities would eliminate approximately 1,500 square feet of developed space, after this structure has been demolished and then landscaped for soil retention. Building 808 is not in an area with suitable habitat for the Alameda whipsnake, so its demolition would have no effect on that species.

Maintenance of facilities, paved roads, and utilities may affect (but are not likely to adversely affect) the California red-legged frog, California tiger salamander, and Alameda whipsnake. These operations would occur primarily within the developed part of Site 300, be representing less than 5 percent of the total site acreage. Maintenance activities would be routinely reviewed by LLNL wildlife biologists to minimize the potential for direct effects on these species.

Landscaping and grounds maintenance may affect (but are not likely to adversely affect) the California red-legged frog, California tiger salamander, and Alameda whipsnake. Since the landscaping and grounds maintenance activities would avoid known wetland breeding areas and associated nonbreeding areas, these activities would pose a minimal risk to California red-legged frogs and California tiger salamanders. The impact of these activities on the Alameda whipsnake would likely be minimal due the relatively small amount of suitable habitat for this reptile at Site 300, with much of it not subject to typical landscaping and grounds maintenance.

Herbicide applications may affect (but are not likely to adversely affect) the California red-legged frog, California tiger salamander, and Alameda whipsnake. Herbicides would likely have minimal impact on these three species when used in accordance with their EPA pesticide label instructions. Also, herbicide projects would proceed only after consultation with a LLNL wildlife biologist.

Ground squirrel control is not likely to affect the California red-legged frog and California tiger salamander since there is presently no active ground squirrel control program anywhere at Site 300. Control is done on an as needed basis using rodenticides in accordance with EPA pesticide label instructions. Ground squirrel control at the surface impoundment would not have an effect on the Alameda whipsnake.

Vehicle traffic may affect (but is not likely to adversely affect) the California red-legged frog, California tiger salamander, and Alameda whipsnake. However, the potential for impact would be reduced because the majority of traffic would occur during the daylight hours when adults of this species are not typically active; most of the California red-legged frog breeding and nonbreeding areas would be in less accessible parts of the site; and migrations of this species are infrequent. The impact of vehicle traffic on the Alameda whipsnake would likely be minimal due the relatively small amount of suitable habitat for this reptile and its unsuitability for most vehicles.

Explosive testing may affect (but is not likely to adversely affect) the California red-legged frog and California tiger salamander. However, the explosive testing sites are in areas that provide suboptimal habitat for these species. Explosive testing would have no effect on the Alameda whipsnake since these sites are not in areas with suitable habitat for this species.

The sewage oxidation pond may affect (but is not likely to adversely affect) the California red-legged frog and California tiger salamander. These two amphibians have been observed at the overflow pond only and not at the sewage oxidation pond. Further, the pond provides suboptimal habitat for these species.

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SPECIES ACCOUNTS

San Joaquin Kit Fox (*Vulpes macrotis mutica*)

The San Joaquin kit fox is the smallest fox in North America, standing 9 to 12 inches at the shoulder (USFWS 2003a). An adult fox has a body length of approximately 20 inches and a tail length of approximately 12 inches, with relatively long legs and large ears and a slender build. The males weigh about 5 pounds, and females slightly less (4.6 pounds) (CDFG 2000). San Joaquin kit fox fur is tan during the summer and silver-gray in the winter. The tip of the tail is black (Brown et al. 1997).

Status

The San Joaquin kit fox was listed as endangered under the *Endangered Species Act* of 1967 and threatened in the State of California in 1971 (USFWS 2003a).

Threats

The most important threats to San Joaquin kit fox populations are habitat loss and fragmentation, reduction of prey populations through rodent control programs, and use of pesticides and rodenticides (USFWS 1998). Other carnivores may compete with and predate on San Joaquin kit fox, including native species such as the coyote (*Canis latrans)* and bobcat (*Felis rufus*) and nonnative species such as red fox *(Vulpes vulpes)* and domestic dogs (*Canis familiaris*) (USFWS 1998).

Range, Habitat, and Life History

Range: Prior to 1930, the San Joaquin kit fox prior to 1930 ranged over most of the San Joaquin Valley from southern Kern County north to eastern Contra Costa County and eastern Stanislaus County (Grinnell et al. 1937, Brown et al. 1997, USFWS 1998). No recent extensive surveys have been conducted in the historical range. However, based on small-scale surveys and sightings, kit fox are thought to inhabit suitable habitat in the San Joaquin Valley and surrounding foothills and the Sierra Nevada and Tehachapi mountains. Kit fox have been found in Kern, Tulare, Kings, Fresno, Madera, San Benito, Merced, Stanislaus, San Joaquin, Alameda, and Contra Costa counties. They are also known from Monterey, San Benito, San Luis Obispo, Ventura, Santa Barbara, San Luis Obispo, and possibly Santa Clara counties (USFWS 1998). Observations of San Joaquin kit fox in the 1980s and early 1990s are known from areas near Site 300, including the Carnegie New Town in northwestern San Joaquin county and Midway Substation on the San Joaquin and Alameda counties border, Bethany Reservoir, and Los Vaqueros Reservoir/Altamont Pass area (Orloff et al. 1986, Sproul and Flett 1993). Additionally, a kit fox has been observed at Brushy Peak north of the Livermore Site.

Habitat: San Joaquin kit foxes use grassland and scrubland, oak woodland, alkali sink scrubland, vernal pool, and alkali meadow communities. San Joaquin kit fox dig dens for temperature regulation, shelter, reproduction, and escape from predators (USFWS 1998). They may dig their own dens or modify dens constructed by other species such as ground squirrels, badgers, and coyotes (Morrell 1972, Berry et al. 1987). Loose-textured soils are preferred for den construction. San Joaquin kit fox may also use human-made structures such as culverts, pipelines, and banks in sumps or roadbeds (USFWS 1998). Home ranges vary from 1 square mile to approximately 12 square miles, depending on prey abundance (Morrell 1972, USFWS 1998).

Life History: San Joaquin kit fox are primarily nocturnal but can also be seen during the day on occasion, and are active throughout the year. Kit fox feed on small mammals, birds, insects, and vegetation. Common prey items include California ground squirrels, harvest and pocket mice, kangaroo rats, Jerusalem crickets, and black-tailed hares (Orloff et al. 1986, USFWS 1998). Kit foxes reach sexual maturity at one year of age, but may not breed their fist year of adulthood (Morrell 1972). Pairs usually remain together all year, although they may not occupy the same den (USFWS 1998). Female kit foxes begin preparing a natal pupping den in September and October. Mating occurs between December and March. Gestation takes between 48 to 52 days, and litters are usually born in February and March (Morrell 1972, USFWS 1998). Litters generally consist of two to six pups. Pups emerge aboveground at around one month of age, and disperse after 4 to 5 months, usually in August or September. Reproductive success depends on abundance of prey (USFWS 1998). Drought may lead to low reproductive success by reducing prey abundance. Kit foxes may live up to 10 years, but generally do not live that long in the wild, as adult mortality is high. Adult mortality may be as high as 50 percent, and juvenile mortality may be around 70 percent (Berry et al. 1987). Predation by larger carnivores such as coyote may account for the majority of kit fox mortality (USFWS 1998).

Large-Flowered Fiddleneck (*Amsinckia grandiflora*)

Status

Large-flowered fiddleneck *(Amsinckia grandiflora)* was federally listed as endangered in 1985. On May 8, 1985, 160 acres of Site 300 surrounding the native large-flowered fiddleneck population in the Drop Tower Canyon, was designated critical habitat by the United States Fish and Wildlife Service (USFWS). In 1997, the USFWS published the final recovery plan for the species (USFWS 1997). On April 28, 2000, the Secretary of the United States Department of Energy established the *Amsinckia grandiflora* reserve on the 160 acres of critical habitat and signed a memorandum of agreement with the USFWS, describing technical services, management, and access to the reserve (USDOE 2000).

Range, Habitat, and Life History

Large-flowered fiddleneck (Gray) Kleeb. ex Greene (Boraginaceae), is a rare annual forb native to the California winter annual grasslands. Large-flowered fiddleneck has been recently known from only three natural populations containing individuals numbering from fewer than 30 to several thousand. All natural populations occur on steep, well-drained, north-facing slopes in the Altamont Hills of the Diablo range, about 19 miles southeast of San Francisco, California. The populations occur at low elevations, approximately 950 feet, and border on blue oak woodland and coastal sage scrub communities. Two of the natural populations occur on Site 300, a high-explosive testing facility operated by the University of California for the United States Department of Energy. The two natural populations at Site 300 are known as the Drop Tower population and the Draney Canyon population. Located in the north/southwest-trending Drop Tower Canyon, the Drop Tower population is the larger of the two populations at Site 300 and was the only known population of large-flowered fiddleneck up through 1987. In 1987, the Draney Canyon population was discovered in a north/southwest-trending canyon west of the Drop Tower Canyon. This population is now believed to have been eliminated. In 1993, a large large-flowered fiddleneck population, known as the Carnegie Canyon population, was discovered on private rangelands near the southeast border of Site 300.

Attempts at establishing two experimental populations have also occurred near Site 300. An ecological reserve, owned by the California Department of Fish and Game (CDFG), is located adjacent to the southeast border of Site 300. An attempt was made to establish an experimental population of large-flowered fiddleneck at this site (known in Pavlik 1994 as the Corral Hollow population), but no reproductive plants have been observed at this site in recent years, suggesting the establishment was not successful. A second experimental population was attempted at the Connolly Ranch, a privately owned ranch near the southwest border of Site 300. This attempt failed, paossibly as a result of extremely high rodent activity (Pavlik 1994).

Restoration efforts began in 1988 by researchers from Mills College. These efforts focused on determining the factors necessary for the successful establishment of additional populations of large-flowered fiddleneck (Pavlik 1988a, 1988b) and have resulted in the establishment of at least one apparently successful experimental population at Lougher Ridge in the Black Diamond Mines East Bay Regional Park (Pavlik 1994). Between 1993 and 1995, using funds obtained through a grant from LLNL's Laboratory Directed Research and Development Program, LLNL researchers teamed with researchers from Mills College to further investigate the causes of large-flowered fiddleneck rarity and to establish an additional population at Site 300. The experimental population was established near the Drop Tower native population on a north-facing slope on the eastern fork of the Drop Tower Canyon where it splits in two around the Drop Tower facility parking lot. This population is known as the Drop Tower experimental population.

Research on the Drop Tower experimental population, the Lougher Ridge experimental population, and data from management of the Drop Tower natural population indicated that competition from exotic annual grasses was contributing to the decline of *A. grandiflora.* In addition, long-term management proved necessary to reduce exotic annual grass cover and restore and maintain the native perennial bunch grass community to ensure the persistence of this species (Pavlik et al. 1993, Pavlik 1994, Carlsen et al. 2000). Long-term financial support is being provided through LLNL Site 300 management.

The goal of the ongoing management of the Site 300 large-flowered fiddleneck populations is to control the cover of exotic annual grasses while developing techniques to restore native perennial grasslands (Carlsen et al. 2003). The use of controlled burning is being investigated as a tool for developing and maintaining perennial grasslands. Finally, the impact of seed predation is being investigated to determine its impact on the population dynamics of *A. grandiflora*.

The low numbers of large-flowered fiddleneck plants observed over the past several years at Site 300 have also been observed in other existing natural and experimental populations of the fiddleneck throughout its existing range. Encroachment of bush lupine (*Lupinus albifrons*) has been observed both at the native population at Site 300 and the experimental population at Lougher Ridge. A significant level of spring and summer seed predation has been observed at the Site 300 experimental population, although its magnitude does not appear to correlate with plant establishment the following year. To enhance the experimental population at Site 300 and Lougher Ridge, LLNL began a rapid seedbank enhancement project in October 2003 with funding provided by the United States Bureau of Reclamation.

Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus*)

The valley elderberry longhorn beetle is a stout-bodied beetle with long antennae. Males range from 1/2 to 1 inch in length and have antennae as long as their bodies. Females are slightly larger, ranging from 3/4 to 1 inch, with shorter antennae. Adult males have red-orange wing covers with four elongated dark spots, while females have dark colored wing covers (USFWS 1999a).

Status

The valley elderberry longhorn beetle was listed in 1980 as threatened under the United States *Endangered Species Act* (USFWS 1999a).

Threats

The primary threats to valley elderberry longhorn beetles are habitat loss (destruction of riparian forests and associated elderberry trees), invasive insect species such as the Argentine ant, and insecticide and herbicide use. Activities that threaten individual beetles include dewatering or flooding, pesticide application, trimming of plants, and ant invasions (Huxel 2000, Collinge et al. 2001).

Range, Habitat, and Life History

Range: The valley elderberry longhorn beetle is found in the Central Valley of California from Shasta County in the north to Kern County in the south (Barr 1991) and east into the foothills of the Sierra Nevada (Arnold 2002). Adult valley longhorn elderberry beetles have been observed at Site 300 and at the neighboring CDFG site southeast of Site 300 (Arnold 2002).

Habitat: Valley elderberry longhorn beetles use riparian forests and adjacent upland habitats (USFWS 1999a). They are primarily associated with elderberry (*Sambucus* species) trees and shrubs (Arnold 2002, USFWS 1999b). The beetle requires elderberry shrubs with a basal diameter greater than 1 inch (Barr 1991).

Life History: In the spring (April/May), female valley elderberry longhorn beetles lay eggs in crevices in the bark of living elderberry plants. Eggs hatch in a few days and the larvae bore into the pith of the elderberry stem, trunk, or roots (Arnold 2002). The larvae feed on the pith until metamorphosis, which occurs one to two years after hatching (Arnold 2002). Prior to metamorphosis, the larvae chew an exit hole in the trunk of the elderberry, anywhere from ground level to 25 feet or more (Barr 1991). The exit holes are generally between 0.15 and 0.4 inches in diameter. Adults emerge when the host plant begins to flower (Barr 1991). Adult elderberry beetles appear to feed on elderberry flowers and foliage (Arnold 2002). Elderberry beetles are not strong fliers, tend not to leave their host plant, and do not seem to disperse between drainages (Collinge et al. 2001).

California Red-Legged Frog (*Rana aurora draytonii)*

The California red-legged frog is a large frog, reaching up to 5.5 inches from snout to vent in length, with a prominent dorsolateral fold. It is predominantly brown to reddish brown, with moderate-sized dark brown to black spots that sometimes have light centers (Jennings and Hayes 1994). It often has red to orange coloration to the belly and undersurfaces of the thighs, legs, and feet. However, distribution of the red coloration is highly variable. Some individuals have red pigment extending over all undersurfaces and upper surfaces of the body; other individuals lack red pigment entirely or have it restricted to the feet (Jennings and Hayes 1994). There is a whitish stripe along the jaw (Stebbins 2003).

Status

The California red-legged frog was listed in 1996 as threatened under the *Endangered Species Act* (61 FR 25813). Critical habitat was designated for the California red-legged frog in March 2001, although most was rescinded due to a court decision in 2003(USFWS 2002a). In April 2004, the USFWS re-proposed to designate critical for this species in compliance with a court order (69 FR 19620).

Range, Habitat, and Life History

Range: The current range of the California red-legged frog includes Pacific slope drainages from Napa and Sonoma counties to Baja California. Isolated populations are also found in the Sierra Nevada foothills north of Sacramento (USFWS 2002b). Historically, the California red-legged frog was known from 46 counties but now has been eliminated from 24 of these (61 FR 25813). The California red-legged frog is found at both Site 300 and at the Livermore Site (van Hattem 2003a).

Habitat: The California red-legged frog is found in a variety of aquatic, riparian, and upland habitats in areas below 4,900 feet. Aquatic systems used by California red-legged frogs include dune swales, ephemeral ponds, intermittent streams, seasonal wetlands, springs, seeps, permanent ponds, perennial creeks, man-made ponds, and virtually any aquatic system that is in close proximity to some permanent water source (USFWS 2001, 2002b). California red-legged frogs have been observed in streams up to 2 miles from breeding habitat and in riparian vegetation adjacent to streams (USFWS 2002b). In heavily grazed areas, adult California red-legged frogs often are observed hundreds of feet from breeding ponds, presumably foraging, seeking appropriate microhabitats or dispersing (van Hattem 2003). California red-legged frogs often use California ground squirrel burrows, deep desiccation cracks, or woody vegetation as thermal refuge during both dry and cold periods of the year. Breeding adults are frequently associated with relatively deep, greater than 2 feet, slow-moving water in areas of dense riparian vegetation, although breeding frogs are found in areas without dense emergent or riparian vegetation in water depths less than 2 feet (USFWS 2001, 2002b).

Life History: Adult California red-legged frogs have a variable diet including invertebrates, small mammals, and other amphibians (Arnold and Halliday 1986, Hayes and Tennant 1986). Larvae are thought to be algae eaters (Jennings and Hayes 1994). California red-legged frogs can complete their entire life cycle in one pond or use a mosaic of habitat types (USFWS 2001). The breeding period for California red-legged frogs is from late November to late April, although most frogs lay their eggs in March (Jennings and Hayes 1994, USFWS 2002b). Emergent vegetation, twigs, and roots are typically used for oviposition sites. Eggs develop into larvae in 20 to 22 days. Although over-wintering tadpoles have been observed in some areas, tadpoles typically develop into frogs in 11 to 20 weeks (USFWS 2002b). During periods of wet weather, California red-legged frogs can move over upland habitats to other aquatic habitats. During dry periods, California red-legged frogs can disperse from breeding habitat to forage or to seek summer habitat in response to declining water levels. A radio-tagged California red-legged frog in the Guadalupe Dunes of California was observed to move approximately 1.75 miles through upland and aquatic habitats over the course of a wet season (Rathbun and Schneider 2001). The California red-legged frog recovery plan (USFWS 2002b) describes unpublished research conducted in Santa Cruz County indicating that California red-legged frogs traveled distances of 0.25 to 2 miles without regard to topography, vegetation type, or riparian corridors.

Alameda Whipsnake (*Masticophis lateralis euryxanthus*)

The Alameda whipsnake is a slender, fast moving snake with a narrow neck and a relatively broad head with large eyes (Swaim 2002). Its dorsal side is sooty black, with yellow-orange dorso-lateral stripes. The anterior portion of the underside is orange to rufus (Stebbins 2003, Swaim 2002). Adult snakes reach up to 5 feet in length (Swaim 2002).

Status

The Alameda whipsnake was listed in 1997 as threatened under the *Endangered Species Act* and threatened in the State of California in 1971 (USFWS 2003c).

Threats

The main threats to the Alameda whipsnake are habitat alteration such as loss of chaparral and coastal sage scrub and fire suppression, which allows vegetation to overgrow its preferred open habitat. Habitat fragmentation has lead to isolation of populations (USFWS 2003c).

Range, Habitat, and Life History

Range: Alameda whipsnakes are found in the inner coast range in western and central Contra Costa and Alameda counties (USFWS 2003). The Alameda whipsnake is found at Site 300 (Swaim 2002).

Habitat: Alameda whipsnakes are found in chaparral, sage scrub, northern coyote brush scrub, and riparian scrub (Swaim 2002). They also use grasslands and oak woodlands adjacent to scrub habitats (Swaim 1994). Rocky outcrops appear to be important to the whipsnake as a source of cover and increased density of prey items such as lizards (Stebbins 1985, Swaim 1994).

Life History: Alameda whipsnakes are active during the day, during spring and summer. In the winter and early spring (November – March), they often remain in a hibernaculum (shelter), although they may be active for short periods of time (USFWS 2003). Mating occurs in late March through mid-June. Little is known about oviposition sites. Whipsnakes feed primarily on western fence lizards (*Sceloporus occidentalis*). They also feed on skinks, frogs, snakes, and birds (USFWS 2003c).

California Tiger Salamander *(Ambystoma californiense)*

The California tiger salamander is a large black salamander with large pale yellow to white spots, growing up to 5 inches from snout to vent (Stebbins 2003). Undersurfaces are highly variable, ranging from uniform white or pale yellow to variegated white or pale yellow and black (Jennings and Hayes 1994). California tiger salamander larvae are yellowish gray to olive above with dark mottling on the back and have large feathery gills (Stebbins 2003).

Status

The California tiger salamander is a state species of special concern and is listed as threatened under the *Endangered Species Act* (USFWS 2003a, 69 FR 47212). The Santa Barbara County population was listed as endangered in 2000, and the Sonoma County population was listed as endangered in 2003 (USFWS 2000, 2003b). In August 2004,the USFWS issued a proposed rule to designate critical habitat for the central population of the California tiger salamander in Alameda and San Joaquin Counties, but not at either the Livermore Site or Site 300 (69 FR 48570).

Threats

The most important threat to California tiger salamander populations is habitat loss and fragmentation, especially due to urban expansion and conversion of aquatic and upland habitat to agriculture (USFWS 2000). Additional significant population threats include predation by introduced species such as fish and bullfrogs (*Rana catesbeiana*) (Shaffer et al. 1993), vehicle-related mortality during breeding migrations (Gibbs 1998), and rodent control programs (Loredo et al. 1996).

Range, Habitat, and Life History

Range: The California tiger salamander is found in the Central Valley and adjacent foothills and coastal grasslands of California (Loredo and van Vuren 1996). The range of this California endemic extends from Sonoma County and the Colusa-Yolo County border in the north, south through the Central Valley and the Coast Range to Santa Barbara and Tulare counties (Shaffer et al. 1993, Jennings and Hayes 1994). Alameda and Contra Costa counties are among the remaining regions that support the greatest concentration of California tiger salamanders (Shaffer et al. 1993). California tiger salamanders are found at Site 300 (van Hattem 2003a).

Habitat: California tiger salamanders inhabit grasslands and open woodlands with available small mammal burrows and breeding sites (Jennings and Hayes 1994) in areas with a Mediterranean climate of cool wet winters and hot dry summers (Loredo and van Vuren 1996). California tiger salamanders require standing water for breeding (Petranka 1998).

Life History: California tiger salamanders breed in temporary rain pools and permanent waters of grasslands and open woodland of low hills and valleys (Stebbins 1985). Breeding sites can include both natural (vernal pools) and artificial (stock ponds) lentic environments. California tiger salamanders spend much of the year underground, in the burrows of ground squirrels (*Spermophilus beecheyi*), pocket gophers (*Thomys bottae*), and badgers (*Taxidea taxus*). They usually emerge for only brief periods to breed (Stebbins 1985), typically after the first rains of the year in November or December (Jennings and Hayes 1994, Loredo and van Vuren 1996) and sometimes through April (Petranka 1998). The larval period lasts from 3 to 6 months (Petranka 1998) and, because of this, California tiger salamanders require breeding pools to remain hydrated for at least this length of time. Metamorphosis of salamander larvae begins in late spring or early summer and is followed by the dispersal of metamorphs from their natal ponds into terrestrial habitat (Holland et al. 1990, Loredo et al. 1996). Trenham (2001) recorded adult California tiger salamanders using burrows up to 814 feet from release points adjacent to breeding pools and juvenile salamanders have been reported to use burrows up to 0.75 mile from breeding sites (Jennings and Hayes 1994).

Swainson's Hawk (*Buteo swainsoni*)

The Swainson's hawk is a buteo of the plains, proportioned like a red-tailed hawk but with wings that are a slightly more pointed. When gliding, wings are held slightly above horizontal

(Peterson 1990). Adult females weigh 28 to 34 ounces and males weigh 25 to 31 ounces (CDFG 2003d).

Status

The Swainson's hawk was listed as threatened in the State of California on April 17, 1983 (CDFG 2003d).

Threats

Threats to the Swainson's hawk include the destruction of California native grasslands as well as the loss of agricultural lands to various residential and commercial developments throughout California (CDFG 2003a, 2003d).

Range, Habitat, and Life History

Range: During the early 1900s, the Swainson's hawk nested in lowlands throughout most of California. By 1980, the population of this species had dwindled to approximately 110 pairs with about two-thirds of the California population present in the southern Sacramento Valley and northern San Joaquin Valley (CDFG 2003e).

Habitat: The Swainson's hawk breeds in stands with few trees in juniper-sage flats, riparian areas, and in oak savannah in the Central Valley. The Swainson's hawk forages in grasslands suitable grain or alfalfa fields, or livestock pastures adjacent to breeding stands (CDFG 2003e).

Life History: The Swainson's hawk is diurnal. Common prey include mice, gophers, ground squirrels, rabbits, large arthropods, amphibians, reptiles, birds, and, rarely, fish. It soars at low and high levels in search of prey. It also may walk on the ground to catch invertebrates and other prey and catches insects and bats in flight. Breeding occurs from late March to late August, with peak activity in late May through July. The Swainson's hawk nests on a platform of sticks, bark, and fresh leaves in a tree, bush, or utility pole from 4 to 100 feet above ground. It nests in open riparian habitat, in scattered trees or small groves, in sparsely vegetated flatlands. Its clutch size is usually 2 or 3 eggs, which incubate in 25 to 28 days (CDFG 2003e).

Willow Flycatcher (*Empidonax traillii*)

The willow flycatcher is a member of several small (approximately 5.75 inches long), drab flycatchers in the Empidonax complex and share the characteristics of light eye-ring and two pale wing bars. During breeding, these birds are separated by voice, habitat, and manner of nesting (Peterson 1990).

Status

The willow flycatcher was listed as endangered in the State of California on January 2, 1991 (CDFG 2003a).

Threats

Loss and degradation of riparian habitat is the principal reason for the decline of the willow flycatcher population and the decrease in geographic range of the species. Impacts of livestock grazing to both the habitat and nests of breeding birds have also been implicated in the decline of the species. Nest parasitism by brown-headed cowbirds has contributed to population reductions (CDFG 2003a).

Range, Habitat, and Life History

Range: The willow flycatcher was formerly a common summer resident throughout California. The species has now been eliminated as a breeding bird from most of its former range in California. Only small, scattered populations remain in isolated meadows of the Sierra Nevada and along the Kern, Santa Margarita, San Luis Rey, and Santa Ynez rivers in Southern California. The smallest of these populations consists of about five pairs and the largest about 50 pairs (CDFG 2003a).

Habitat: The willow flycatcher's breeding range in California formerly extended wherever extensive willow thickets occurred. Dense willow thickets are required for nesting and roosting. Low, exposed branches are used for singing posts and hunting perches. In the Sierra Nevada, the willow flycatcher is consistently absent from otherwise apparently suitable areas where the lower branches of willows have been browsed heavily by livestock (CDFG 2003a).

Life History: The willow flycatcher is diurnal in nature. It arrives from Central and South American wintering grounds in May and June and departs in August; transients are noted through mid-September (CDFG 2003f). Willow fly catcher nests are frequently parasitized by the brown-headed cowbird. Willow flycatchers are monogamous, with peak egg laying occurring in June. The incubation period is 12 to 13 days, with clutches averaging 3 or 4 eggs. The fledging age for this bird is 13 to 14 days (CDFG 2003f).

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Appendix B. Ecological Risk Assessment in Support of Renewal of Permit for the Explosive Waste Treatment Facility (EWTF) at Site 300 of Lawrence Livermore National Laboratory

B.1 Introduction

This ecological risk assessment (ERA) is a supplement to the human health risk assessment (HRA) for the Explosive Waste Treatment Facility (EWTF). The EWTF is located near the center of Site 300 in a small, isolated canyon (see Figures 2 through 6 in the text). The ERA described in detail in this Appendix was prepared in accordance with guidance on currently accepted practice provided by the Human and Ecological Risk Division (HERD) at the Department of Toxic Substances Control (DSTC) of the State of California Environmental Protection Agency (CalEPA) in Sacramento, California.

The technical basis for this ERA was an analysis that screened each contaminant of potential ecological concern (CPEC) for its potential to produce an adverse ecological impact in a particular wildlife species at a specific location based on the relationship between its predicted soil concentration and the ecological soil screening levels (ESSLs) determined for each of the nine different wildlife representative receptors of ecological interest (RREI) that are members of the food network. There were four steps in the ERA analysis:

1) Each CPEC in emissions from the Open Burn/Open Detonation (OB/OD) operations at the Site 300 EWTF was identified, and its soil concentration over a 6-inch (15-cm) depth (mg/kg_{soil}) was predicted for a receptor location of interest based on atmospheric dispersion and deposition modeling.
2) An RREI with a distinct diet type was selected in the habitat of interest for each trophic level of the applicable wildlife food web.
3) An ecological soil screening level (ESSL)—i.e., a CPEC-specific concentration in soil that is protective of a particular wildlife (wlf) receptor (e.g., mammal, bird, or invertebrate) that might have contact with such soil, directly or indirectly—was determined. An $ESSL_{wlf}$ for a reptile (wlf = rep), an avian (wlf = brd), and a mammalian (wlf = mam) RREI was based on a species-specific, derived toxic reference value (TRV_{wlf}). The ESSL applicable to soil invertebrates (e.g., earthworms) was based on the no-observed effect concentration in soil that was found in the literature to be applicable to the earthworm.
4) The *lowest* $ESSL_{wlf}$ for each CPEC among those determined to be applicable to the soil invertebrate (wlf = inv), the reptile (wlf = rep), the avian (wlf = brd) and the mammalian (wlf = mam) RREI was compared to the respective CPEC-specific soil concentration predicted from atmospheric dispersion and deposition modeling over a depth of 6 inches (15 cm) at specific receptor locations near and around the EWTF. This was determined by dividing each CPEC-specific soil concentration value at a specific location by the applicable lowest $ESSL_{wlf}$ value, where the result equates to an ESSL-equivalent ecological hazard quotient (EHQ) for each RREI with respect to the CPEC at the selected location. An EHQ greater than unity suggests a possibility for adverse ecological impact. CPEC-specific EHQs also were computed at the