Risks of Bensulide Use to the Federally Threatened

Bay Checkerspot Butterfly (*Euphydryas editha bayensis*), Delta Smelt (*Hypomesus transpacificus*), California Tiger Salamander (*Ambystoma californiense*) Central California Distinct Population Segment, and Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus*),

And the Federally Endangered

California Clapper Rail (*Rallus longirostris obsoletus*), California Freshwater Shrimp (*Syncaris pacifica*), California Tiger Salamander (*Ambystoma californiense*) Sonoma County Distinct Population Segment and Santa Barbara County Distinct Population Segment, San Francisco Garter Snake (*Thamnophis sirtalis tetrataenia*), and Tidewater Goby (*Eucyclogobius newberryi)*

Pesticide Effects Determinations
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Primary Authors:
Anita Ullagaddi, Biologist
He Zhong, Biologist

Secondary Review:
Faruque Khan, Senior Fate Scientist
Robin Sternberg, Wildlife Biologist

Nancy Andrews, Branch Chief
Environmental Risk Branch 1

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List of Commonly Used Abbreviations and Nomenclature

µg/kg	Symbol for "micrograms per kilogram"
µg/L	Symbol for "micrograms per liter"
ºC	Symbol for "degrees Celsius"
AAPCO	Association of American Pesticide Control Officials
a.i.	Active Ingredient
AIMS	Avian Incident Monitoring System
Acc#	Accession Number
amu	Atomic Mass Unit
BCB	Bay Checkerspot Butterfly
BCF	Bioconcentration Factor
BEAD	Biological and Economic Analysis Division
bw	Body Weight
CAM	Chemical Application Method
CARB	California Air Resources Board
AW	Alameda Whipsnake
CBD	Center for Biological Diversity
CCR	California Clapper Rail
CDPR	California Department of Pesticide Regulation
CDPR-PUR	California Department of Pesticide Regulation Pesticide Use Reporting Database
CFWS	California Freshwater Shrimp
CI	Confidence Interval
CL	Confidence Limit
CTS	California Tiger Salamander
CTS-CC	California Tiger Salamander Central California Distinct Population Segment
CTS-SB	California Tiger Salamander Santa Barbara County Distinct Population Segment
CTS-SC	California Tiger Salamander Sonoma County Distinct Population Segment
DS	Delta Smelt
EC	Emulsifiable Concentrate
EC_{05}	5% Effect Concentration
EC_{25}	25% Effect Concentration
EC_{50}	50% (or Median) Effect Concentration

ECOTOX	EPA managed database of Ecotoxicology data
EEC	Estimated Environmental Concentration
EFED	Environmental Fate and Effects Division
e.g.	Latin *exempli gratia* (“for example”)
EIM	Environmental Information Management System
EPI	Estimation Programs Interface
ESU	Evolutionarily significant unit
et al.	Latin *et alii* (“and others”)
etc.	Latin *et cetera* (“and the rest” or “and so forth”)
EXAMS	Exposure Analysis Modeling System
FIFRA	Federal Insecticide Fungicide and Rodenticide Act
FQPA	Food Quality Protection Act
ft	Feet
GENEEC	Generic Estimated Exposure Concentration model
HPLC	High Pressure Liquid Chromatography
IC_{05}	5% Inhibition Concentration
IC_{50}	50% (or median) Inhibition Concentration
i.e.	Latin for *id est* (“that is”)
IECV1.1	Individual Effect Chance Model Version 1.1
KABAM	$\underline{K}_{OW}$ (based) <u>A</u>quatic <u>B</u>io<u>A</u>ccumulation <u>M</u>odel
kg	Kilogram(s)
kJ/mole	Kilojoules per mole
km	Kilometer(s)
K_{AW}	Air-water Partition Coefficient
K_d	Soil-water Distribution Coefficient
K_f	Freundlich Soil-Water Distribution Coefficient
K_{OC}	Organic-carbon Partition Coefficient
K_{OW}	Octanol–water Partition Coefficient
LAA	Likely to Adversely Affect
lb a.i./A	Pound(s) of active ingredient per acre
LC_{50}	50% (or Median) Lethal Concentration
LD_{50}	50% (or Median) Lethal Dose
LOAEC	Lowest Observable Adverse Effect Concentration
LOAEL	Lowest Observable Adverse Effect Level
LOC	Level of Concern
LOD	Level of Detection

LOEC	Lowest Observable Effect Concentration
LOQ	Level of Quantitation
m	Meter(s)
MA	May Affect
MATC	Maximum Acceptable Toxicant Concentration
m^2/day	Square Meters per Days
ME	Microencapsulated
mg	Milligram(s)
mg/kg	Milligrams per kilogram (equivalent to ppm)
mg/L	Milligrams per liter (equivalent to ppm)
mi	Mile(s)
mmHg	Millimeter of mercury
MRID	Master Record Identification Number
MW	Molecular Weight
NA	Not applicable
NASS	National Agricultural Statistics Service
NAWQA	National Water Quality Assessment
NCOD	National Contaminant Occurrence Database
NE	No Effect
NLAA	Not Likely to Adversely Affect
NLCD	National Land Cover Dataset
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOAEC	No Observable Adverse Effect Concentration
NOAEL	No Observable Adverse Effect Level
NOEC	No Observable Effect Concentration
NRCS	Natural Resources Conservation Service
OPP	Office of Pesticide Programs
OPPTS	Office of Prevention, Pesticides and Toxic Substances
ORD	Office of Research and Development
PCE	Primary Constituent Element
pH	Symbol for the negative logarithm of the hydrogen ion activity in an aqueous solution, dimensionless
pKa	Symbol for the negative logarithm of the acid dissociation constant, dimensionless
ppb	Parts per Billion (equivalent to µg/L or µg/kg)

ppm	Parts per Million (equivalent to mg/L or mg/kg)
PRD	Pesticide Re-Evaluation Division
PRZM	Pesticide Root Zone Model
ROW	Right of Way
RQ	Risk Quotient
SFGS	San Francisco Garter Snake
SJKF	San Joaquin Kit Fox
SLN	Special Local Need
SMHM	Salt Marsh Harvest Mouse
TG	Tidewater Goby
T-HERPS	Terrestrial Herpetofaunal Exposure Residue Program Simulation
T-REX	Terrestrial Residue Exposure Model
UCL	Upper Confidence Limit
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VELB	Valley Elderberry Longhorn Beetle
WP	Wettable Powder
wt	Weight

1. Executive Summary

1.1. Purpose of Assessment

The purpose of this assessment is to evaluate potential direct and indirect effects of bensulide (PC code: 009801) on the bay checkerspot butterfly (*Euphydryas editha bayensis*) (BCB), California clapper rail (*Rallus longirostris obsoletus*) (CCR), California tiger salamander (*Ambystoma californiense*) Central California Distinct Population Segment (CTS-CC), Santa Barbara County Distinct Population Segment (CTS-SB), and Sonoma County Distinct Population Segment (CTS-SC), California freshwater shrimp (*Syncaris pacificus*) (CFWS), delta smelt (*Hypomesus transpacificus*) (DS), San Francisco garter snake (*Thamnophis sirtalis tetrataenia*) (SFGS), tidewater goby (*Eucyclogobius newberryi*) (TG), and the valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) (VELB) arising from FIFRA regulatory actions regarding use of bensulide on agricultural and non-agricultural sites. In addition, this assessment evaluates whether these actions can be expected to result in modification of designated critical habitat for the BCB, DS, VELB, CTS-CC, CTS-SB, and TG; the other assessed species do not have designated critical habitats. This assessment was completed in accordance with the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) *Endangered Species Consultation Handbook* (USFWS/NMFS, 1998), procedures outlined in the Agency's Overview Document (USEPA, 2004), and consistent with a suit in which bensulide was alleged to be of concern to the BCB, CCR, CFWS, CTS-CC, CTS-SC, CTS-SB, DS, SFGS, TG, and VELB (*Center for Biological Diversity (CBD) vs. EPA et al*. (Case No. 07-2794-JCS)).

Below are brief descriptions of when each San Francisco Bay species being assessed was listed and a short description of their associated Primary Constituent Element (PCEs) (when applicable).

The BCB was listed as threatened in 1987 by the USFWS. The species primarily inhabits native grasslands on serpentine outcrops around the San Francisco Bay Area in California. The PCEs for BCBs are areas on serpentinite-derived soils that support the primary larval host plant (*i.e.*, dwarf plantain) and at least one of the species' secondary host plants. Additional BCB PCEs include the presence of adult nectar sources, aquatic features that provide moisture during the spring drought and areas that provide adequate shelter during the summer diapause.

The CCR was listed by the USFWS as an endangered species in 1970. The species is found only in California in coastal wetlands along the San Francisco estuary and Suisun Bay.

The CFWS was listed as endangered in 1988 by the USFWS. The CFWS inhabits freshwater streams in Central California in the lower Russian River drainage and westward to the Pacific Ocean and coastal streams draining into Tomales Bay and southward into the San Pablo Bay.

There are currently three CTS Distinct Population Segments (DPSs): the Sonoma County (SC) DPS, the Santa Barbara (SB) DPS, and the Central California (CC) DPS. Each DPS is considered separately in the risk assessment as they occupy different geographic areas. The main difference in the assessment will be in the spatial analysis. The CTS-SB was listed by the USFWS as endangered in 2000, the CTS-SC in 2002, and the CTS-CC as threatened in 2004. The CTS-SB and CTS-SC were downlisted from endangered to threatened in 2004 by the USFWS, however, the downlisting was vacated by the U.S. District Court. Therefore, the Sonoma and Santa Barbara DPSs are currently listed as endangered while the CTS-CC is listed as threatened. All CTS populations utilize vernal pools, semi-permanent ponds, and permanent ponds, and the terrestrial environment in California. The aquatic environment is essential for breeding and reproduction and mammal burrows are also important habitat for aestivation. The PCEs for the CTS are standing bodies of freshwater sufficient for the species to complete the aquatic portion of its life cycle that are adjacent to barrier-free uplands that contain small mammal burrows. An additional PCE is upland areas between sites (as described above) that allow for dispersal of the species.

The DS was listed as threatened on March 5, 1993 (58 FR 12854) by the USFWS (USFWS, 2007). DS are mainly found in the Suisun Bay and the Sacramento-San Joaquin estuary near San Francisco Bay. During spawning, the smelt move into freshwater.

The SFGS was listed as endangered in 1967 by the USFWS. The species is endemic to the San Francisco Peninsula and San Mateo County in California in densely vegetated areas near marshes and standing open water.

The TG was listed as endangered on March 7, 1994 (59 FR 5494) by the USFWS. The animals are benthic in nature and all life stages are found in lagoons, estuaries, and marshes in areas of low to moderate salinity[1]. The TG also occurs in freshwater streams up gradient and tributary to brackish habitats (68920 FR Vol 71, No 228).

The VELB was listed as threatened in 1980 by the USFWS. The species is found in areas with elderberry shrubs throughout California's Central Valley and associated foothills on the east and the watershed of the Central Valley on the west. The PCEs for the VELBs include areas that contain its host plant (*i.e.*, elderberry trees).

1.2. Scope of Assessment

1.2.1. Uses Assessed

Bensulide (*O,O*-diisopropyl *S*-2-phenylsulfonylaminoethyl phosphorodithioate) is a non-systemic, organophosphate herbicide currently registered for pre-plant use for a variety of field and vegetable crops and ornamental and residential lawns and turf, as well as golf course turf. Bensulide is formulated into emulsifiable concentrate and granular products. As a pre-emergent herbicide that inhibits meristematic root tissues and seedling growth, target weed species include annual grasses such as crabgrass and broadleaf weeds. Although current registrations of bensulide allow for use nationwide, this ecological risk assessment and effects determination addresses currently registered uses of bensulide in California only. Uses in California generally comprise the full range of agricultural and non-agricultural registrations and all types of formulations for bensulide. Labels specify ground applications only, and applications can be made by chemigation, broadcast treatment, and band treatment.

[1] USFWS 2011. http://www.fws.gov/arcata/es/fish/Goby/goby.html

1.2.2. Stressors of Concern

Bensulide is a persistent herbicide that may be transported away from the site of application by runoff or spray drift (in the case of the EC formulation). A degradate is considered to be major if it forms at amounts >10% of the applied parent. Benzenesulfonamide, a minor degradate, only reached a maximum level of 0.52% and is not considered in this assessment. Bensulide oxon, a major degradate, is considered in this assessment. In an aerobic soil metabolism study, bensulide oxon reached a maximum concentration of 13.8%.

Available data on the affinity of bensulide to acetylcholinesterase (Knudsen *et al.*, 2011) indicate that bensulide does not bind to the enzyme, an observation consistent with the non-direct acting mechanism of this chemical. Therefore, it is assumed that animal toxicity observed with bensulide exposure is the product of endogenous or exogenous exposure to the oxon form of the chemical, again in accordance with the non-direct acting mechanism of bensulide and consistent with the understanding that the oxon product of thionated phosphate esters binds with acetylcholinesterase. Based on magnitude of residue studies in *Brassica* leafy vegetables (MRID 473550-01), bensulide oxon is produced, and available environmental fate studies suggest that the oxon is produced under aerobic conditions in the soil microbial community. However, there are no data to allow for an oxon-based assessment of toxicity. Therefore, the aquatic and terrestrial exposure assessments consider the potential for both parent and oxon to be present and assume that observed toxicity data is mediated by exogenous and endogenous production of the oxon. For aquatic exposures, this is accounted for with a total toxic residue approach. Because available data show detectable residues of parent and oxon for *Brassica* leafy vegetables at 33 days but no detectable levels in vegetables at more protracted intervals, it is believed that the use of a 35-day dissipation half-life (for terrestrial exposures) is a conservative way to account for the role of both parent (as an endogenous source of oxon when consumed) and oxon produced in the environment.

1.3. Assessment Procedures

A description of routine procedures for evaluating risk to the San Francisco Bay Species is provided in **Attachment I**.

1.3.1. Exposure Assessment

1.3.1.a. Aquatic Exposures

The Tier II models used to predict aquatic estimated environmental concentrations (EECs) are the Pesticide Root Zone Model coupled with the Exposure Analysis Model System (PRZM/EXAMS). Tier II aquatic exposure models estimated high-end exposures of bensulide and its major degradate, bensulide oxon, in aquatic habitats resulting from runoff and spray drift from labeled uses. The AgDRIFT model is also used to estimate deposition of bensulide on aquatic habitats from spray drift. Acute EECs resulting from different bensulide uses range from 10.88 to 463.70 µg/L, and chronic EECs range from 9.17 to 427.00 µg/L. No surface water monitoring data were available for bensulide or its degradate bensulide oxon

1.3.1.b. Terrestrial Exposures

To estimate bensulide and bensulide oxon exposures to terrestrial species resulting from uses involving bensulide applications, the T-REX model is used for spray and granular uses. The AgDRIFT model is also used to estimate deposition of bensulide on terrestrial habitats from spray drift. The TerrPlant model is used to estimate bensulide exposures to terrestrial-phase habitat, including plants inhabiting semi-aquatic and dry areas. The T-HERPS model is used to allow for further characterization of dietary exposures of terrestrial-phase amphibians and reptiles.

1.3.2. Toxicity Assessment

The assessment endpoints include direct toxic effects on survival, reproduction, and growth of individuals, as well as indirect effects, such as reduction of the food source and/or modification of habitat. Federally-designated critical habitat has been established for the BCB, CTS-CC, CTS-SB, DS, and TG. Primary constituent elements (PCEs) were used to evaluate whether bensulide has the potential to modify designated critical habitat. The Agency evaluated registrant-submitted studies and data from the open literature to characterize toxicity of bensulide. The most sensitive toxicity value available from acceptable or supplemental studies for each taxon relevant for estimating potential risks to the assessed species and/or their designated critical habitat was used.

Section 4 summarizes the ecotoxicity data available on bensulide. In general, bensulide is highly toxic to freshwater and estuarine/marine fish on an acute basis. Bensulide is highly toxic to freshwater invertebrates, very highly toxic to estuarine/marine invertebrates, and highly toxic to aquatic plants. Chronic effects were observed for all aquatic taxa. Bensulide is slightly toxic to birds on an acute oral basis, practically non-toxic to birds on a subacute dietary basis, moderately toxic to mammals on an acute oral basis, and practically non-toxic to honey bees on an acute contact basis. Chronic effects that were observed in avian studies included a decrease in eggshell thickness, increase in the number of cracked eggs, decrease in the percent of eggs hatched, and decrease in the percent survival of 3-week embryos and 14-day chicks. Chronic effects that were observed in mammalian studies included decreased pup survival and reduction in plasma cholinesterase activity. Phytotoxic effects were observed in terrestrial plant studies at rates that were much lower than maximum labeled application rates. No amphibian or reptile data were available; therefore, birds were used as a surrogate for terrestrial-phase amphibians and reptiles, and fish were used as a surrogate for aquatic-phase amphibians. No data were available that evaluated the toxicity of the degradate bensulide oxon, and the bensulide oxon was assumed to have similar toxicity to the parent (see **Section 2.2.1** for more information).

1.3.3. Measures of Risk

Risk quotients (RQs) are calculated by dividing the lowest acute and chronic taxon-specific effects concentration by the appropriate expected environmental concentration (EEC) for each use scenario. Acute and chronic RQs are compared to the Agency's Levels of Concern (LOCs) to identify instances where bensulide use has the potential to adversely affect the assessed species or adversely modify their designated critical habitat. When RQs for a particular type of effect are below LOCs, the pesticide is considered to have "no effect" on the species and its designated critical habitat. Where RQs exceed LOCs, a potential to cause adverse effects or habitat modification is identified, leading to a conclusion of "may affect". If bensulide use "may affect" the assessed species, and/or may cause effects to designated critical habitat, the best available additional information is considered to refine the potential for exposure and effects and distinguish actions that are Not Likely to Adversely Affect (NLAA) from those that are Likely to Adversely Affect (LAA).

1.4. Summary of Conclusions

In fulfilling its obligations under Section 7(a)(2) of the Endangered Species Act, the information presented in this endangered species risk assessment represents the best data currently available to assess the potential risks of bensulide and its degradate bensulide oxon to BCB, CCR, CFWS, CTS, DS, SFGS, TG, and VELB and their designated critical habitat.

Based on the best available information, the Agency makes a Likely to Adversely Affect determination for the BCB, CCR, CFWS, CTS (all DPS), DS, SFGS, TG, and VELB. Additionally, the Agency has determined that there is the potential for modification of the designated critical habitat for the BCB, CTS-CC, CTS-SB, DS, TG, and VELB from the use of the chemical. Given the LAA determination for the BCB, CCR, CFWS, CTS (all DPS), DS, SFGS, TG, and VELB and potential modification of designated critical habitat for BCB, CTS-CC, CTS-SB, DS, TG, and VELB, a description of the baseline status and cumulative effects is provided in **Attachment III**.

A summary of the risk conclusions and effects determinations for the BCB, CCR, CFWS, CTS (all DPS), DS, SFGS, TG, and VELB and their critical habitat, given the uncertainties discussed in **Section 6** and **Attachment I**, is presented in **Table 1-1** and **Table 1-2**. Use-specific effects potentials are provided in **Table 1-3** and **Table 1-4**.

Table 1-1. Effects Determination Summary for Effects of Bensulide Use on the BCB, CCR, CFWS, CTS, DS, SFGS, TG, and VELB

Species	Effects Determination	Basis for Determination
Bay Checkerspot Butterfly (*Euphydryas editha bayensis*)	May affect, likely to adversely affect (LAA)	**Potential for Direct Effects**
		Terrestrial It is possible for bensulide to directly impact the BCB based on RQs exceeding the LOC for all uses of bensulide.
		Potential for Indirect Effects
		Terrestrial food items, habitat Indirect effects from impacts on food and habitat are not anticipated due RQs not exceeding the LOC for terrestrial plants inhabiting areas in which BCB inhabit (LOCs are only exceeded for plants that inhabit semi-aquatic areas, which the BCB does not inhabit).
Valley Elderberry		**Potential for Direct Effects**

Table 1-1. Effects Determination Summary for Effects of Bensulide Use on the BCB, CCR, CFWS, CTS, DS, SFGS, TG, and VELB		
Species	**Effects Determination**	**Basis for Determination**
Longhorn Beetle (*Desmocerus californicus dimorphus)*	May affect, likely to adversely affect (LAA)	***Terrestrial*** It is possible for bensulide to directly impact the VELB based on RQs exceeding the LOC for all uses of bensulide
		Potential for Indirect Effects
		Terrestrial food items, habitat Indirect effects from impacts on food and habitat are not anticipated due RQs not exceeding the LOC for terrestrial plants inhabiting areas in which VELB inhabit (LOCs are only exceeded for plants that inhabit semi-aquatic areas, which the VELB does not inhabit).
California Tiger Salamander (All 3 DPS) (*Ambystoma californiense)*	May affect, likely to adversely affect (LAA)	**Potential for Direct Effects**
		Aquatic-phase (Eggs, Larvae, and Adults) & Terrestrial-phase (Juveniles and Adults) It is possible for bensulide to directly impact the CTS based on RQs exceeding LOCs for terrestrial-phase amphibians, using avian surrogate species data, for all uses on an acute and chronic basis. Based on RQs exceeding LOCs for aquatic-phase amphibians, using freshwater fish surrogate species data, it is possible for bensulide to directly impact the CTS on an acute basis for the following use groups: ornamental lawns and turf, canola, cole crops, leafy vegetables, row crops, melons, and the high rate for onions/bulb vegetables. On a chronic basis, it is possible for bensulide to directly impact the CTS based on the RQ for the high rate for cole crops exceeding the LOC.
		Potential for Indirect Effects
		Aquatic prey items, aquatic habitat, cover, and primary productivity & Terrestrial prey items, habitat Indirect effects from impacts on prey are possible based on RQs exceeding LOCs for terrestrial-phase amphibians (for all uses), using avian surrogate species data, mammals (for all uses), terrestrial invertebrates (for all uses), freshwater fish (for ornamental lawns and turf, canola, cole crops, leafy vegetables, row crops, melons, and the high rate for onions/bulb vegetables on an acute basis; for the high rate for cole crops on a chronic basis), freshwater invertebrates (for all uses except residential lawns and the low rate for onions/bulb vegetables on an acute basis; for all uses on a chronic basis) and aquatic plants (for the high rate for canola, medium and high rate for cole crops, leafy vegetables, and the high rate for row crops). Indirect effects from impacts on habitat are possible due to effects on aquatic and terrestrial plants and mammal burrow availability. Small mammals are essential in creating the underground habitat that juvenile and adult CTS depend upon for food, shelter, and protection from the elements and predation.
California Clapper Rail (*Rallus longirostris obsoletus*)	May affect, likely to adversely affect (LAA)	**Potential for Direct Effects**
		Terrestrial It is possible for bensulide to directly impact the CCR based on RQs exceeding LOCs for avian species for all uses on an acute and chronic basis.
		Potential for Indirect Effects
		Aquatic prey items, aquatic habitat, cover, and primary productivity & Terrestrial prey items, riparian habitat

Table 1-1. Effects Determination Summary for Effects of Bensulide Use on the BCB, CCR, CFWS, CTS, DS, SFGS, TG, and VELB		
Species	**Effects Determination**	**Basis for Determination**
		Indirect effects from impacts on prey are possible based on RQs exceeding LOCs for birds, mammals, and terrestrial invertebrates for all uses. Indirect effects from impacts on prey are also possible based on RQs exceeding LOCs for aquatic plants (for the high rate for canola, medium and high rate for cole crops, leafy vegetables, and the high rate for row crops), terrestrial plants (for all uses for monocots), freshwater fish (for ornamental lawns and turf, canola, cole crops, leafy vegetables, row crops, melons, and the high rate for onions/bulb vegetables on an acute basis; for the high rate for cole crops on a chronic basis), estuarine/marine fish (for all uses except the low rate for onions/bulb vegetables on an acute basis; for all uses on a chronic basis), freshwater invertebrates (for all uses except residential lawns and the low rate for onions/bulb vegetables on an acute basis; for all uses on a chronic basis), and estuarine/marine invertebrates (for all uses on an acute basis; for all uses except golf course turf, residential lawns, the low rate for row crops, fruiting vegetables, and the low rate for onions/bulb vegetables on a chronic basis). Indirect effects from impacts on habitat are possible due to RQs exceeding the LOC for aquatic plants (for the high rate for canola, medium and high rate for cole crops, leafy vegetables, and the high rate for row crops) and terrestrial plants (for all uses for monocots).
California Freshwater Shrimp (*Syncaris pacifica*)	May affect, likely to adversely affect (LAA)	**Potential for Direct Effects**
		Aquatic It is possible for bensulide to directly impact the CFWS based on RQs exceeding LOCs for freshwater invertebrates for all uses except residential lawns and the low rate for onions/bulb vegetables on an acute basis and for all uses on a chronic basis
		Potential for Indirect Effects
		Aquatic prey items, habitat, cover, and primary productivity & Terrestrial prey items, riparian habitat Indirect effects from impacts on prey are possible based on RQs exceeding LOCs for freshwater invertebrates (for all uses except residential lawns and the low rate for onions/bulb vegetables on an acute basis; for all uses on a chronic basis), aquatic plants (for the high rate for canola, medium and high rate for cole crops, leafy vegetables, and the high rate for row crops), and terrestrial plants (for all uses for monocots). Indirect effects from impacts on habitat are also possible due to RQs exceeding the LOC for aquatic plants (for the high rate for canola, medium and high rate for cole crops, leafy vegetables, and the high rate for row crops) and terrestrial plants (for all uses for monocots).
Delta Smelt	May affect, likely to adversely affect (LAA)	**Potential for Direct Effects**
		Aquatic It is possible for bensulide to directly impact the DS based on RQs exceeding LOCs for freshwater fish (for ornamental lawns and turf, canola, cole crops, leafy vegetables, row crops, melons, and the high rate for onions/bulb vegetables on an acute basis; for the high rate for cole crops on a chronic basis) and estuarine/marine fish (for all uses except the low rate for onions/bulb vegetables on an acute basis; for all uses on a chronic basis).
		Potential for Indirect Effects

Table 1-1. Effects Determination Summary for Effects of Bensulide Use on the BCB, CCR, CFWS, CTS, DS, SFGS, TG, and VELB		
Species	**Effects Determination**	**Basis for Determination**
		Aquatic prey items, habitat, cover, and primary productivity & Terrestrial riparian habitat Indirect effects from impacts on prey are possible based on RQs exceeding LOCs for freshwater invertebrates (for all uses except residential lawns and the low rate for onions/bulb vegetables on an acute basis; for all uses on a chronic basis), estuarine/marine invertebrates (for all uses on an acute basis; for all uses except golf course turf, residential lawns, the low rate for row crops, fruiting vegetables, and the low rate for onions/bulb vegetables on a chronic basis), and aquatic plants (for the high rate for canola, medium and high rate for cole crops, leafy vegetables, and the high rate for row crops). Indirect effects from impacts on habitat are also possible due to RQs exceeding the LOC for aquatic plants (for the high rate for canola, medium and high rate for cole crops, leafy vegetables, and the high rate for row crops) and terrestrial plants (for all uses for monocots).
San Francisco Garter Snake (*Thamnophis sirtalis tetrataenia*)	May affect, likely to adversely affect (LAA)	**Potential for Direct Effects**
		Terrestrial It is possible for bensulide to directly impact the SFGS based on RQs exceeding the LOC for reptiles, using avian surrogate species data, for all uses on an acute and chronic basis.
		Potential for Indirect Effects
		Aquatic prey items, aquatic habitat, cover, and primary productivity& Terrestrial prey items, riparian habitat Indirect effects from impacts on prey are possible based on RQs exceeding LOCs for terrestrial-phase amphibians and reptiles (for all uses), using avian surrogate species data, mammals (for all uses), terrestrial invertebrates (for all uses), freshwater fish and aquatic-phase amphibians (for ornamental lawns and turf, canola, cole crops, leafy vegetables, row crops, melons, and the high rate for onions/bulb vegetables on an acute basis; for the high rate for cole crops on a chronic basis), and freshwater invertebrates (for all uses except residential lawns and the low rate for onions/bulb vegetables on an acute basis; for all uses on a chronic basis). Indirect effects from impacts on habitat are also possible due to effects on aquatic and terrestrial plants and mammal burrow availability. SFGS rely on the burrows of small mammals for shelter and aestivation.
Tidewater Goby	May affect, likely to adversely affect (LAA)	**Potential for Direct Effects**
		Aquatic It is possible for bensulide to directly impact the TG based on RQs exceeding LOCs for freshwater fish (for ornamental lawns and turf, canola, cole crops, leafy vegetables, row crops, melons, and the high rate for onions/bulb vegetables on an acute basis; for the high rate for cole crops on a chronic basis) and estuarine/marine fish (for all uses except the low rate for onions/bulb vegetables on an acute basis; for all uses on a chronic basis).
		Potential for Indirect Effects
		Aquatic prey items, aquatic habitat, cover, and primary productivity & Terrestrial riparian habitat Indirect effects from impacts on prey are possible based on RQs exceeding LOCs for freshwater invertebrates (for all uses except residential lawns and the low rate for onions/bulb vegetables on an acute basis; for all uses on a

Table 1-1. Effects Determination Summary for Effects of Bensulide Use on the BCB, CCR, CFWS, CTS, DS, SFGS, TG, and VELB		
Species	**Effects Determination**	**Basis for Determination**
		chronic basis), estuarine/marine invertebrates (for all uses on an acute basis; for all uses except golf course turf, residential lawns, the low rate for row crops, fruiting vegetables, and the low rate for onions/bulb vegetables on a chronic basis), and aquatic plants (for the high rate for canola, medium and high rate for cole crops, leafy vegetables, and the high rate for row crops). Indirect effects from impacts on habitat are also possible due to RQs exceeding the LOC for aquatic plants (for the high rate for canola, medium and high rate for cole crops, leafy vegetables, and the high rate for row crops) and terrestrial plants (for all uses for monocots).

Table 1-2. Effects Determination Summary for the Critical Habitat Impact Analysis		
Species with Designated Critical Habitat	**Effects Determination**	**Basis for Determination**
Bay Checkerspot Butterfly	Habitat modification	Impacts on habitat are not anticipated due to RQs not exceeding the LOC for terrestrial plants inhabiting areas in which BCB inhabit (*i.e.*, LOCs are only exceeded for plants that inhabit semi-aquatic areas, which the BCB does not inhabit). However, direct effects to the BCB are possible. There is overlap between the areas of the LAA effects determination for bensulide and BCB range.
California Tiger Salamander Central California Distinct Population Segment	Habitat modification	Impacts on habitat are possible due to RQs exceeding LOCs for aquatic and terrestrial plants and mammal burrow availability. Small mammals are essential in creating the underground habitat that juvenile and adult CTS depend upon for food, shelter, and protection from the elements and predation. There is overlap between the areas of the LAA effects determination for bensulide and CTS range.
California Tiger Salamander Santa Barbara County Distinct Population Segment	Habitat modification	Impacts on habitat are possible due to RQs exceeding LOCs for aquatic and terrestrial plants and mammal burrow availability. Small mammals are essential in creating the underground habitat that juvenile and adult CTS depend upon for food, shelter, and protection from the elements and predation. There is overlap between the areas of the LAA effects determination for bensulide and CTS range.
Delta Smelt	Habitat modification	Impacts on habitat are possible based on RQs exceeding LOCs for aquatic and terrestrial plants. There is overlap between the areas of the LAA effects determination for bensulide and the DS range.
Tidewater Goby	Habitat modification	Impacts on habitat are possible based on RQs exceeding LOCs for aquatic and terrestrial plants. There is overlap between the areas of the LAA effects determination for bensulide and the TG range.
Valley Elderberry Longhorn Beetle	Habitat modification	Impacts on habitat are not anticipated due to RQs not exceeding the LOC for terrestrial plants inhabiting areas in which VELB inhabit (*i.e.*, LOCs are only exceeded for plants that inhabit semi-aquatic areas, which the VELB does not inhabit). However, direct effects to the VELB are possible. There is overlap between the areas of the LAA effects determination for bensulide and VELB range.

Table 1-3. Use Specific Summary of the Potential for Adverse Effects to Aquatic Taxa										
Use & Application Rate	Potential for Effects to Identified Taxa Found in the Aquatic Environment:									
	DS, TG, and Estuarine/Marine Vertebrates[1]		CTS (all DPS), DS, TG, and Freshwater Vertebrates[2]		CFWS and Freshwater Invertebrates[3]		Estuarine/Marine Invertebrates[4]		Vascular Plants[5]	Non-vascular Plants[5]
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic		
CA Turf RLF (golf course turf for use on tees, greens, and bentgrass fairways only) 2 apps @ 16 lb a.i./acre (120 days) Granular	**Yes***	**Yes**	No	No	**Yes***	**Yes**	**Yes***	No	No	No
CA Turf RLF (ornamental lawns and turf) 2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	**Yes***	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	**Yes**	No	No
CA Turf RLF (golf course turf for use on tees, greens, and bentgrass fairways only) 2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	**Yes***	**Yes**	No	No	**Yes***	**Yes**	**Yes***	No	No	No
CA Residential RLF (residential lawns) 2 apps @ 12.6 lb a.i./acre (120 days) Granular	**Yes***	**Yes**	No	No	No	**Yes**	**Yes***	No	No	No
CA Residential RLF (residential lawns) 2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	**Yes***	**Yes**	No	No	No	**Yes**	**Yes***	No	No	No
CA Wheat (canola) 3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	**Yes**	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	**Yes**	**Yes**	No
CA Wheat (canola) 2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	**Yes***	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	**Yes**	No	No
CA Wheat (canola) 1 app @ 6 lb a.i./acre	**Yes***	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	**Yes**	No	No

Table 1-3. Use Specific Summary of the Potential for Adverse Effects to Aquatic Taxa										
Use & Application Rate	Potential for Effects to Identified Taxa Found in the Aquatic Environment:									
	DS, TG, and Estuarine/Marine Vertebrates[1]		CTS (all DPS), DS, TG, and Freshwater Vertebrates[2]		CFWS and Freshwater Invertebrates[3]		Estuarine/Marine Invertebrates[4]		Vascular Plants[5]	Non-vascular Plants[5]
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic		
Emulsifiable Concentrate										
CA Cole Crop RLF (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) 3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	No
CA Cole Crop RLF (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) 2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	**Yes**	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	**Yes**	**Yes**	No
CA Cole Crop RLF (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) 1 app @ 6 lb a.i./acre Emulsifiable Concentrate	**Yes***	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	**Yes**	No	No
CA Lettuce No-irrig. (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula)) 2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	**Yes**	**Yes**	**Yes***	No	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	No
CA Lettuce No-irrig.	**Yes***	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	**Yes**	**Yes**	No

Table 1-3. Use Specific Summary of the Potential for Adverse Effects to Aquatic Taxa										
Use & Application Rate	**Potential for Effects to Identified Taxa Found in the Aquatic Environment:**									
	DS, TG, and Estuarine/Marine Vertebrates[1]		**CTS (all DPS), DS, TG, and Freshwater Vertebrates[2]**		**CFWS and Freshwater Invertebrates[3]**		**Estuarine/Marine Invertebrates[4]**		**Vascular Plants[5]**	**Non-vascular Plants[5]**
	Acute	**Chronic**	**Acute**	**Chronic**	**Acute**	**Chronic**	**Acute**	**Chronic**		
(corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula)) 1 app @ 6 lb a.i./acre Emulsifiable Concentrate										
CA Row Crop RLF (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) 3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	**Yes**	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	**Yes**	**Yes**	No
CA Row Crop RLF (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) 2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	**Yes***	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	**Yes**	No	No
CA Row Crop RLF (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) 1 app @ 6 lb a.i./acre Emulsifiable Concentrate	**Yes***	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	No	No	No
CA Melon RLF (cantaloupe, chayote, cucumber, cucurbit vegetables, cucuzzi, gherkin, gourds, gourd (wax), melons (bitter, honeydew, citron, mango, musk, water, winter melons), pepino, pumpkin, squash (butternut, summer, zucchini squash)) 2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	**Yes***	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	**Yes**	No	No

Table 1-3. Use Specific Summary of the Potential for Adverse Effects to Aquatic Taxa										
Use & Application Rate	Potential for Effects to Identified Taxa Found in the Aquatic Environment:									
	DS, TG, and Estuarine/Marine Vertebrates[1]		CTS (all DPS), DS, TG, and Freshwater Vertebrates[2]		CFWS and Freshwater Invertebrates[3]		Estuarine/Marine Invertebrates[4]		Vascular Plants[5]	Non-vascular Plants[5]
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic		
CA Melon RLF (cantaloupe, chayote, cucumber, cucurbit vegetables, cucuzzi, gherkin, gourds, gourd (wax), melons (bitter, honeydew, citron, mango, musk, water, winter melons), pepino, pumpkin, squash (butternut, summer, zucchini squash)) 1 app @ 9 lb a.i./acre Emulsifiable Concentrate	**Yes***	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	**Yes**	No	No
CA Tomato No-irrig. (bell pepper, eggplant, groundcherry (strawberry tomato/tomatillo), pepper, pepper (chili), pimento) 1 app @ 6 lb a.i./acre Emulsifiable Concentrate	**Yes***	**Yes**	No	No	**Yes***	**Yes**	**Yes***	No	No	No
CA Onion No-Irrig. (garlic, onion (dry bulb and green), radish, shallot) 3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	**Yes***	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	**Yes**	No	No
CA Onion No-Irrig. (garlic, onion (dry bulb and green), radish, shallot) 1 app @ 6 lb a.i./acre Emulsifiable Concentrate	No	**Yes**	No	No	No	**Yes**	**Yes***	No	No	No

[1] A yes in this column also indicates a potential for indirect effects to CCR. Chronic risk conservatively assumed in the absence of data based on one exceeding chronic RQ for freshwater fish and slight increased acute toxicity of bensulide to estuarine/marine fish compared to freshwater fish.
[2] A yes in this column also indicates a potential for indirect effects to CCR, CTS (all DPS), and SFGS.
[3] A yes in this column also indicates a potential for indirect effects to CCR, CFWS, CTS (all DPS), DS, SFGS, and TG.
[4] A yes in this column also indicates a potential for indirect effects to CCR, DS, and TG.
[5] A yes in this column also indicates a potential for indirect effects to CCR, CFWS, CTS (all DPS), DS, SFGS, and TG.
* RQ exceeds the LOC for listed species but not for non-listed species. LOCs are 0.05 for acute risk to listed aquatic species, 0.5 for acute risk to non-listed aquatic species, 1.0 for chronic risk to all aquatic species, and 1.0 for risk to aquatic plants.

Table 1-4. Use Specific Summary of the Potential for Adverse Effects to Terrestrial Taxa											
Uses	**Potential for Effects to Identified Taxa Found in the Terrestrial Environment:**										
	Small Mammals[1]		**CCR and Small Birds[2]**		**CTS (all DPS) and Amphibians[3]**		**SFGS and Reptiles[4]**		**BCB, VELB, and Invertebrates (Acute)[5]**	**Dicots[6]**	**Monocots[6]**
	Acute	**Chronic**	**Acute**	**Chronic**	**Acute**	**Chronic**	**Acute**	**Chronic**			
All Uses	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	No	**Yes+**

[1] A yes in this column indicates a potential for indirect effects to CCR, CTS (all DPS), and SFGS.
[2] A yes in this column also indicates a potential for indirect effects to the CCR, CTS (all DPS), and SFGS.
[3] A yes in this column also indicates a potential indirect effects to CCR, CTS (all DPS), and SFGS. .
[4] A yes in this column also indicates the potential for direct and indirect effects to SFGS.
[5] A yes in this column also indicates a potential for indirect effects to CCR, CTS (all DPS), and SFGS.
[6] A yes in this column indicates a potential for indirect effects to BCB, CCR, CFWS, CTS (all DPS), DS, SFGS, TG, and VELB. For the BCB and VELB, this is based on the listed species LOC because of the obligate relationship with terrestrial monocots and dicots. For other species, the LOC exceedances are evaluated based on the LOC for non-listed species.
*LOCs are 0.05 for acute risk to listed terrestrial invertebrates, 0.1 for acute risk to other listed terrestrial species, 0.5 for acute risk to non-listed terrestrial species, 1.0 for chronic risk to all terrestrial species, and 1.0 for risk to terrestrial plants.
+LOCs exceeded for listed monocots in semi-aquatic areas only.

Based on the conclusions of this assessment, a formal consultation with the U. S. Fish and Wildlife Service under Section 7 of the Endangered Species Act should be initiated.

When evaluating the significance of this risk assessment's direct/indirect and adverse habitat modification effects determinations, it is important to note that pesticide exposures and predicted risks to the assessed listed species and their resources (*i.e*., food and habitat) are not expected to be uniform across the action area. In fact, given the assumptions of drift and downstream transport (*i.e*., attenuation with distance), pesticide exposure and associated risks to the species and its resources are expected to decrease with increasing distance away from the treated field or site of application. Evaluation of the implication of this non-uniform distribution of risk to the species would require information and assessment techniques that are not currently available. Examples of such information and methodology required for this type of analysis would include the following:

- Enhanced information on the density and distribution of BCB, CCR, CFWS, CTS-CC, CTS-SC, CTS-SB, DS, SFGS, TG, and VELB life stages within the action area and/or applicable designated critical habitat. This information would allow for quantitative extrapolation of the present risk assessment's predictions of individual effects to the proportion of the population extant within geographical areas where those effects are predicted. Furthermore, such population information would allow for a more comprehensive evaluation of the significance of potential resource impairment to individuals of the assessed species.
- Quantitative information on prey base requirements for the assessed species. While existing information provides a preliminary picture of the types of food sources utilized by the assessed species, it does not establish minimal requirements to sustain healthy individuals at varying life stages. Such information could be used to establish biologically relevant thresholds of effects on the prey base, and ultimately establish geographical limits to those effects. This information could be used together with the density data discussed above to characterize the likelihood of adverse effects to individuals.
- Information on population responses of prey base organisms to the pesticide. Currently, methodologies are limited to predicting exposures and likely levels of direct mortality, growth or reproductive impairment immediately following exposure to the pesticide. The degree to which repeated exposure events and the inherent demographic characteristics of the prey population play into the extent to which prey resources may recover is not predictable. An enhanced understanding of long-term prey responses to pesticide exposure would allow for a more refined determination of the magnitude and duration of resource impairment, and together with the information described above, a more complete prediction of effects to individual species and potential modification to critical habitat.

2. Problem Formulation

Problem formulation provides a strategic framework for the risk assessment. By identifying the important components of the problem, it focuses the assessment on the most relevant life history stages, habitat components, chemical properties, exposure routes, and endpoints. The structure of this risk assessment is based on guidance contained in U.S. EPA's *Guidance for Ecological Risk Assessment* (USEPA, 1998), the Services' *Endangered Species Consultation Handbook* (USFWS/NMFS, 1998) and is consistent with procedures and methodology outlined in the Overview Document (USEPA, 2004) and reviewed by the U.S. Fish and Wildlife Service and National Marine Fisheries Service (USFWS/NMFS/NOAA, 2004).

2.1. Purpose

The purpose of this endangered species assessment is to evaluate potential direct and indirect effects on individuals of the federally threatened BCB, DS, CTS-CC, and VELB and federally endangered CCR, CFWS, CTS-SC, CTS-SB, SFGS, and TG arising from FIFRA regulatory actions regarding agricultural and non-agricultural uses of bensulide. This ecological risk assessment has been prepared to be consistent with a stipulated injunction in the case *Center for Biological Diversity (CBD) vs. EPA et al*. (Case No. 07-2794-JCS) entered in Federal District Court for the Northern District of California on May 17, 2010.

In this assessment, direct and indirect effects to the BCB, CCR, CFWS, CTS-CC, CTS-SC, CTS-SB, DS, SFGS, TG, and VELB and potential modification to designated critical habitat for the BCB, CTS-CC, CTS-SB, DS, TG, and VELB are evaluated in accordance with the methods described in the Agency's Overview Document (USEPA, 2004).

The BCB was listed as threatened in 1987 by the USFWS. The species primarily inhabits native grasslands on serpentine outcrops around the San Francisco Bay Area in California. The PCEs for BCBs are areas on serpentinite-derived soils that support the primary larval host plant (*i.e*., dwarf plantain) and at least one of the species' secondary host plants. Additional BCB PCEs include the presence of adult nectar sources, aquatic features that provide moisture during the spring drought and areas that provide adequate shelter during the summer diapause.

The CCR was listed by the USFWS as an endangered species in 1970. The species is found only in California in coastal wetlands along the San Francisco estuary and Suisun Bay.

The CFWS was listed as endangered in 1988 by the USFWS. The CFWS inhabits freshwater streams in Central California in the lower Russian River drainage and westward to the Pacific Ocean and coastal streams draining into Tomales Bay and southward into the San Pablo Bay.

There are currently three CTS Distinct Population Segments (DPSs): the Sonoma County (SC) DPS, the Santa Barbara (SB) DPS, and the Central California (CC) DPS. Each DPS is considered separately in the risk assessment as they occupy different geographic areas. The main difference in the assessment will be in the spatial analysis. The CTS-SB was listed by the USFWS as endangered in 2000, the CTS-SC in 2002, and the CTS-CC as threatened in 2004. The CTS-SB and CTS-SC were downlisted from endangered to threatened in 2004 by the USFWS, however, the downlisting was vacated by the U.S. District Court. Therefore, the Sonoma and Santa Barbara DPSs are currently listed as endangered while the CTS-CC is listed as threatened. All CTS populations utilize vernal pools, semi-permanent ponds, and permanent ponds, and the terrestrial environment in California. The aquatic environment is essential for breeding and reproduction and mammal burrows are also important habitat for aestivation. The PCEs for the

CTS are standing bodies of freshwater sufficient for the species to complete the aquatic portion of its life cycle that are adjacent to barrier-free uplands that contain small mammal burrows. An additional PCE is upland areas between sites (as described above) that allow for dispersal of the species.

The DS was listed as threatened on March 5, 1993 (58 FR 12854) by the USFWS (USFWS, 2007). DS are mainly found in the Suisun Bay and the Sacramento-San Joaquin estuary near San Francisco Bay. During spawning, the smelt move into freshwater.

The SFGS was listed as endangered in 1967 by the USFWS. The species is endemic to the San Francisco Peninsula and San Mateo County in California in densely vegetated areas near marshes and standing open water.

The TG was listed as endangered on March 7, 1994 (59 FR 5494) by the USFWS. The animals are benthic in nature and all life stages are found in lagoons, estuaries, and marshes in areas of low to moderate salinity[2]. The TG also occurs in freshwater streams up gradient and tributary to brackish habitats (68920 FR Vol 71, No 228).

The VELB was listed as threatened in 1980 by the USFWS. The species is found in areas with elderberry shrubs throughout California's Central Valley and associated foothills on the east and the watershed of the Central Valley on the west. The PCEs for the VELBs include areas that contain its host plant (*i.e.*, elderberry trees).

In accordance with the Overview Document, provisions of the ESA, and the Services' *Endangered Species Consultation Handbook*, the assessment of effects associated with registrations of bensulide is based on an action area. The action area is the area directly or indirectly affected by the federal action, as indicated by the exceedance of the Agency's Levels of Concern (LOCs). It is acknowledged that the action area for a national-level FIFRA regulatory decision associated with a use of bensulide may potentially involve numerous areas throughout the United States and its Territories. However, for the purposes of this assessment, attention will be focused on relevant sections of the action area including those geographic areas associated with locations of the BCB, DS, CTS-CC, and VELB and federally endangered CCR, CFWS, CTS-SC, CTS-SB, SFGS, and TG and their designated critical habitat (if any) within the state of California. As part of the "effects determination," one of the following three conclusions will be reached separately for each of the assessed species in the lawsuits regarding the potential use of bensulide in accordance with current labels:

- "No effect";
- "May affect, but not likely to adversely affect"; or
- "May affect and likely to adversely affect".

Additionally, for habitat and PCEs, a "No Effect" or a "Habitat Modification" determination is made.

[2] USFWS 2011. http://www.fws.gov/arcata/es/fish/Goby/goby.html

A description of routine procedures for evaluating risk to the San Francisco Bay Species is provided in **Attachment I**.

2.2. Scope

The end result of the EPA pesticide registration process (*i.e.*, the FIFRA regulatory action) is an approved product label. The label is a legal document that stipulates how and where a given pesticide may be used. Product labels (also known as end-use labels) describe the formulation type (*e.g.*, liquid or granular), acceptable methods of application, approved use sites, and any restrictions on how applications may be conducted. Thus, the use or potential use of bensulide in accordance with the approved product labels for California only is "the action" relevant to this ecological risk assessment.

Bensulide is a pre-emergent non-systemic organophosphate herbicide registered for the control of grasses and broadleaf weeds in agricultural crops including a wide variety of field and vegetable crops. It is also used on residential lawns, golf course turf, and ornamental turf. It is applied via the ground application methods of chemigation, broadcast, and band treatment. Bensulide is not labeled for aerial application.

Although current registrations of bensulide allow for use nationwide, this ecological risk assessment and effects determination addresses currently registered uses of bensulide in portions of the action area that are reasonably assumed to be biologically relevant to the assessed species and their designated critical habitats (if any). Further discussion of the action area for the assessed species and their critical habitat is provided in **Section 2.7**.

2.2.1. Evaluation of Degradates

Bensulide is a persistent herbicide that may be transported away from the site of application by runoff or spray drift (in the case of the EC formulation). A degradate is considered to be major if it forms at amounts >10% of the applied parent. Benzenesulfonamide, a minor degradate, only reached a maximum level of 0.52% and is not considered in this assessment. Bensulide oxon, a major degradate, is considered in this assessment. In an aerobic soil metabolism study, bensulide oxon reached a maximum concentration of 13.8%.

Available data on the affinity of bensulide to acetylcholinesterase (Knudsen *et al.*, 2011) indicate that bensulide does not bind to the enzyme, an observation consistent with the non-direct acting mechanism of this chemical. Therefore, it is assumed that animal toxicity observed with bensulide exposure is the product of endogenous or exogenous exposure to the oxon form of the chemical, again in accordance with the non-direct acting mechanism of bensulide and consistent with the understanding that the oxon product of thionated phosphate esters binds with acetylcholinesterase. Based on magnitude of residue studies in *Brassica* leafy vegetables (MRID 473550-01), bensulide oxon is produced, and available environmental fate studies suggest that the oxon is produced under aerobic conditions in the soil microbial community. However, there are no data to allow for an oxon-based assessment of toxicity. Therefore, the aquatic and terrestrial exposure assessments consider the potential for both parent and oxon to be present and assume that observed toxicity data is mediated by exogenous and endogenous production of the oxon. For aquatic exposures, this is accounted for with a total toxic residue approach. Because available data show detectable residues of parent and oxon for *Brassica* leafy vegetables at 33 days but no detectable levels in vegetables at more protracted intervals, it is believed that the use of a 35-day dissipation half-life (for terrestrial exposures) is a conservative way to account for the role of both parent (as an endogenous source of oxon when consumed) and oxon produced in the environment.

2.2.2. Evaluation of Mixtures

The Agency does not routinely include, in its risk assessments, an evaluation of mixtures of active ingredients, either those mixtures of multiple active ingredients in product formulations or those in the applicator's tank. In the case of the product formulations of active ingredients (that is, a registered product containing more than one active ingredient), each active ingredient is subject to an individual risk assessment for regulatory decision regarding the active ingredient on a particular use site. If effects data are available for a formulated product containing more than one active ingredient, they may be used qualitatively or quantitatively in accordance with the Agency's Overview Document and the Services' Evaluation Memorandum (USEPA, 2004; USFWS/NMFS/NOAA, 2004).

There are two registered products that contain bensulide and another registered active ingredient, oxadiazon. Analysis of the available acute oral mammalian LD_{50} data for multiple active ingredient products relative to the single active ingredient is provided in **Appendix A**. This data set is limited, and a qualitative analysis does not support any broad conclusions about the interactive nature of bensulide in combination with other pesticides. Given that the active and inert ingredients would not be expected to have similar mechanisms of action, metabolites or toxicokinetic behavior, it is reasonable to conclude that an assumption of dose-addition would be inappropriate. Consequently, the focus of this assessment is based on the toxicity of the single active ingredient of bensulide.

2.3. Previous Assessments

There are four previously published, relevant risk assessments for bensulide: the 1998 Bensulide Reregistration Eligibility Document (EPA, 1998), the 2000 Interim Reregistration Eligibility Decision (IRED) (U.S. EPA, 2000), the 2000 Addendum to the Bensulide RED: Revised Risk Assessment and Risk Characterization for Risk to Aquatic Organisms from Use on Turf (U.S. EPA, 2000), and the 2007 Pesticide Effects Determination for Risks of Bensulide to the Federally Listed California Red-legged Frog (*Rana aurora draytonii*) (U.S. EPA, 2007).

The 2000 IRED indicated the potential for risk to birds and mammals on an acute and chronic basis, freshwater and estuarine/marine fish and invertebrates on an acute and chronic basis, and aquatic plants. The 2007 Pesticide Effects Determination for Risks of Bensulide to the Federally Listed California Red-legged Frog indicated that bensulide was likely to adversely affect the California red-legged frog and reduce certain prey items, as well as affect designated critical habitat.

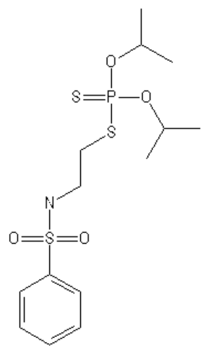
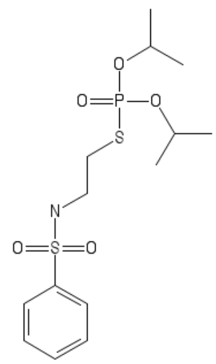
In addition, EPA completed the Registration Review Ecological Risk Assessment Problem Formulation for Bensulide on June 11, 2008. Two new effects studies have been received and reviewed after the CRLF effects assessment and the Registration Review problem formulation were completed (see **Sections 4.2.2** and **4.2.4**). The problem formulation requested the submission of additional toxicity data for registration review, including daphnid and mysid full life cycle toxicity studies and freshwater and estuarine/marine fish full life cycle toxicity studies.

Subsequent to the 2008 Registration Review problem formulation, the Agency also communicated to the registrant of bensulide (Gowan Company), in a response to data waiver requests memo (DP 381471; September 22, 2010), that several other studies were still needed. Environmental fate data needed to evaluate environmental exposure to bensulide include an aerobic soil metabolism study (OCSPP Guideline 835.4100) conducted on at least three additional soils, an aerobic aquatic metabolism study (OCSPP Guideline 835.4300) of two sediment/water systems, and an anaerobic aquatic metabolism study (OCSPP Guideline 835.4400) of two sediment/water systems. In addition, data are needed as well to upgrade a submitted field dissipation study to an acceptable classification. Ecotoxicity data needed to evaluate the oxon of bensulide include an acute freshwater fish toxicity test on both a cold water (rainbow trout, *Oncorhynchus mykiss*) and warm water species (bluegill sunfish, *Lepomis macrochirus*) (OCSPP Guideline 850.1075), an acute freshwater invertebrate toxicity test on *Daphnia magna* (OCSPP Guideline 850.1010), an acute avian oral toxicity test on either an upland game (Northern bobwhite quail, *Colinus virginianus*) or a waterfowl (mallard duck, *Anas platyrhynchos*) and passerine species (OCSPP Guideline 850.2100), and also a full toxicity profile for HED. The full toxicity profile for HED includes an acute oral toxicity test with a rat (OCSPP Guideline 870.1100); an acute dermal toxicity test (OCSPP Guideline 870.1200); an acute inhalation toxicity test with a rat (OCSPP Guideline 870.1300); a primary eye irritation toxicity test with a rabbit (OCSPP Guideline 870.2400); a primary dermal irritation toxicity test (OCSPP Guideline 870.2500); and a dermal sensitization toxicity test (OCSPP Guideline 870.2600).

Although several studies were requested for the Registration Review of bensulide, this effects determination is based on currently available data, and conservative assumptions are made in the absence of data when necessary.

2.4. Physical Properties, Environmental Fate Properties, Mechanism of Action, and Use Characterization of Bensulide

Table 2-1 contains the physical, chemical, and environmental fate properties of bensulide and its major degradate, bensulide oxon submitted by the registrant. The degradate bensulide oxon is more soluble in water (EPISuite v. 4.10) and more mobile in soil (MRID 431807-01) than the parent bensulide (MRID 415320-01).

Table 2-1. Physical and Chemical and Environmental Fate Properties of Bensulide and Its Major Degradate Bensulide Oxon				
Parameter	**Bensulide (Parent)**		**Bensulide Oxon (Major Degradate)**	
	Value	**Reference**	**Value**	**Reference**
Chemical Name	O,O-Diisopropyl-S-2-phenylsulfonylaminoethyl phosphorodithioate	MRID 457618-01	O,O-diisopropyl-S-2-phenylsulphonylaminoethylphosphorothioate	MRID 457618-01
CAS Number	741-58-2	MRID 457618-01	20243-81-6	MRID 476604-03
Empirical Formula	$C_{14}H_{24}NO_4PS_3$	MRID 457618-01	$C_{14}H_{24}NO_5PS_2$	EPI Suite (v 4.10)
Molecular Weight (g/mole)	397.54	MRID 457618-01	381.44	EPI Suite (v 4.10)
Chemical Structure		EPI Suite (v 4.10)		EPI Suite (v 4.10)
SMILES Code	CC(C)OP(=S)(OC(C)C)SCCNS(=O)(=O)c1ccccc1	EPI Suite v4.10	CC(C)OP(=O)(OC(C)C)SCCNS(=O)(=O)c1ccccc1	EPI Suite (v 4.10)
Melting Point (ºC)	36	MRID 415320-01	89.97	EPI Suite (v 4.10)
Boiling Point (ºC)	424.96	EPI Suite (v 4.10)	476.9	EPI Suite (v 4.10)
Vapor pressure (mm Hg @ 25^{o}C)	8.2×10^{-7}	MRID 415320-01	$2.48\ 10^{-8}$	EPI Suite (v 4.10)
Henry's Constant (atm m^3 $mole^{-1}$)	7.7×10^{-8}	MRID 415320-01	7.10×10^{-12}	EPI Suite (v 4.10)
Solubility (mg//L @ 25^{o}C)	5.6	MRID 415320-01	461.24	EPI Suite (v 4.10)
K_{ow}	4.20	EPI Suite (v 4.10)	2.35	EPI Suite (v 4.10)
K_d (mL/g)	10.9 Sand 30.5 Sandy Loam Soil 34.0 Clay Loam Soil 1 96.8 Clay Loam Soil 2	MRID 428267-01	1.96 Sand 4.23 Sandy Loam Soil 6.05 Clay Loam Soil 1 26.5 Clay Loam Soil 2	MRID 431807-01
K_{oc} (mL/g)	3479.93 Sand 1348.26 Sandy Loam Soil 4379.47 Clay Loam Soil 1 2327.52 Clay Loam Soil 2	MRID 428267-01 (2884 mL/g) (average of 4 values, EFED Guideline)	625.75 Sand 186.99 Sandy Loam Soil 778.70 Clay Loam Soil 1 636.70 Clay Loam Soil 2	MRID 431807-01 (557 mL/g) (average of 4 values, EFED Guideline)

An aerobic aquatic metabolism study was not available for this assessment. The aerobic soil study was classified as supplemental as only one soil type was used ($t_{1/2}$ = 363 days). Information from acceptable and supplemental laboratory studies indicates bensulide is persistent. Neither abiotic hydrolysis nor photolysis are major degradation processes in water or on soil surfaces. The main route of dissipation of bensulide appears to be aerobic soil metabolism. Under aerobic conditions, mineralization of bensulide to carbon dioxide (up to 21% CO_2) appears to be the major mechanisms of dissipation in the soil (MRID 404603-01). Under anaerobic soil conditions in the laboratory, bensulide did not degrade and considered stable in anaerobic terrestrial ecosystems (MRID 404603-02).

Information from acceptable laboratory studies indicates that bensulide is slightly mobile in the four soils tested (K_{oc}'s ranged from 1,433 to 4,326 mL/g) (MRID 428267-01); however, the major degradate bensulide oxon (N-[(2-(diisopropoxyphosphinoy1thio)-1-ethyl]-benzenesulfonamide) (average K_{oc} = 557) (MRID 431807-01) and the minor degradate benzenesulphonamide) (average K_{oc} = 17.72) (MRID 431807-02) ranged from moderately mobile to highly mobile in the same four test soils. Bensulide has the potential to be transported dissolved in water and on suspended sediment in runoff to surface waters where, based on laboratory data, it is expected to persist. Bensulide is not expected to leach to ground water.

Of the nine field dissipation studies submitted, three are classified as invalid and six are supplemental. Among supplemental studies, three was conducted in California with reported half-lives ranged from 15-34 days (MRID 405349-02, 405349-04 and 405349-05) and others were conducted in Mississippi with the half-lives ranged from 30-210 days (MRID 405349-01, 405349-03 and 405349-06). The field dissipation data confirmed the laboratory findings that bensulide is a persistent herbicide. Bensulide and its major degradate bensulide oxon were found in the top 3 inches of the soil, but the residues were detected down to 6-12 inches soil in both California (MRID 405349-02, 405349-04 and 405349-05) and Mississippi (MRID 405349-01, 405349-03 and 405349-06). .

With a reported fish whole body bioconcentration factor (BCF) of 550 and a whole body elimination of 98% after 14 days depuration, bensulide does not appear to have the potential to substantially bioaccumulate in fish.

2.4.1. Environmental Transport Mechanisms

Ground spray applications may potentially result in transport and loading of bensulide to off-field soil and foliage via spray drift. Granular ground application methods are not expected to result in granules being distributed to off-field soil; however on-field bensulide soil residues, from either ground spray or granular application methods, have the potential to be transported both dissolved in water and on suspended soil in runoff to off-field terrestrial areas and to adjacent surface waters. Once in the aquatic system, bensulide is expected to partition primarily to sediment where it will be relatively stable. However as discussed above, based on results of a fish bioconcentration study in which the BCF was not significant and the depuration rate was relatively fast, biomagnification up through the food web is not expected to be a significant transport pathway.

In general, deposition of drifting or volatilized pesticides is expected to be greatest close to the site of application. A computer model of spray drift (AgDRIFT Version 2.1.1) is used to determine if the exposures to aquatic and terrestrial organisms are below the Agency's LOCs. If the limit of exposure that is below the LOC can be determined using AgDRIFT, longer-range transport is not considered in defining the action area. For example, if a buffer zone <1,000 feet (the optimal range for AgDRIFT) results in terrestrial and aquatic exposures that are below LOCs, no further drift analysis is required. In addition to the use of spray drift models to determine potential off-site transport of pesticides, other factors such as available air monitoring data and the physicochemical properties of the chemicals are also considered (**Table 2-1**).

2.4.2. Mechanism of Action

Bensulide is a pre-emergent organophosphate herbicide that inhibits meristematic tissues in root tips and inhibits seedling growth by conjugation of acetyl co-enzyme A; the specific site of conjugation is unknown. It is usually applied to bare ground before crops are planted and is not translocated in the plant.

The mode of toxic action to non-target organisms (*e.g.*, mammals) is via the inhibition of cholinesterase and accumulation of acetylcholine at the nerve synapses, resulting in classic symptoms of organophosphate poisoning.

2.4.3. Use Characterization

Analysis of labeled use information is the critical first step in evaluating the federal action. The current labels for bensulide represent the FIFRA regulatory action; therefore, use and application rates specified on the label form the basis of this assessment. The assessment of use information is critical to the development of the action area and selection of appropriate modeling scenarios and inputs.

Bensulide is an organophosphate herbicide currently registered for use on a variety of field and vegetable crops and ornamental and residential lawns and turf, as well as golf course turf (see **Appendix B** for Verification Memo for the use pattern of bensulide). The use profile is based on the current, federally registered uses (Section 3) and California special local needs uses (Section 24c). Section 3 (nation-wide) and Section 24(c) (California) registered uses for bensulide were reviewed, including, when available, the labeled single maximum application rate, number of applications allowed per year, the minimum time between treatments, and the application type . **Table 2-2** includes representative maximum labeled application rates for bensulide in California.

Table 2-2. Maximum Labeled Application Rates for Bensulide in California

Use	Application Method[1,2]	Maximum Single Application Rate (lb a.i./A)	Maximum Number of Applications per Year	Maximum Yearly Application Rate (lb a.i./A)	Application Interval (days)
Golf course turf	Broadcast – granular	16	2	NS (32)	NS (120)
Golf course turf, ornamental lawns and turf	Broadcast – spray	12.5	2	25	NS (120)
Residential lawns	Broadcast – granular	12.5	2	NS (25)	NS (120)

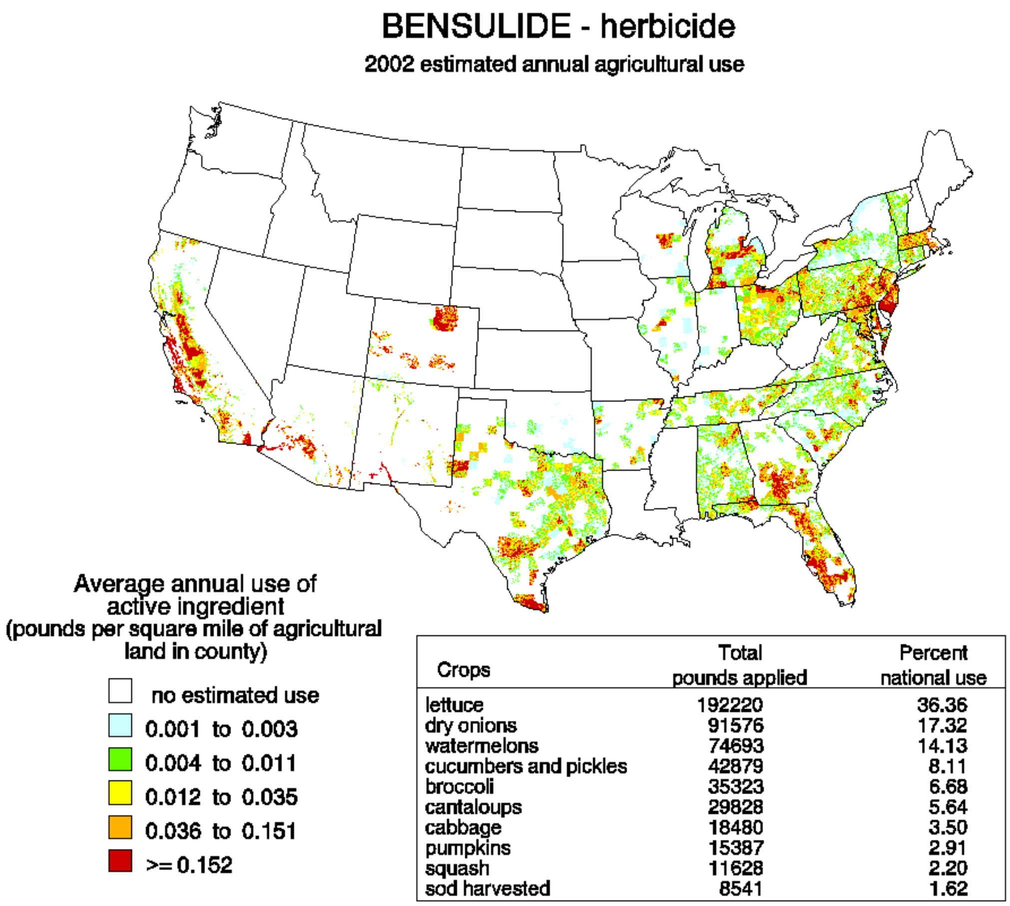
Table 2-2. Maximum Labeled Application Rates for Bensulide in California					
Use	**Application Method[1,2]**	**Maximum Single Application Rate (lb a.i./A)**	**Maximum Number of Applications per Year**	**Maximum Yearly Application Rate (lb a.i./A)**	**Application Interval (days)**
	Broadcast – spray	9	NS (2)	NS (18)	120
Artichokes, beans, beet, bell pepper, *Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cardoon, cauliflower, celery, celtuce, chervil, chicory/radicchio, chrysanthemum (garland), cole crops, collards, corn salad, cress (garden, upland), dandelion, dock (sorrel), eggplant, endive, fennel, garlic, greens, groundcherry (strawberry tomato/tomatillo), kale, kohlrabi, leafy vegetables, lettuce (head, leaf), mustard, mustard cabbage, okra, onion (dry bulb and green), orach (mountain spinach), parsley, peas, pepper, pepper (chili), pimento, radish, roquette (arugula), shallot, spinach, Swiss chard	Broadcast – spray	6	NS (1, 2, or 3)	NS (6, 12, or 18)	NS (120)
Cantaloupe, chayote, cucumber, cucurbit vegetables, cucuzzi, gherkin, gourds, gourd (wax), melons (bitter, honeydew, citron, mango, musk, water, winter melons), pepino, pumpkin, squash (butternut, summer, zucchini squash)	Broadcast – spray	9	NS (1 or 2)	NS (9 or 18)	NS (120)

[1]When there are several application methods (because of different types of formulation), the chosen method would either result in the highest environmental exposure or was labeled for a higher maximum rate than other application methods.
NS – Not specified. Number in parentheses is assumed. When yearly application rates were not specified on the label, the Agency utilized information obtained from BEAD for the number of crop cycles per year in California, which was determined for methomyl (U.S. EPA, 2007b).
Note: Pineapple was included in BEAD's LUIS report; however, the 24(c) SLN label (CA960003) did not include this use site. Therefore, pineapple is not included in this assessment.

Most bensulide product labels specify application rates on a per season basis (not on a per year basis). Information from the Agency's Biological and Economic Analysis Division (BEAD) indicates that many crops can be grown more than once per year in California (USEPA, 2007b). Although standard PRZM scenarios consist of only one crop cycle per year, multiple crop cycles were considered using multiple applications with a 120-day retreatment interval. All crops that can be treated with bensulide may be grown multiple times in a calendar year. The cropping seasons range between two and four cycles per year; for this assessment, one, two, and/or three cycles were modeled.

According to the United States Geological Survey's (USGS) national pesticide usage data (based on information from 1999 to 2004), an average of 520,555 lb of bensulide is applied nationally to agricultural use sites in the U.S. (non-agricultural uses are not included) (**Figure 2-1**). Of this, about 36% of the total usage was on lettuce, 17% was on dry onions, and 14% was on watermelons.

Figure 2-1. Bensulide Use in Total Pounds per County.
(http://water.usgs.gov/nawqa/pnsp/usage/maps/show_map.php?year=02&map=m1098)



Crops	Total pounds applied	Percent national use
lettuce	192220	36.36
dry onions	91576	17.32
watermelons	74693	14.13
cucumbers and pickles	42879	8.11
broccoli	35323	6.68
cantaloups	29828	5.64
cabbage	18480	3.50
pumpkins	15387	2.91
squash	11628	2.20
sod harvested	8541	1.62

BEAD provided an analysis of both national- and county-level usage information (USEPA, 2011a) using state-level usage data obtained from USDA-NASS[3], Doane (www.doane.com; the full dataset is not provided due to its proprietary nature) and the California's Department of Pesticide Regulation Pesticide Use Reporting (CDPR PUR) database.[4] CDPR PUR is considered a more comprehensive source of usage data than USDA-NASS or EPA proprietary databases, and thus the usage data reported for bensulide by county in this California-specific assessment were generated using CDPR PUR data. Twelve years (1999-2010) of usage data were included in this analysis. Data from CDPR PUR were obtained for every agricultural pesticide application

[3] United States Depart of Agriculture (USDA), National Agricultural Statistics Service (NASS) Chemical Use Reports provide summary pesticide usage statistics for select agricultural use sites by chemical, crop and state. See http://www.pestmanagement.info/nass/app_usage.cfm.
[4] The California Department of Pesticide Regulation's Pesticide Use Reporting database provides a census of pesticide applications in the state. See http://www.cdpr.ca.gov/docs/pur/purmain.htm.

made on every use site at the section level (approximately one square mile) of the public land survey system.[5] BEAD summarized these data to the county level by site, pesticide, and unit treated. Calculating county-level usage involved summarizing across all applications made within a section and then across all sections within a county for each use site and for each pesticide. The county level usage data that were calculated include: average annual pounds applied, average annual area treated, and average and maximum application rate across all eleven years. The units of area treated are also provided where available. Between 1999 and 2010, annual use of bensulide in California ranged from approximately 188,800 to 282,200 pounds a.i. A summary of bensulide usage for all California usage sites is provided below in **Table 2-3.** It should be noted that several of the maximum application rates greatly exceed the labeled application rates and should be considered misuses unless they can be accounted for due to errors in reporting.

Table 2-3. Summary of California Department of Pesticide Registration (CDPR) Pesticide Use Reporting (PUR) Data from 1999 to 2010 for Bensulide[1]

Site Name	Average Application Rate (lb a.i./A)	Maximum Application Rate (lb a.i./A)
ALFALFA	2.0	2.0
ANISE	3.9	4.0
ARRUGULA	4.7	35.4
ARTICHOKE, GLOBE	3.8	4.0
AVOCADO	5.9	5.9
BASIL, SWEET	3.0	3.0
BEAN, SUCCULENT	2.5	2.5
BEET	5.4	6.6
BOK CHOY	4.6	48.6
BROCCOLI	2.6	40.0
BRUSSELS SPROUT	2.6	5.9
CABBAGE	4.3	39.7
CABBAGE, SAVOY	5.0	5.0
CANOLA (RAPE)	4.2	5.0
CANTALOUPE	2.3	185.9
CARDOON	5.0	7.1
CARROT	0.6	0.6
CAULIFLOWER	2.9	47.6
CELERY	4.8	9.6
CHERVIL	1.6	1.6
CHICORY	2.9	11.9
CHINESE CABBAGE (NAPPA)	4.3	24.8
CHINESE GREENS	5.1	13.8
CILANTRO	4.6	19.8
COLE CROP	2.4	6.0
COLLARD	5.0	25.6

[5] Most pesticide applications to parks, golf courses, cemeteries, rangeland, pastures, and along roadside and railroad rights of way, and postharvest treatments of agricultural commodities are reported in the database. The primary exceptions to the reporting requirement are home-and-garden use and most industrial and institutional uses (http://www.cdpr.ca.gov/docs/pur/purmain.htm).

Table 2-3. Summary of California Department of Pesticide Registration (CDPR) Pesticide Use Reporting (PUR) Data from 1999 to 2010 for Bensulide[1]		
Site Name	**Average Application Rate (lb a.i./A)**	**Maximum Application Rate (lb a.i./A)**
CORN, HUMAN CONSUMPTION	3.3	6.0
COTTON	0.4	0.8
CUCUMBER	4.0	8.9
DANDELION GREEN	6.2	59.1
EGGPLANT	5.3	21.5
ENDIVE (ESCAROLE)	3.5	39.7
FENNEL	5.4	49.9
GAI CHOY	3.8	9.9
GAI LON	4.7	7.5
GRAPE, WINE	2.0	4.0
HERB, SPICE	4.0	5.0
KALE	4.8	47.6
KOHLRABI	3.2	6.4
LANDSCAPE MAINTENANCE	3.3	9.5
LETTUCE, HEAD	2.6	24.6
LETTUCE, LEAF	3.4	152.0
MELON	2.1	13.9
MIZUNA	4.5	31.7
MUSTARD	4.8	48.2
MUSTARD GREENS	4.0	4.0
N-GRNHS FLOWER	0.3	0.3
N-GRNHS PLANTS IN CONTAINERS	0.4	0.6
N-OUTDR FLOWER	4.8	27.8
N-OUTDR PLANTS IN CONTAINERS	3.0	5.0
N-OUTDR TRANSPLANTS	5.0	8.2
OAT	2.0	2.0
ONION, DRY	2.8	6.9
ONION, GREEN	3.1	5.9
PARSLEY	5.2	51.0
PEAS	4.1	11.2
PEPPER, FRUITING	3.5	15.9
PEPPER, SPICE	3.3	5.9
PIMENTO	4.0	4.0
PUMPKIN	4.6	8.9
RADISH	4.2	5.7
RANGELAND	4.7	5.9
RAPPINI	4.0	5.9
RESEARCH COMMODITY	4.5	7.9
RIGHTS OF WAY	3.7	5.0
SOIL FUMIGATION/PREPLANT	5.0	6.0
SPINACH	3.2	6.0
SQUASH	4.4	24.1
SQUASH, SUMMER	3.6	8.9
SQUASH, WINTER	6.2	49.6
SQUASH, ZUCCHINI	3.9	5.9

Table 2-3. Summary of California Department of Pesticide Registration (CDPR) Pesticide Use Reporting (PUR) Data from 1999 to 2010 for Bensulide[1]		
Site Name	**Average Application Rate (lb a.i./A)**	**Maximum Application Rate (lb a.i./A)**
STRAWBERRY	0.2	0.2
SWISS CHARD	4.0	5.9
TOMATILLO	3.0	3.0
TOMATO	5.2	5.5
TURF/SOD	5.7	12.6
TURNIP	4.0	6.0
UNCULTIVATED AG	3.9	5.9
UNCULTIVATED NON-AG	3.1	5.0
UNKNOWN	5.4	158.6
VEGETABLE	4.7	5.9
VEGETABLES, LEAFY	3.7	5.9
VERTEBRATE CONTROL	0.9	1.3
WATERMELON	4.4	39.7

[1] Based on data supplied by BEAD (USEPA, 2011a). Data is only shown when reported on an acre basis. Several reports of usage were made for sites on which bensulide is not registered for use. In addition, many maximum application rates are higher than those registered on labels.

2.5. Assessed Species

Table 2-4 provides a summary of the current distribution, habitat requirements, and life history parameters for the listed species being assessed. More detailed life-history and distribution information can be found in **Attachment II**. See **Figures 2-2** through **2-9** for maps of the current range and designated critical habitat, if applicable, of the assessed listed species. See **Section 2.1** for information on when each species was listed and a general description of their ranges.

Table 2-4. Summary of Current Distribution, Habitat Requirements, and Life History Information for the Assessed Listed Species[1]						
Assessed Species	**Size**	**Current Range**	**Habitat Type**	**Designated Critical Habitat?**	**Reproductive Cycle**	**Diet**
Bay Checkerspot Butterfly (BCB) (*Euphydryas editha bayensis*)	Adult butterfly - 5 cm in length	Santa Clara and San Mateo Counties [Because the BCB distribution is considered a metapopulation, any site with appropriate habitat in the vicinity of its historic range (Alameda, Contra Costa, San Francisco, San Mateo, and Santa Clara counties) should be considered potentially occupied by the butterfly (USFWS 1998, p. II-177)].	1) Primary habitat – native grasslands on large serpentine outcrops; 2) Secondary habitat – 'islands' of smaller serpentine outcrops with native grassland; 3) Tertiary habitat – non-serpentine areas where larval food plants occur	Yes	Larvae hatch in March – May and grow to the 4^{th} instar in about two weeks. The larvae enter into a period of dormancy (diapause) that lasts through the summer. The larvae resume activity with the start of the rainy season. Larvae pupate once they reach a weight of 300 - 500 milligrams. Adults emerge within 15 to 30 days depending on thermal conditions, feed on nectar, mate and lay eggs during a flight season that lasts 4 to 6 weeks from late February to early May	Obligate with dwarf plantain. Primary diet is dwarf plantain plants (may also feed on purple owl's-clover or exserted paintbrush if the dwarf plantains senesce before the larvae pupate). Adults feed on the nectar of a variety of plants found in association with serpentine grasslands
California Clapper Rail (CCR) (*Rallus longirostris obsoletus)*	250 - 350 g Juveniles ~50 g[2]	Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma counties	Tidal marsh habitat	No	Breeding: Feb. - August Nesting: mid-March-Aug. Lay Eggs: March - July Incubation: 23 to 29 days; Leave nest: 35 to 42 days after hatch; Juveniles fledge at ten weeks and can breed during the spring after they hatch	Opportunistic feeders: freshwater and estuarine invertebrates, seeds, worms, mussels, snails, clams, crabs, insects, and spiders; occasionally consume small birds and mammals, dead fish, up to 15% plant material
California Freshwater	Up to 50 mm	Marin, Napa, and Sonoma Counties, CA	Freshwater, perennial streams;	No	Breed once a year, typically in Sept. Eggs	Feed on detritus (algae, aquatic

Table 2-4. Summary of Current Distribution, Habitat Requirements, and Life History Information for the Assessed Listed Species[1]						
Assessed Species	**Size**	**Current Range**	**Habitat Type**	**Designated Critical Habitat?**	**Reproductive Cycle**	**Diet**
Shrimp (CFWS) (*Syncaris pacifica*)	postorbital length (from the eye orbit to tip of tail)		they prefer quiet portions of tree-lined streams with underwater vegetation and exposed tree roots		adhere to the pleopods and are cared for 8 – 9 months; embryos emerge during May or early June.	macrophyte fragments, zooplankton, and aufwuchs)
California Tiger Salamander (CTS) (*Ambystoma californiense*)	Adult 14.2-80.5 g[3]	CTS-SC are primarily found on the Santa Rosa Plain in Sonoma County. CTS-CC occupies the Bay Area (central and southern Alameda, Santa Clara, western Stanislaus, western Merced, and the majority of San Benito Counties), Central Valley (Yolo, Sacramento, Solano, eastern Contra Costa, northeast Alameda, San Joaquin, Stanislaus, Merced, and northwestern Madera Counties), southern San Joaquin Valley (portions of Madera, central Fresno, and northern Tulare and Kings Counties), and the Central Coast Range (southern Santa Cruz, Monterey, northern San Luis Obispo, and portions of western San Benito, Fresno, and Kern Counties). CTS-SB are found in Santa Barbara County.	Freshwater pools or ponds (natural or man-made, vernal pools, ranch stock pools, other fishless ponds); Grassland or oak savannah communities, in low foothill regions; Small mammal burrows	Yes	Emerge from burrows and breed: fall and winter rains Eggs: laid in pond Dec. – Feb., hatch: after 10 to 14 days Larval stage: 3-6 months, until the ponds dry out, metamorphose late spring or early summer, migrate to small mammal burrows	Aquatic Phase: algae, snails, zooplankton, small crustaceans, and aquatic larvae and invertebrates, smaller tadpoles of Pacific tree frogs, CRLF, toads; Terrestrial Phase: terrestrial invertebrates, insects, frogs, and worms
Delta Smelt (*Hypomesus transpacificus*)	Up to 120 mm in length	Suisun Bay and the Sacramento-San Joaquin estuary (known as the Delta) near San Francisco	The species is adapted to living in fresh and brackish	Yes	They spawn in fresh or slightly brackish water upstream of the mixing	They primarily eat planktic copepods, cladocerans,

Table 2-4. Summary of Current Distribution, Habitat Requirements, and Life History Information for the Assessed Listed Species[1]						
Assessed Species	**Size**	**Current Range**	**Habitat Type**	**Designated Critical Habitat?**	**Reproductive Cycle**	**Diet**
		Bay, CA	water. They typically occupy estuarine areas with salinities below 2 parts per thousand (although they have been found in areas up to 18ppt). They live along the freshwater edge of the mixing zone (saltwater-freshwater interface).		zone. Spawning season usually takes place from late March through mid-May, although it may occur from late winter (Dec.) to early summer (July-August). Eggs hatch in 9 – 14 days.	amphipods, and insect larvae. Larvae feed on phytoplankton; juveniles feed on zooplankton.
San Francisco Garter Snake (SFGS) (*Thamnophis sirtalis tetrataenia*)	Adult (46-131 cm in length), Females – 227 g, Males – 113 g; Juveniles – 2 g (Cover Jr. and Boyer, 1988) (18–20 cm in length)	San Mateo County	Densely vegetated freshwater ponds near open grassy hillsides; emergent vegetation; rodent burrows	No	Oviparous Reproduction[4] Breeding: Spring (Mar. and Apr.) and Fall (Sept. to Nov.) Ovulation and Pregnancy: Late spring and early summer Young: Born 3-4 months after mating	Juveniles: frogs (Pacific tree frog, CRLF, and bullfrogs depending on size) and insects Adults: primarily frogs (mainly CRLFs; also bullfrogs, toads); to a lesser extent newts; freshwater fish and invertebrates; insects and small mammals
Tidewater goby (*Eucyclogobius newberryi*)	Up to 50 mm in length	Lagoons, estuaries and salt marshes along the coast of California, 5 km south of the California/ Oregon border and 71 km north of the California/Mexico border	Shallow (0.1 – 2 m), still-to-slow moving, aquatic habitat most commonly ranging in salinity from 0.5 to 10 ppt.	Yes	They spawn in slightly brackish water between 2 and 27 ppt. They have been observed spawning in every month of the year except December; reproduction peaks in	They feed mainly on macroinvertebrates such as mysid shrimp, gammarid amphipods, ostracods and aquatic insects such as chironomid larvae.

Table 2-4. Summary of Current Distribution, Habitat Requirements, and Life History Information for the Assessed Listed Species[1]						
Assessed Species	**Size**	**Current Range**	**Habitat Type**	**Designated Critical Habitat?**	**Reproductive Cycle**	**Diet**
					late April to July	Small TG (four to eight mm SL) probably feed on unicellular phytoplankton or zooplankton similar to many other early stage larval fishes.
Valley Elderberry Longhorn Beetle (VELB) (*Desmocerus californicus dimorphus*)	Males: 1.25–2.5 cm length Females: 1.9–2.5 cm length	Central Valley of California (from Shasta County to Fresno County in the San Joaquin Valley)	Completely dependent on its host plant, elderberry (*Sambucus species*), which is a common component of the remaining riparian forests and adjacent upland habitats of California's Central Valley	Yes	The larval stage may last 2 years living within the stems of an elderberry plant. Then larvae enter the pupal stage and transform into adults. Adults emerge and are active from March to June feeding and mating, when the elderberry produces flowers.	Obligates with elderberry trees (*Sambucus* sp). Adults eat the elderberry foliage until about June when they mate. Upon hatching the larvae tunnel into the tree where they will spend 1-2 years eating the interior wood which is their sole food source.

[1] For more detailed information on the distribution, habitat requirements, and life history information of the assessed listed species, see Attachment II.
[2] No data on juvenile CCR body weights are available at this time. As a surrogate for CCR juveniles, data on captive 21-day king rails were averaged for the juvenile body weight. King rails make an appropriate proxy for the CCR in the absence of information. The birds were once considered the same species by taxonomists, are members of the same genus (*Rallus*), and occasionally interbreed where habitats overlap.
[3] See Page 369 of Trenham *et al.* (2000).
[4] Oviparous = eggs hatch within the female's body and young are born live.

Figure 2-2. Bay Checkerspot Butterfly Critical Habitat and Occurrence Sections Identified in Case No. 07-2794-JCS.

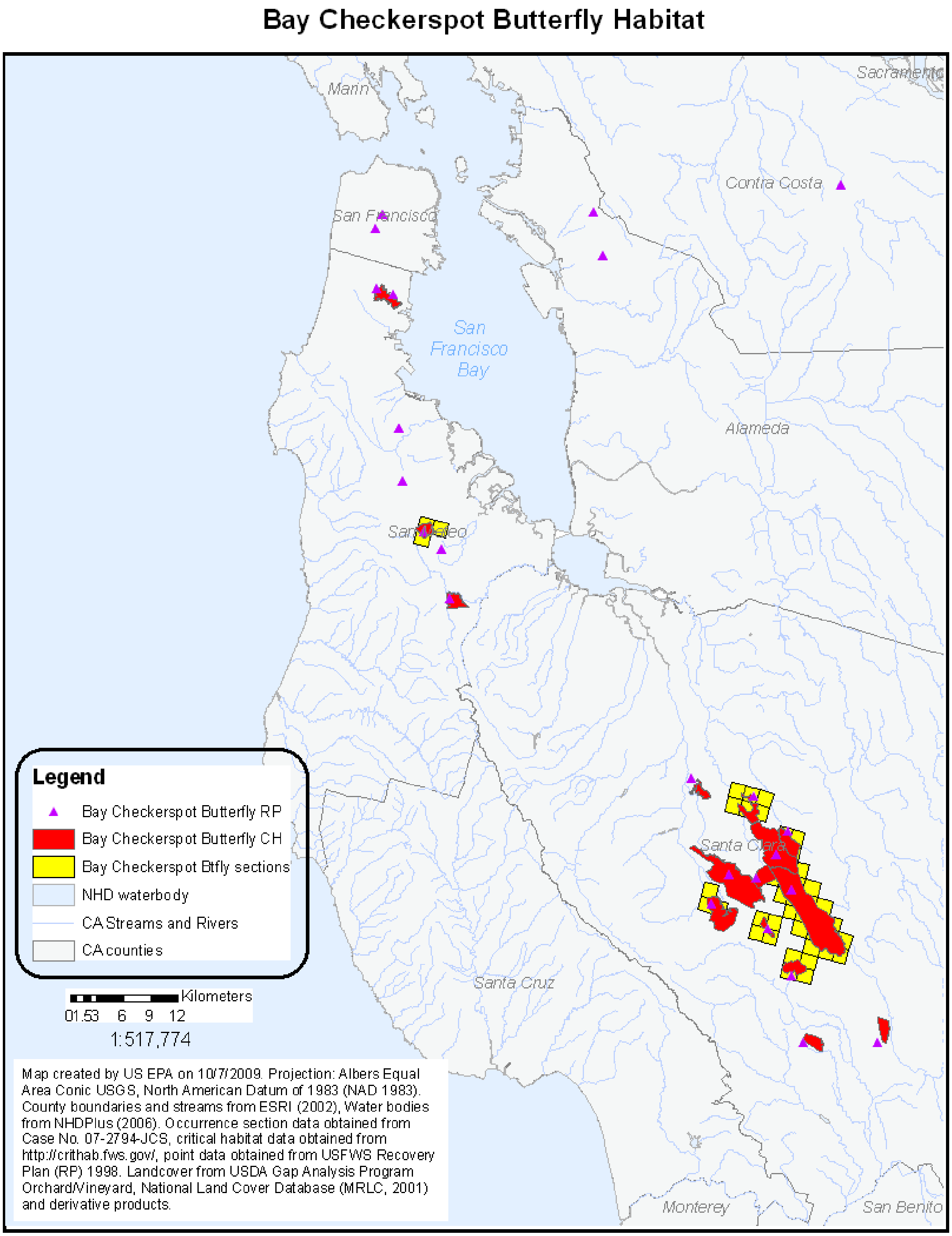


Figure 2-3. California Clapper Rail Habitat and Occurrence Sections Identified in Case No. 07-2794-JCS.

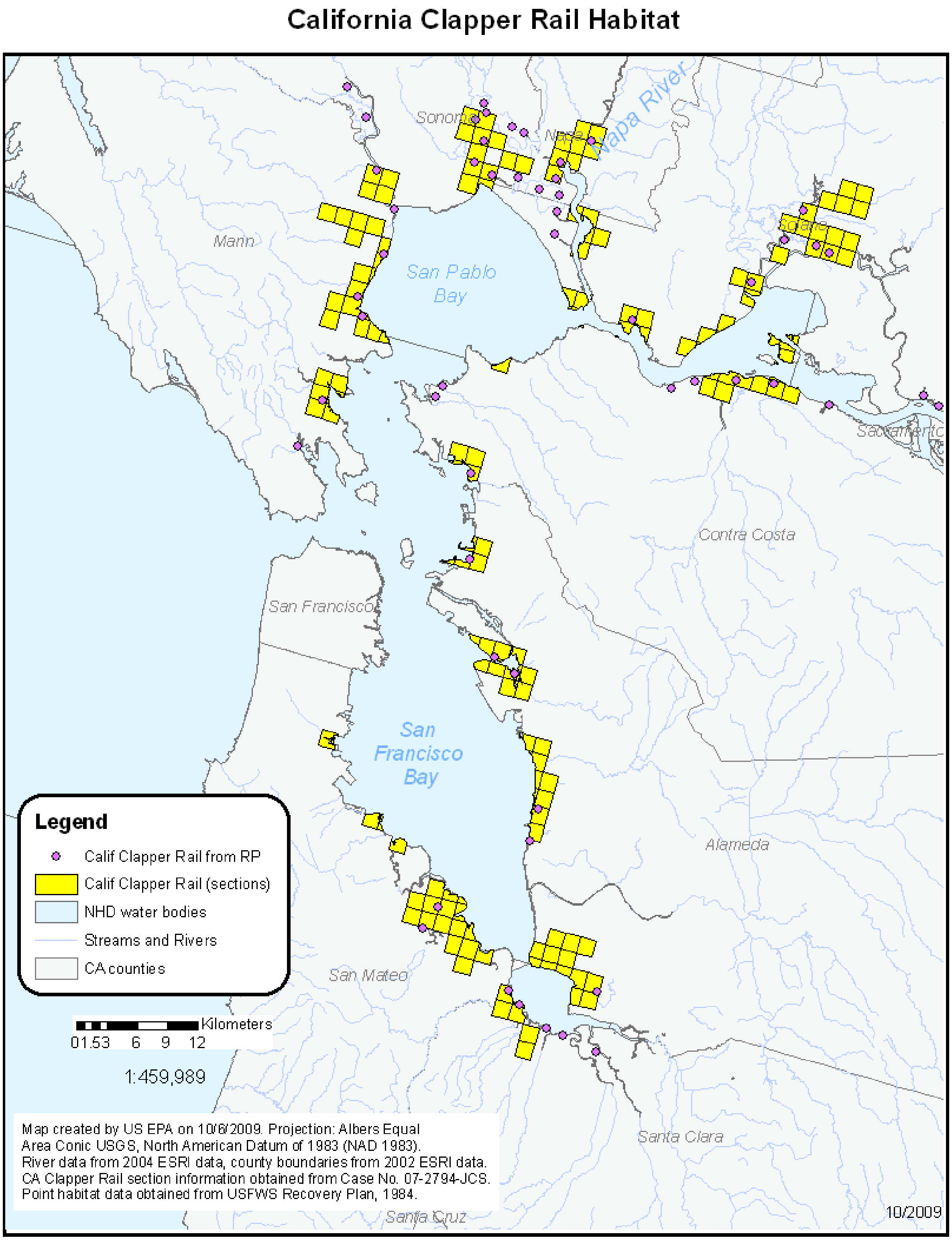


Figure 2-4. California Freshwater Shrimp Habitat and Occurrence Sections identified in Case No. 07-2794-JCS.

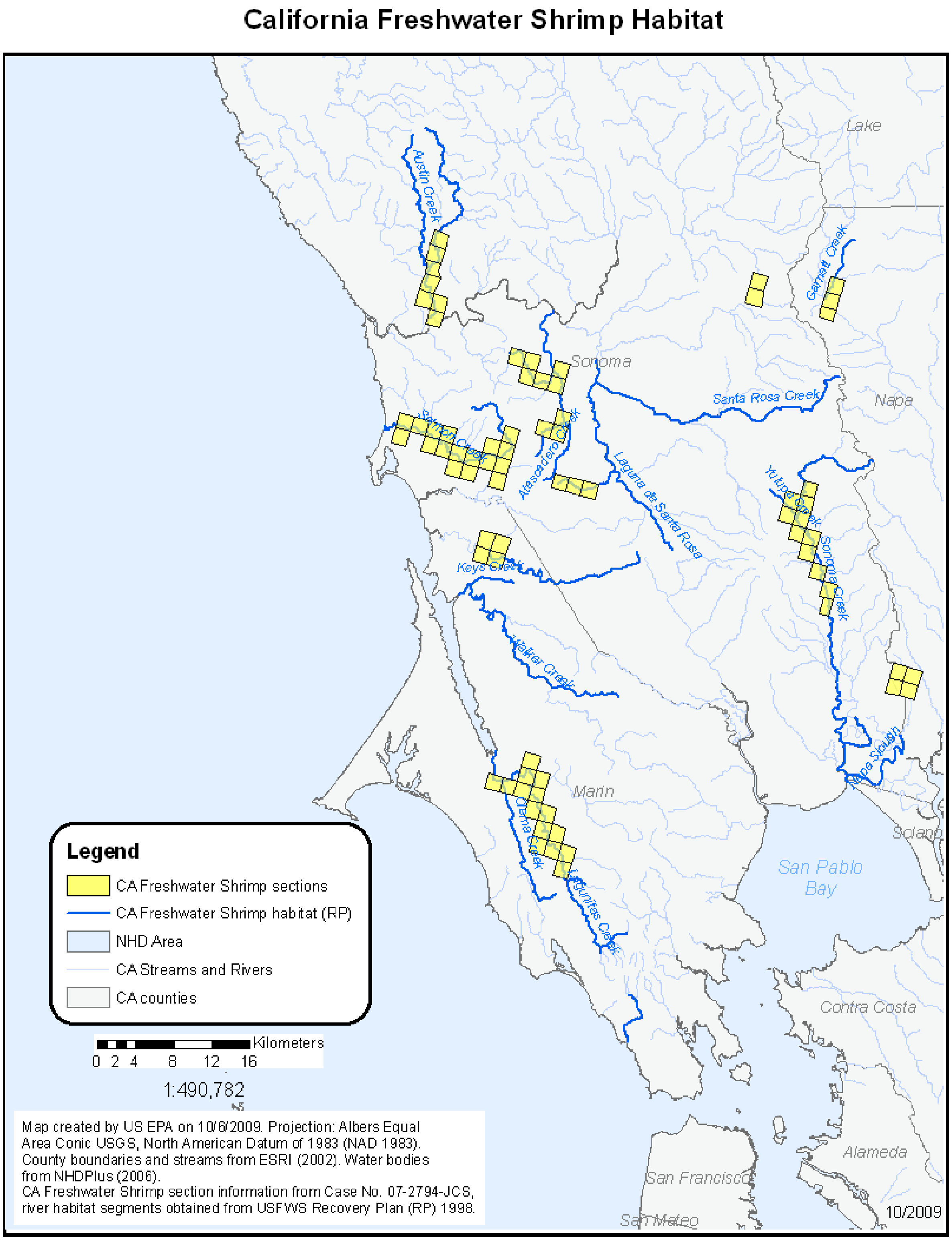


Figure 2-5. California Tiger Salamander Critical Habitat and Occurrence Sections identified in Case No. 07-2794-JCS.

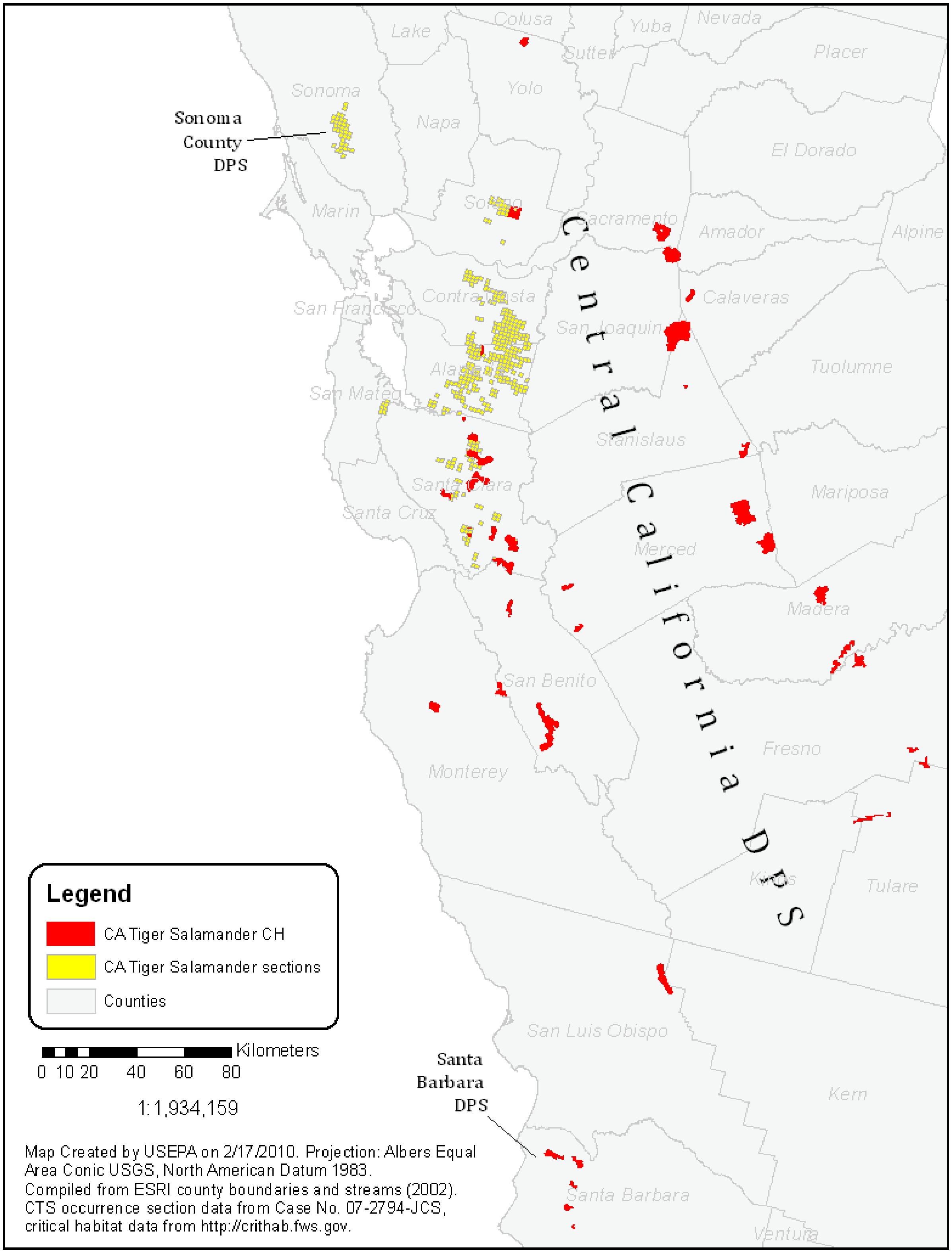


Figure 2-6. Delta Smelt Critical Habitat and Occurrence Sections identified in Case No. 07-2794-JCS.

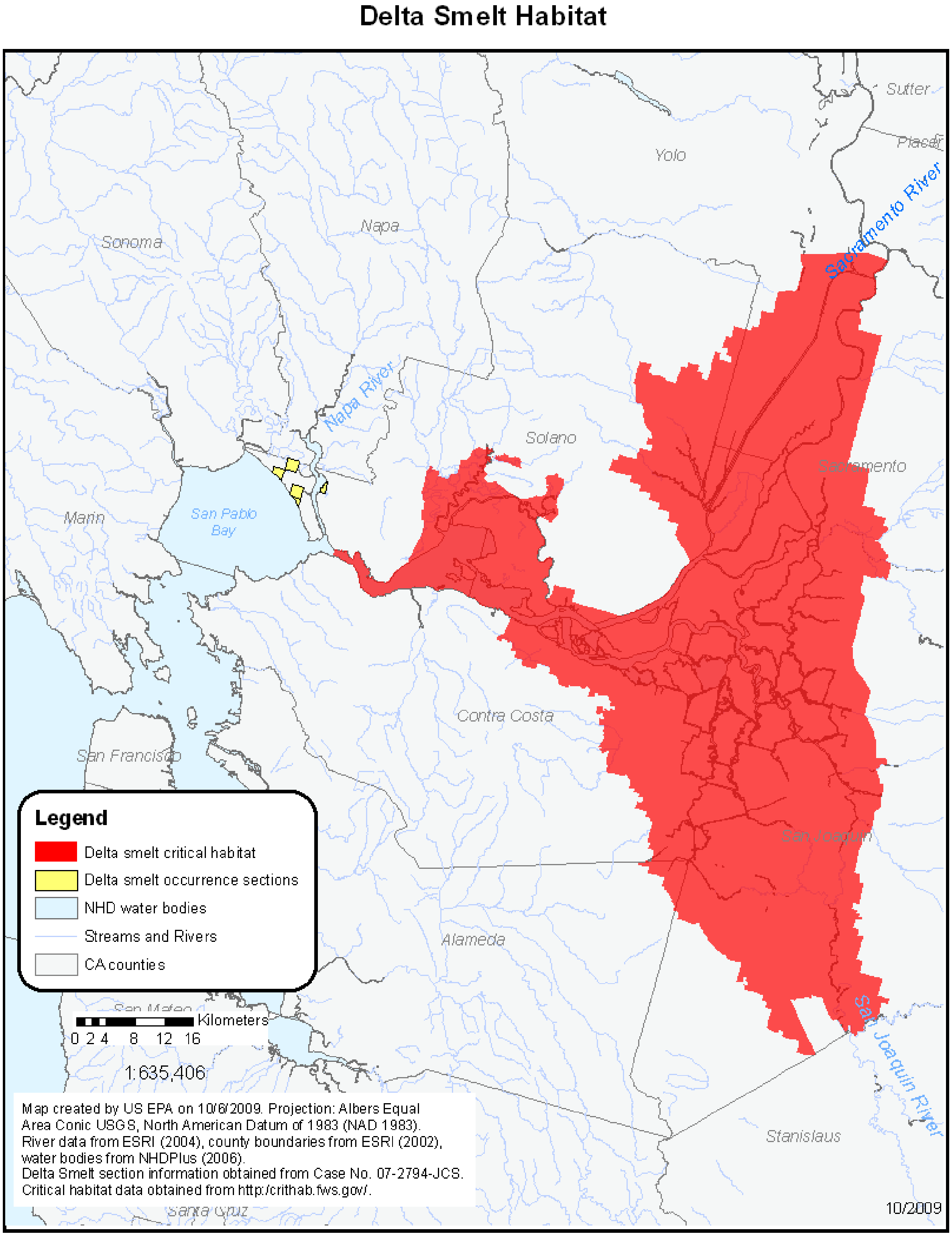


Figure 2-7. San Francisco Garter Snake Habitat and Occurrence Sections identified in Case No. 07-2794-JCS.

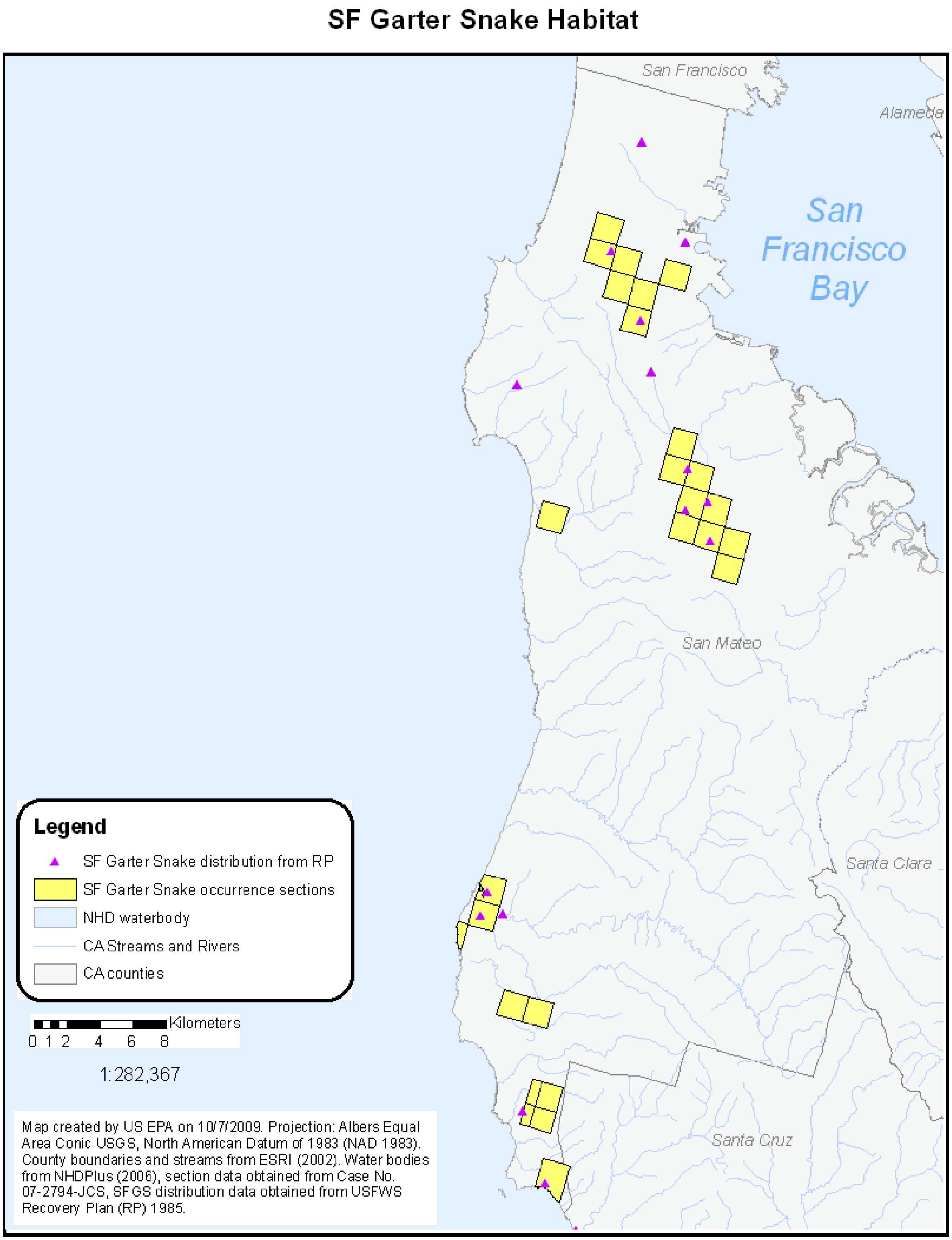


Figure 2-8. Tidewater Goby Critical Habitat identified in Case No. 07-2794-JCS.

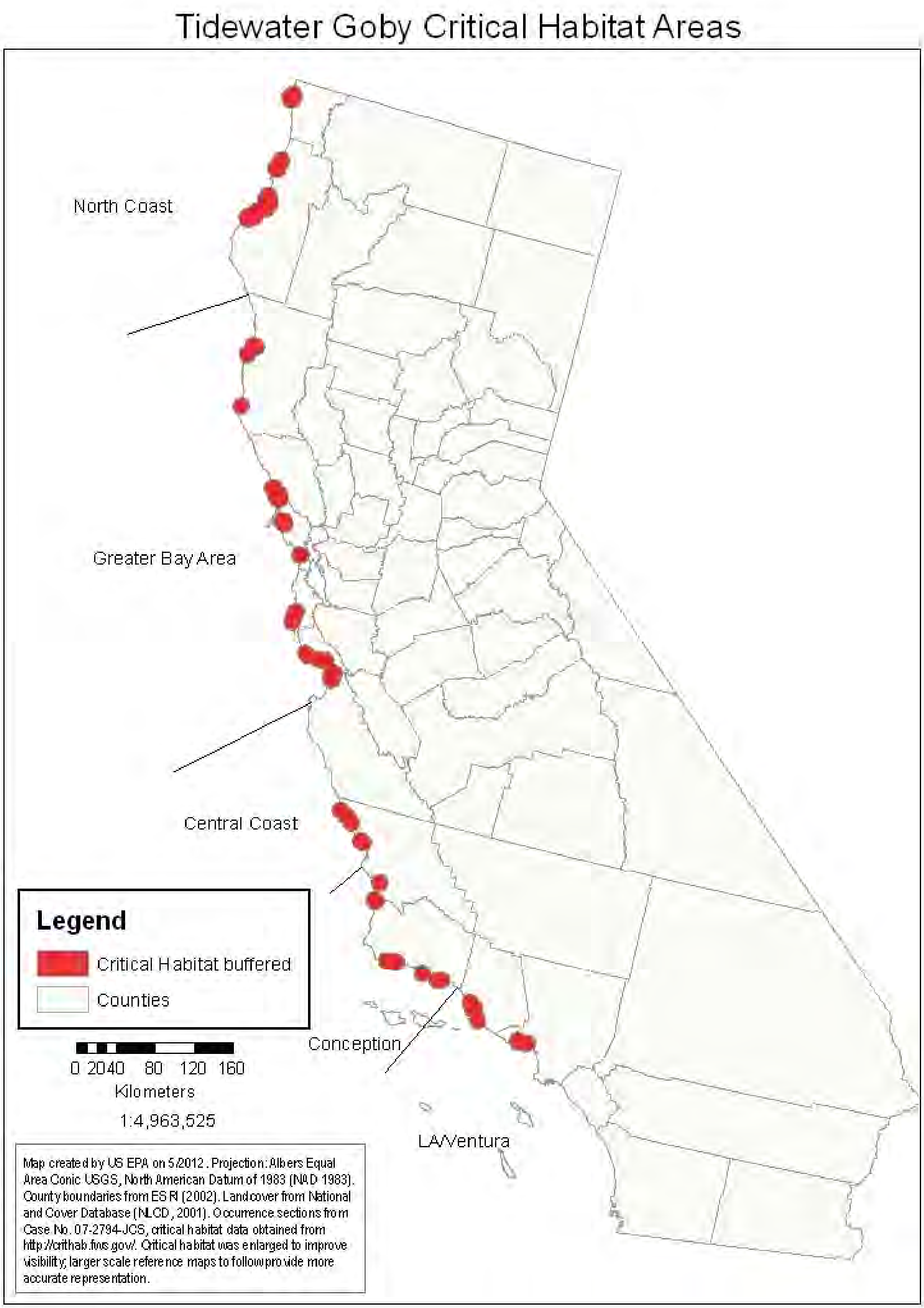
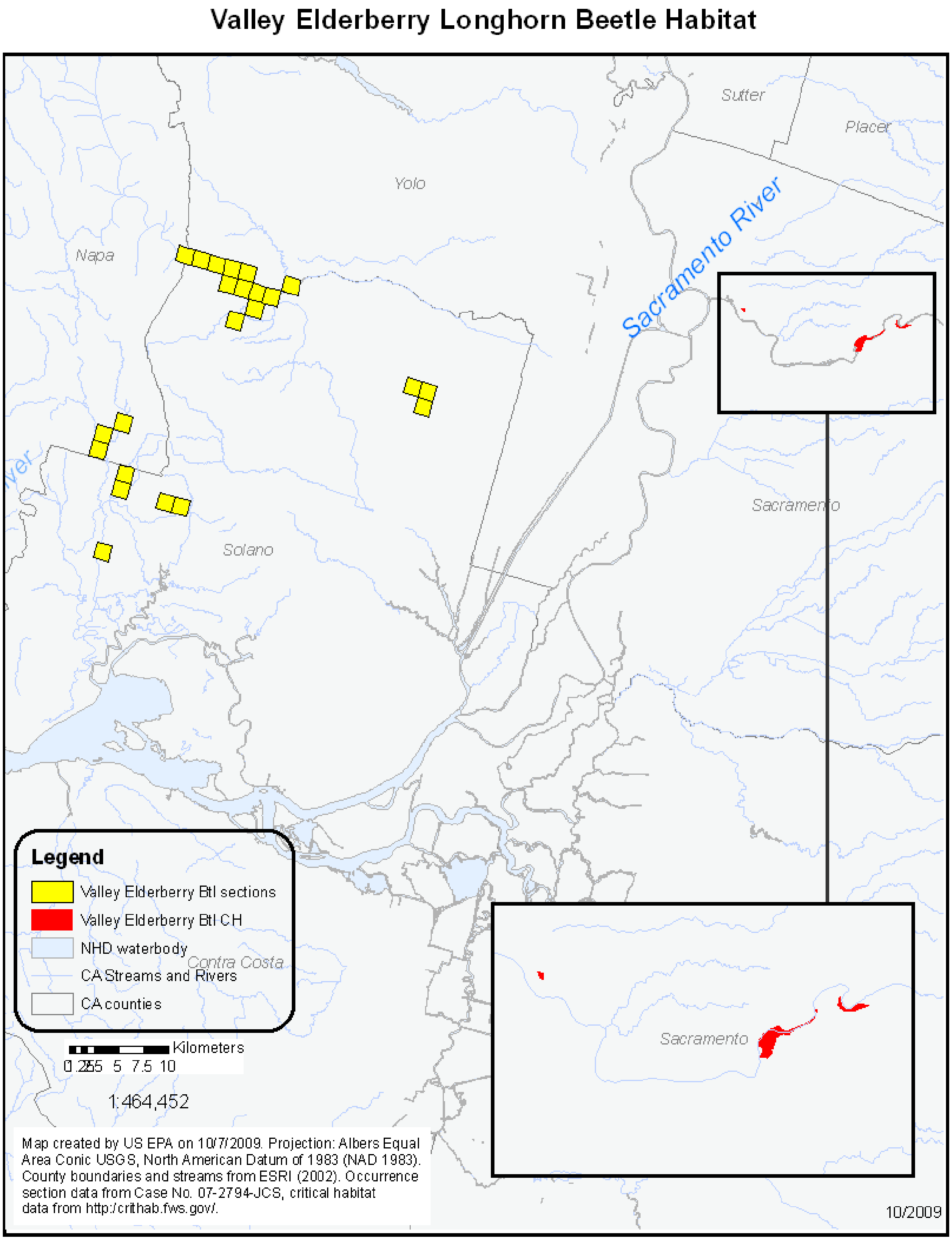


Figure 2-9. Valley Elderberry Longhorn Beetle Critical Habitat and Occurrence Sections Identified in Case No. 07-2794-JCS.



2.6. Designated Critical Habitat

Critical habitat has been designated for the BCB, CTS-CC, CTS-SB, DS, TG, and VELB. Risk to critical habitat is evaluated separately from risk to effects on the species. 'Critical habitat' is defined in the ESA as the geographic area occupied by the species at the time of the listing where the physical and biological features necessary for the conservation of the species exist, and there is a need for special management to protect the listed species. It may also include areas outside the occupied area at the time of listing if such areas are 'essential to the conservation of the species.' Critical habitat designations identify, to the extent known using the best scientific and commercial data available, habitat areas that provide essential life cycle needs of the species or areas that contain certain primary constituent elements (PCEs) (as defined in 50 CFR 414.12(b)). **Table 2-5** describes the PCEs for the critical habitats designated for the BCB, CTS-CC, CTS-SB, DS, TG, and VELB.

Table 2-5. Designated Critical Habitat PCEs for the BCB, CTS-CC, CTS-SB, DS, TG, and VELB

Species	PCEs	Reference
Bay Checkerspot Butterfly (BCB)	The presence of annual or perennial grasslands with little to no overstory that provide north/south and east/west slopes with a tilt of more than 7 degrees for larval host plant survival during periods of atypical weather (*e.g.*, drought).	66 FR 21449 21489, 2001
	The presence of the primary larval host plant, dwarf plantain (*Plantago erecta*) (a dicot) and at least one of the secondary host plants, purple owl's-clover or exserted paintbrush, are required for reproduction, feeding, and larval development.	
	The presence of adult nectar sources for feeding.	
	Aquatic features such as wetlands, springs, seeps, streams, lakes, and ponds and their associated banks, that provide moisture during periods of spring drought; these features can be ephemeral, seasonal, or permanent.	
	Soils derived from serpentinite ultramafic rock (Montara, Climara, Henneke, Hentine, and Obispo soil series) or similar soils (Inks, Candlestick, Los Gatos, Fagan, and Barnabe soil series) that provide areas with fewer aggressive, nonnative plant species for larval host plant and adult nectar plant survival and reproduction.[2]	
	The presence of stable holes and cracks in the soil, and surface rock outcrops that provide shelter for the larval stage of the bay checkerspot butterfly during summer diapause.[2]	
California tiger salamander (CTS-CC and CTS-SB)	Standing bodies of fresh water, including natural and man-made (*e.g.*, stock) ponds, vernal pools, and dune ponds, and other ephemeral or permanent water bodies that typically become inundated during winter rains and hold water for a sufficient length of time (*i.e.*, 12 weeks) necessary for the species to complete the aquatic (egg and larval) portion of its life cycle[2]	FR Vol. 69 No. 226 CTS, 68584, 2004
	Barrier-free uplands adjacent to breeding ponds that contain small mammal burrows. Small mammals are essential in creating the underground habitat that juvenile and adult California tiger salamanders depend upon for food, shelter, and protection from the elements and predation	
	Upland areas between breeding locations (PCE 1) and areas with small mammal burrows (PCE 2) that allow for dispersal among such sites	

Table 2-5. Designated Critical Habitat PCEs for the BCB, CTS-CC, CTS-SB, DS, TG, and VELB		
Species	**PCEs**	**Reference**
Delta Smelt (DS)	Spawning Habitat—shallow, fresh or slightly brackish backwater sloughs and edge waters to ensure egg hatching and larval viability. Spawning areas also must provide suitable water quality (*i.e.*, low concentrations of pollutants) and substrates for egg attachment (*e.g.*, submerged tree roots and branches and emergent vegetation).	59 FR 65256 65279, 1994
	Larval and Juvenile Transport—Sacramento and San Joaquin Rivers and their tributary channels must be protected from physical disturbance and flow disruption. Adequate river flow_is necessary to transport larvae from upstream spawning areas to rearing habitat in Suisun Bay. Suitable water quality must be provided so that maturation is not impaired by pollutant concentrations.	
	Rearing Habitat—Maintenance of the 2 ppt isohaline and suitable water quality (low concentrations of pollutants) within the Estuary is necessary to provide delta smelt larvae and juveniles a shallow protective, food-rich environment in which to mature to adulthood.	
	Adult Migration— Unrestricted access to suitable spawning habitat in a period that may extend from December to July. Adequate flow and suitable water quality_may need to be maintained to attract migrating adults in the Sacramento and San Joaquin River channels and their associated tributaries. These areas also should be protected from physical disturbance and flow disruption during migratory periods.	
Tidewater Goby (TG)	Persistent, shallow (in the range of about 0.1-2 m), still-to-slow-moving, aquatic habitat most commonly ranging in salinity from less than 0.5 ppt to about 10-12 ppt, which provides adequate space for normal behavior and individual and population growth	50 FR 5920 6005, 2008
	Substrates (*e.g.*, sand, silt, mud) suitable for the construction of burrows for reproduction	
	Submerged and emergent aquatic vegetation, such as *Potamogeton pectinatus* and *Ruppia maritima*, that provides protection from predators	
	Presence of a sandbar(s) across the mouth of a lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, thereby providing relatively stable water levels and salinity.	
Valley Elderberry Longhorn Beetle (VELB)	Areas that contain the host plant of this species [*i.e.*, elderberry trees (*Sambucus* sp.)] (a dicot)	43 FR 35636 35643, 1978
[1] These PCEs are in addition to more general requirements for habitat areas that provide essential life cycle needs of the species such as, space for individual and population growth and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, rearing (or development) of offspring; and habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species. [2] PCEs that are abiotic, including, physical-chemical water quality parameters such as salinity, pH, and hardness are not evaluated.		

More detail on the designated critical habitat applicable to this assessment can be found in **Attachment II**. Activities that may destroy or adversely modify critical habitat are those that alter the PCEs and jeopardize the continued existence of the species. Evaluation of actions related to use of bensulide that may alter the PCEs of the designated critical habitat for the BCB, CTS-CC, CTS-SB, DS, TG, and VELB form the basis of the critical habitat impact analysis.

As previously noted in **Section 2.1**, the Agency believes that the analysis of direct and indirect effects to listed species provides the basis for an analysis of potential effects on the designated critical habitat. Because bensulide is expected to directly impact living organisms within the action area, critical habitat analysis for bensulide is limited in a practical sense to those PCEs of critical habitat that are biological or that can be reasonably linked to biologically mediated processes.

2.7. Action Area and LAA Effects Determination Area

2.7.1. Action Area

The action area is used to identify areas that could be affected by the Federal action. The Federal action is the authorization or registration of pesticide use or uses as described on the label(s) of pesticide products containing a particular active ingredient. The action area is defined by the Endangered Species Act as, "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action" (50 CFR §402.2). Based on an analysis of the Federal action, the action area is defined by the actual and potential use of the pesticide and areas where that use could result in effects. Specific measures of ecological effect for the assessed species that define the action area include any direct and indirect toxic effect to the assessed species and any potential modification of its critical habitat, including reduction in survival, growth, and fecundity as well as the full suite of sublethal effects available in the effects literature. It is recognized that the overall action area for the national registration of bensulide is likely to encompass considerable portions of the United States based on the large array of agricultural and non-agricultural uses. However, the scope of this assessment limits consideration of the overall action area to those portions that may be applicable to the protection of the BCB, CCR, CFWS, CTS-CC, CTS-SC, CTS-SB, DS, SFGS, TG, and VELB and their designated critical habitat (if any) within the state of California. For this assessment, the entire state of California is considered the action area. The purpose of defining the action area as the entire state of California is to ensure that the initial area of consideration encompasses all areas where the pesticide may be used now and in the future, including the potential for off-site transport via spray drift and downstream dilution that could influence the San Francisco Bay species. Additionally, the concept of a state-wide action area takes into account the potential for direct and indirect effects and any potential modification to critical habitat based on ecological effect measures associated with reduction in survival, growth, and reproduction, as well as the full suite of sublethal effects available in the effects literature.

It is important to note that the state-wide action area does not imply that direct and/or indirect effects and/or critical habitat modification are expected to or are likely to occur over the full extent of the action area but, rather, serves to identify all areas that may potentially be affected by the action. The Agency uses more rigorous analysis including consideration of available land cover data, toxicity data, and exposure information to determine areas where BCB, CCR, CFWS, CTS-CC, CTS-SC, CTS-SB, DS, SFGS, TG, and VELB and designated critical habitat may be affected or modified via endpoints associated with reduced survival, growth, or reproduction.

2.7.2. LAA Effects Determination Area

A stepwise approach is used to define the Likely to Adversely Affect (LAA) Effects Determination Area. An LAA effects determination applies to those areas where it is expected that the pesticide's use will directly or indirectly affect the species and/or modify its designated critical habitat using EFED's standard assessment procedures (see **Attachment I**) and effects endpoints related to survival, growth, and reproduction. This is the area where the "Potential Area of LAA Effects" (initial area of concern + drift distance or downstream dilution distance) overlaps with the range and/or designated critical habitat for the species being assessed. If there is no overlap between the potential area of the LAA effects determination and the habitat or occurrence areas, a no effect determination is made. The first step in defining the LAA Effects Determination Area is to understand the federal action. The federal action is defined by the currently labeled uses for bensulide. An analysis of labeled uses and review of available product labels was completed. Some of the currently labeled uses are special local needs (SLN) uses not specified for use in California or are restricted to specific states and are excluded from this assessment. In addition, a distinction has been made between agricultural use crops and those that are non-agricultural uses. For a detailed list of both agricultural and non-agricultural uses relevant to the assessed species, see **Table 2-2**.

Following a determination of the assessed uses, an evaluation of the potential "footprint" of bensulide use patterns (*i.e*., the area where pesticide application may occur) is determined. This "footprint" represents the initial area of concern, based on an analysis of available land cover data for the state of California. The initial area of concern is defined as all land cover types and the stream reaches within the land cover areas that represent the labeled uses described above.

Once the initial area of concern is defined, the next step is to define the potential boundaries of the Potential Area of LAA Effects by determining the extent of offsite transport via spray drift and runoff where exposure of one or more taxonomic groups to the pesticide will result in exceedances of the listed species LOCs.

The AgDRIFT model (Version 2.1.1) is used to define how far from the initial area of concern (*i.e.*, distance in feet from the edge of the field) an effect to a given species may be expected via spray drift (*e.g*., the drift distance). Further detail on the spray drift analysis is provided in **Section 5.2.9.a**.

In addition to the buffered area from the spray drift analysis, the Potential Area of LAA Effects also considers the downstream extent of bensulide that exceeds the LOC based on downstream dilution analysis (discussed in **Section 5.2.9.b**).

An evaluation of usage information was conducted to determine the area where use of bensulide may impact the assessed species. This analysis is used to characterize where predicted exposures are most likely to occur, but does not preclude use in other portions of the action area. A more detailed review of the county-level use information was also completed. These data suggest that bensulide has historically been used on a wide variety of agricultural and non-agricultural uses.

2.8. Assessment Endpoints and Measures of Ecological Effect

For more information on the assessment endpoints, measures of ecological effect, see **Attachment I**.

2.8.1. Assessment Endpoints

A complete discussion of all the toxicity data available for this risk assessment, including resulting measures of ecological effect selected for each taxonomic group of concern, is included in **Section 4** of this document. **Table 2-6** identifies the taxa used to assess the potential for direct and indirect effects from the uses of bensulide for each listed species assessed here. The specific assessment endpoints used to assess the potential for direct and indirect effects to each listed species are provided in **Table 2-7**.

Table 2-6. Taxa Used in the Analyses of Direct and Indirect Effects for the Assessed Listed Species.										
Listed Species	**Birds**	**Mammals**	**Terr. Plants**	**Terr. Inverts.**	**FW Fish**	**FW Inverts.**	**Aquatic Phase Amphibians**	**Estuarine /Marine Fish**	**Estuarine /Marine Inverts.**	**Aquatic Plants**
Bay Checkerspot Butterfly	NA	NA	Indirect (food/ habitat) *	Direct	NA	NA	NA	NA	NA	NA
California Clapper Rail	Direct Indirect (prey)	Indirect (prey)	Indirect (food/ habitat)	Indirect (prey)	Indirect (prey)	Indirect (prey)	NA	Indirect (prey)	Indirect (prey)	Indirect (food/ habitat)
California Freshwater Shrimp	NA	NA	Indirect (food/ habitat)	NA	NA	Direct Indirect (prey)	NA	NA	NA	Indirect (food/ habitat)
California Tiger Salamander	Direct Indirect (prey)	Indirect (prey/ habitat)	Indirect (habitat)	Indirect (prey)	Direct Indirect (prey)	Indirect (prey)	Direct	NA	NA	Indirect (food/ habitat)
Delta Smelt	NA	NA	Indirect (habitat)	NA	Direct	Indirect (prey)	NA	Direct	Indirect (prey)	Indirect (food/ habitat
San Francisco Garter Snake	Direct Indirect (prey)	Indirect (prey/ habitat)	Indirect (habitat)	Indirect (prey)	Indirect (prey)	Indirect (prey)	Indirect (prey)	NA	NA	Indirect (habitat)
Tidewater Goby	NA	NA	Indirect (habitat)	NA	Direct	Indirect (prey)	NA	Direct	Indirect (prey)	Indirect (food/ habitat
Valley Elderberry Longhorn Beetle	NA	NA	Indirect (food/ habitat) *	Direct	NA	NA	NA	NA	NA	NA
NA = Not applicable; Terr. = Terrestrial; Invert. = Invertebrate; FW = Freshwater *Obligate relationship										

Table 2-7. Taxa and Assessment Endpoints Used to Evaluate the Potential for Use of Bensulide to Result in Direct and Indirect Effects to the Assessed Listed Species or Modification of Critical Habitat			
Taxa Used to Assess Direct and Indirect Effects to Assessed Species and/or Modification to Critical Habitat or Habitat	**Assessed Listed Species**	**Assessment Endpoints**	**Measures of Ecological Effects**
1. Freshwater Fish and/or Aquatic-Phase Amphibians	Direct Effect CA Tiger Salamander Delta Smelt Tidewater Goby	Survival, growth, and reproduction of individuals via direct effects	1a. Most sensitive fish acute LC_{50} (guideline or ECOTOX) 1b. Most sensitive fish chronic NOAEC (guideline or ECOTOX) 1c. Most sensitive aquatic-phase amphibian acute LC_{50} (guideline or ECOTOX)
	Indirect Effect (prey) CA Clapper Rail SF Garter Snake	Survival, growth, and reproduction of individuals or modification of habitat via indirect effects on aquatic prey food supply (*i.e.*, fish and aquatic-phase amphibians)	
2. Freshwater Invertebrates	Direct Effect CA FW Shrimp	Survival, growth, and reproduction of individuals via direct effects	2a. Most sensitive freshwater invertebrate EC_{50} (guideline or ECOTOX) 2b. Most sensitive freshwater invertebrate chronic NOAEC (guideline or ECOTOX)
	Indirect Effect (prey) CA Clapper Rail CA FW shrimp CA Tiger Salamander Delta Smelt SF Garter Snake Tidewater Goby	Survival, growth, and reproduction of individuals or modification of critical habitat/habitat via indirect effects on aquatic prey food supply (*i.e.*, freshwater invertebrates)	
3. Estuarine/Marine Fish	Direct Effect Delta Smelt Tidewater Goby	Survival, growth, and reproduction of individuals via direct effects	3a. Most sensitive estuarine/marine fish LC_{50} (guideline or ECOTOX) 3b. Most sensitive estuarine/marine fish chronic NOAEC (guideline or ECOTOX)
	Indirect Effect (prey) CA Clapper Rail	Survival, growth, and reproduction of individuals or modification of habitat via indirect effects on aquatic prey food supply (*i.e.*, estuarine/marine fish)	
4. Estuarine/Marine Invertebrates	Direct Effect none	NA	4a. Most sensitive estuarine/marine invertebrate EC_{50} (guideline or ECOTOX) 4b. Most sensitive estuarine/marine invertebrate chronic NOAEC (guideline or ECOTOX)
	Indirect Effect (prey) CA Clapper Rail Delta Smelt Tidewater Goby	Survival, growth, and reproduction of individuals or modification of habitat via indirect effects on aquatic prey food supply	

Table 2-7. Taxa and Assessment Endpoints Used to Evaluate the Potential for Use of Bensulide to Result in Direct and Indirect Effects to the Assessed Listed Species or Modification of Critical Habitat			
Taxa Used to Assess Direct and Indirect Effects to Assessed Species and/or Modification to Critical Habitat or Habitat	**Assessed Listed Species**	**Assessment Endpoints**	**Measures of Ecological Effects**
		(*i.e.*, estuarine/marine invertebrates)	
5. Aquatic Plants (freshwater/marine)	Direct Effect none	NA	5a. Vascular plant acute EC_{50} (duckweed guideline test or ECOTOX vascular plant) 5b. Non-vascular plant acute EC_{50} (freshwater algae or diatom, or ECOTOX non-vascular)
	Indirect Effect (food/habitat) SF Garter Snake CA Clapper Rail CA Tiger Salamander CA FW Shrimp Delta Smelt Tidewater Goby	Survival, growth, and reproduction of individuals or modification of critical habitat/habitat via indirect effects on habitat, cover, food supply, and/or primary productivity (*i.e.*, aquatic plant community)	
6. Birds	Direct Effect SF Garter Snake CA Clapper Rail CA Tiger Salamander	Survival, growth, and reproduction of individuals via direct effects	6a. Most sensitive bird* or terrestrial-phase amphibian acute LC_{50} or LD_{50} (guideline or ECOTOX) 6b. Most sensitive bird* or terrestrial-phase amphibian chronic NOAEC (guideline or ECOTOX)
	Indirect Effect (prey/rearing sites) SF Garter Snake CA Clapper Rail	Survival, growth, and reproduction of individuals or modification of habitat via indirect effects on terrestrial prey (birds)	
7. Mammals	Direct Effect none	NA	7a. Most sensitive laboratory mammalian acute LC_{50} or LD_{50} (guideline or ECOTOX) 7b. Most sensitive laboratory mammalian chronic NOAEC (guideline or ECOTOX)
	Indirect Effect (prey/habitat from burrows/rearing sites) SF Garter Snake CA Clapper Rail CA Tiger Salamander	Survival, growth, and reproduction of individuals or modification of critical habitat/habitat via indirect effects on terrestrial prey (mammals) and/or burrows/rearing sites	
8. Terrestrial Invertebrates	Direct Effect Bay Checkerspot Butterfly Valley elderberry longhorn beetle	Survival, growth, and reproduction of individuals via direct effects	8a. Most sensitive terrestrial invertebrate acute EC_{50} or LC_{50} (guideline or ECOTOX) 8b. Most sensitive terrestrial invertebrate chronic NOAEC (guideline or ECOTOX)
	Indirect Effect (prey) SF Garter Snake CA Clapper Rail CA Tiger Salamander	Survival, growth, and reproduction of individuals or modification of critical	

Table 2-7. Taxa and Assessment Endpoints Used to Evaluate the Potential for Use of Bensulide to Result in Direct and Indirect Effects to the Assessed Listed Species or Modification of Critical Habitat			
Taxa Used to Assess Direct and Indirect Effects to Assessed Species and/or Modification to Critical Habitat or Habitat	**Assessed Listed Species**	**Assessment Endpoints**	**Measures of Ecological Effects**
		habitat/habitat via indirect effects on terrestrial prey (terrestrial invertebrates)	
9. Terrestrial Plants	Direct Effect none	NA	9a. Distribution of EC_{25} for monocots (seedling emergence, vegetative vigor, or ECOTOX 9b. Distribution of EC_{25} (EC_{05} or NOAEC for the BCB and the VELB) for dicots (seedling emergence, vegetative vigor, or ECOTOX)
	Indirect Effect (food/habitat) (non-obligate relationship) CA Clapper Rail CA Tiger Salamander SF Garter Snake Delta Smelt Tidewater Goby	Survival, growth, and reproduction of individuals or modification of critical habitat/habitat via indirect effects on food and habitat (*i.e.*, riparian and upland vegetation)	
	Indirect Effect (food/habitat) (obligate relationship) Bay Checkerspot Butterfly Valley Elderberry Longhorn Beetle		
SF=San Francisco; NA=Not Applicable * Birds are used as a surrogate for terrestrial-phase amphibians and reptiles. Fish are used as a surrogate for aquatic-phase amphibians.			

2.8.2. Assessment Endpoints for Designated Critical Habitat

As previously discussed, designated critical habitat is assessed to evaluate actions related to the use of bensulide that may alter the PCEs of the assessed species' designated critical habitat. PCEs for the assessed species were previously described in **Section 2.6**. Actions that may modify critical habitat are those that alter the PCEs and jeopardize the continued existence of the assessed species. Therefore, these actions are identified as assessment endpoints. It should be noted that evaluation of PCEs as assessment endpoints is limited to those of a biological nature (*i.e.*, the biological resource requirements for the listed species associated with the critical habitat) and those for which bensulide effects data are available.

Assessment endpoints used to evaluate potential for direct and indirect effects are equivalent to the assessment endpoints used to evaluate potential effects to designated critical habitat. If a potential for direct or indirect effects is found, then there is also a potential for effects to critical habitat. Some components of these PCEs are associated with physical abiotic features (*e.g.*, presence and/or depth of a water body, or distance between two sites), which are not expected to be measurably altered by use of pesticides.

2.9. Conceptual Model

2.9.1. Risk Hypotheses

Risk hypotheses are specific assumptions about potential adverse effects (*i.e.,* changes in assessment endpoints) and may be based on theory and logic, empirical data, mathematical models, or probability models (USEPA, 1998). For this assessment, the risk is stressor-linked, where the stressor is the release of bensulide to the environment. The following risk hypotheses are presumed in this assessment:

The labeled use of bensulide within the action area may:

- directly affect BCB, CCR, CFWS, CTS (all DPS), DS, SFGS, TG, and VELB by causing mortality or by adversely affecting growth or fecundity;
- indirectly affect BCB, CCR, CFWS, CTS (all DPS), DS, SFGS, TG, and VELB and/or modify their designated critical habitat by reducing or changing the composition of food supply;
- indirectly affect CCR, CFWS, CTS (all DPS), DS, SFGS, and TG and/or modify their designated critical habitat by reducing or changing the composition of the aquatic plant community in the species' current range, thus affecting primary productivity and/or cover;
- indirectly affect BCB, CCR, CFWS, CTS (all DPS), DS, SFGS, TG, and VELB and/or modify their designated critical habitat by reducing or changing the composition of the terrestrial plant community in the species' current range;
- indirectly affect CCR, CFWS, CTS (all DPS), DS, SFGS, and TG and/or modify their designated critical habitat by reducing or changing aquatic habitat in their current range (via modification of water quality parameters, habitat morphology, and/or sedimentation); and
- indirectly affect CTS (all DPS) and SFGS and/or modify their designated critical habitat by reducing or changing terrestrial habitat in their current range (via reduction in small burrowing mammals leading to reduction in underground refugia/cover).

2.9.2. Diagram

The conceptual model is a graphic representation of the structure of the risk assessment. It specifies the bensulide release mechanisms, biological receptor types, and effects endpoints of potential concern. The aquatic and terrestrial conceptual models for BCB, CCR, CFWS, CTS-CC, CTS-SC, CTS-SB, DS, SFGS, TG, and VELB and PCE components of designated critical habitat are shown in **Figure 2-10** and **Figure 2-11**, respectively. Although the conceptual models for direct/indirect effects and modification of designated critical habitat PCEs are shown on the same diagrams, the potential for direct/indirect effects and modification of PCEs will be evaluated separately in this assessment. Exposure routes shown in dashed lines are not quantitatively considered because the contribution of those potential exposure routes to potential risks to BCB, CCR, CFWS, CTS (all DPS), DS, SFGS, TG, and VELB and modification to designated critical habitat is expected to be negligible.

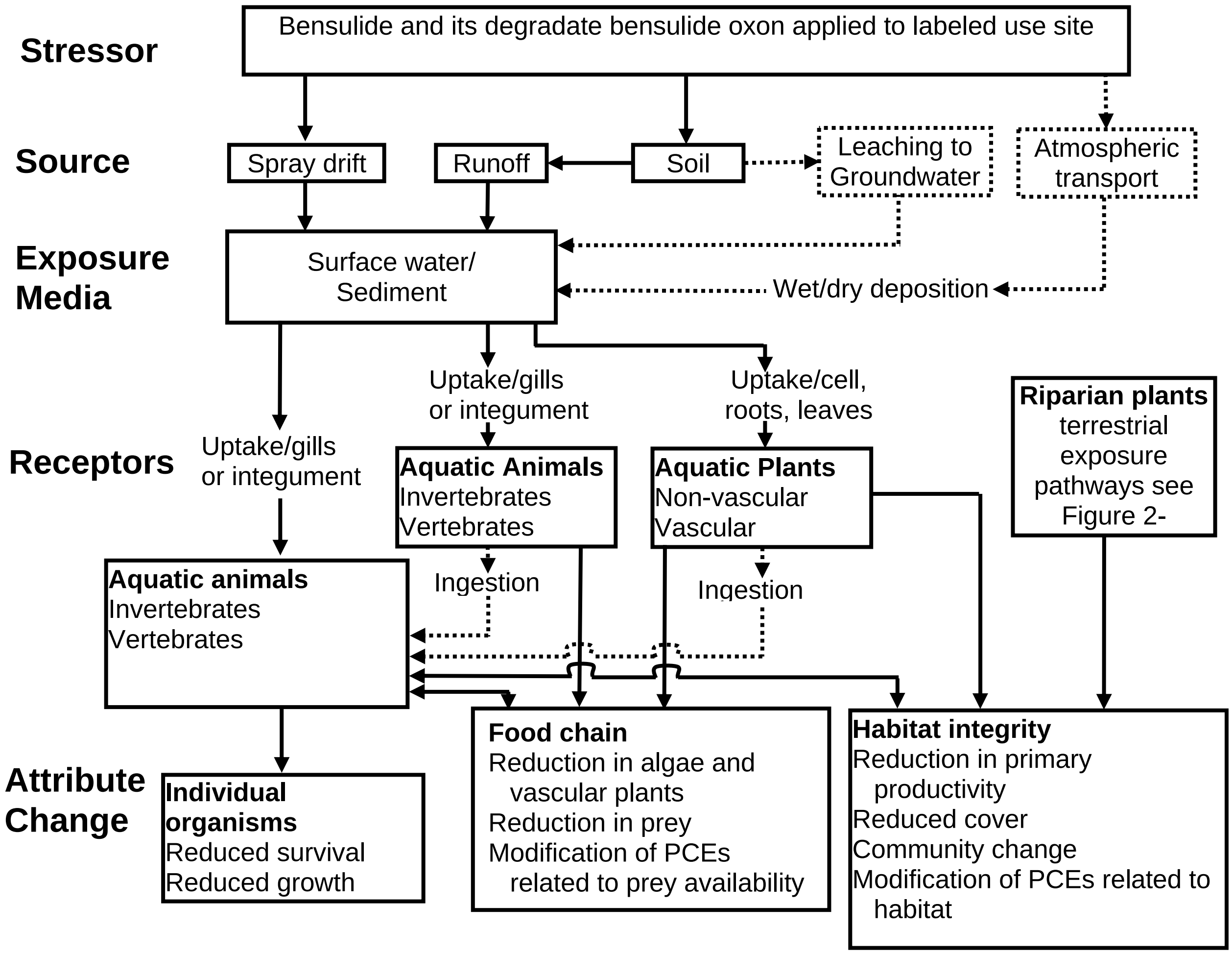


Figure 2-10. Conceptual Model Depicting Stressors, Exposure Pathways, and Potential Effects to Aquatic Organisms from the Use of Bensulide.
Dotted lines indicate exposure pathways that have a low likelihood of contributing to ecological risk.

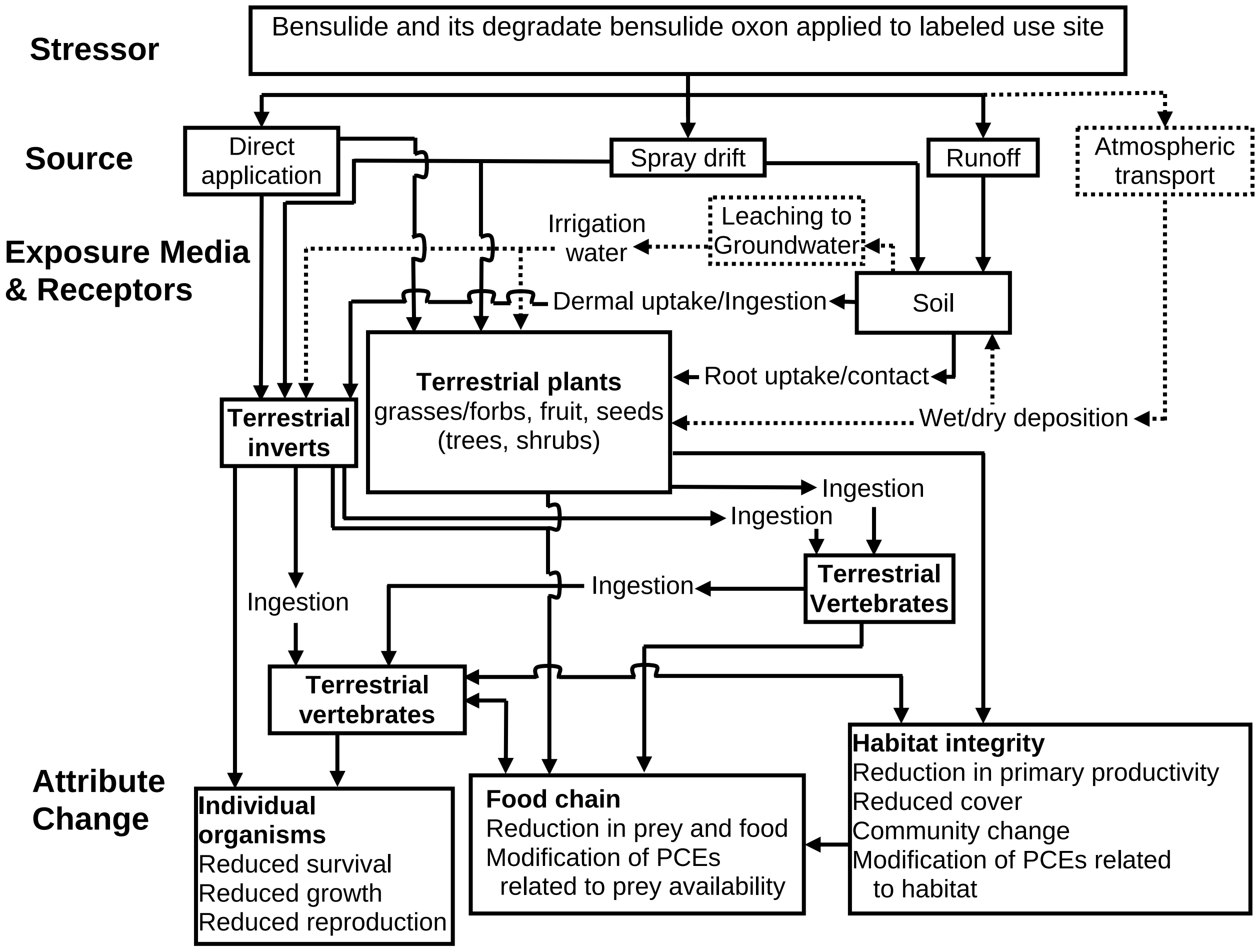


Figure 2-11. Conceptual Model Depicting Stressors, Exposure Pathways, and Potential Effects to Terrestrial Organisms from the Use of Bensulide.
Dotted lines indicate exposure pathways that have a low likelihood of contributing to ecological risk.

2.10. Analysis Plan

In order to address the risk hypothesis, the potential for direct and indirect effects to the assessed species, prey items, and habitat is estimated based on a taxon-level approach. In the following sections, the use, environmental fate, and ecological effects of bensulide are characterized and integrated to assess the risks. This is accomplished using a risk quotient (ratio of exposure concentration to effects concentration) approach. Although risk is often defined as the likelihood and magnitude of adverse ecological effects, the risk quotient-based approach does not provide a quantitative estimate of likelihood and/or magnitude of an adverse effect. However, as outlined in the Overview Document (USEPA, 2004), the likelihood of effects to individual organisms from particular uses of bensulide is estimated using the probit dose-response slope and either the level of concern (discussed below) or actual calculated risk quotient value.

Descriptions of routine procedures for evaluating risk to the San Francisco Bay Species are provided in **Attachment I**.

2.10.1. Measures of Exposure

The environmental fate properties of bensulide along with available monitoring data indicate that water and sediment runoff and spray drift are the principle potential transport mechanisms of bensulide to the aquatic and terrestrial habitats. In this assessment, transport of bensulide through runoff and spray drift is considered in deriving quantitative estimates of bensulide exposure to BCB, CCR, CFWS, CTS (all DPS), DS, SFGS, TG, and VELB, their prey, and their habitats. Based on chemical properties and the results of laboratory studies, volatilization, groundwater, and bioaccumulation are not considered likely routes of exposure for bensulide.

Measures of exposure are based on aquatic and terrestrial models that predict estimated environmental concentrations (EECs) of bensulide using maximum labeled application rates and methods of application. The models used to predict aquatic EECs are the Pesticide Root Zone Model coupled with the Exposure Analysis Model System (PRZM/EXAMS). The model used to predict terrestrial EECs on food items is the Terrestrial Residue Exposure (T-REX) model. The T-HERPS model is used to allow for further characterization of dietary exposures of terrestrial-phase amphibians and reptiles relative to birds. The model used to derive EECs relevant to terrestrial and wetland plants is TerrPlant. The AgDRIFT model is also used to estimate deposition of bensulide on aquatic and terrestrial habitats from spray drift. These models are parameterized using relevant reviewed registrant-submitted environmental fate data and use information found on registered labels. More information on these models is available in **Attachment I**.

2.10.2. Measures of Effect

Data identified in **Section 2.8** are used as measures of effect for direct and indirect effects. Data were obtained from registrant-submitted studies or from literature studies identified by ECOTOX. More information on the ECOTOXicology (ECOTOX) database and how toxicological data is used in assessments is available in **Attachment I**.

2.10.3. Integration of Exposure and Effects

Risk characterization is the integration of exposure and ecological effects characterization to determine the potential ecological risk from agricultural and non-agricultural uses of bensulide and the likelihood of direct and indirect effects to the assessed species in aquatic and terrestrial habitats. The exposure and toxicity effects data are integrated in order to evaluate the risks of adverse ecological effects to non-target species. The risk quotient (RQ) method is used to compare exposure and measured toxicity values. EECs are divided by acute and chronic toxicity values. The resulting RQs are then compared to the Agency’s levels of concern (LOCs) (USEPA, 2004) (see **Appendix C**). More information on standard assessment procedures is available in **Attachment I**.

2.10.4. Data Gaps

Several environmental fate and ecotoxicity studies have been identified as data gaps, which are included in **Section 2.3**.

3. Exposure Assessment

The exposure assessment takes into consideration the use information on registered labels, the available environmental fate and transport data, and the conceptual model of exposure to determine estimated environmental concentrations (EECs) of bensulide. Bensulide is a persistent herbicide that may be transported away from the site of application by runoff or spray drift (in the case of the EC formulation).

A degradate is considered to be major if it forms at amounts >10% of the applied parent. Benzenesulfonamide, a minor degradate, only reached a maximum level of 0.52% and is not considered in this assessment. Bensulide oxon, a major degradate, is considered in this assessment. In an aerobic soil metabolism study, bensulide oxon reached a maximum concentration of 13.8%. The aquatic and terrestrial exposure assessments consider the potential for both parent and oxon to be present and assume that observed toxicity data is mediated by exogenous and endogenous production of the oxon. For aquatic exposures, this is accounted for with a total toxic residue approach. Because available data show detectable residues of parent and oxon for *Brassica* leafy vegetables at 33 days but no detectable levels in vegetables at more protracted intervals, it is believed that the use of a 35-day dissipation half-life (for terrestrial exposures) is a conservative way to account for the role of both parent (as an endogenous source of oxon when consumed) and oxon produced in the environment (see **Section 2.2.1** for more information).

3.1. Label Information

Exposure form ground applications are considered in this assessment. Bensulide formulations include emulsifiable concentrates and granules. Applications are applied via broadcast methods, band treatment, and chemigation methods. The registered uses of bensulide in California include vegetable crops, golf course turf, ornamental lawns and turf, and residential lawns (see **Table 2-2** for complete list). On most labels, information regarding the application intervals, number of applications per year, and total amount of a.i. allowed to be applied in a year was not specified. Conservative assumptions were made when selecting model inputs for use patterns (see **Section 2.4.3** and **Table 3-2**).

3.2. Aquatic Exposure Assessment

3.2.1. Conceptual Model of Exposure

Aquatic exposure to the assessed species within the action area is estimated with the PRZM and EXAMS models (USEPA, 2004). Screening-level exposures (EECs) are produced using the standard farm pond of 20,000 cubic meters volume. Watersheds where bensulide is used are assumed to have 100% cropped area. The downstream extent of streams with exposures above the Level of Concern (LOC) is estimated (using GIS methods) by expanding the watershed considered until uncontaminated stream flow dilutes the initial pond concentration to below the LOC.

3.2.2. Modeling Approach

PRZM scenarios were chosen in accordance with current guidance for scenario selection or previous California endangered species assessments (see **Table 3-2**). The California PRZM scenarios chosen for this assessment include lettuce, row crop, melon, turf, garlic, onion, tomato, cole crops, and residential lawns.

Risk quotients (RQs) were initially based on EECs derived using the PRZM/EXAMS standard ecological pond scenario according to the methodology specified in the Overview Document (USEPA, 2004).

The general conceptual model of exposure for this assessment is that the highest exposures are expected to occur in the headwater streams adjacent to agricultural fields. Many of the streams and rivers within the action area defined for this assessment are in close proximity to agricultural use sites.

3.2.3. Model Inputs

The estimated water concentrations from surface water sources were calculated using the Tier 2 PRZM/ EXAMS model. PRZM is used to simulate pesticide transport as a result of runoff and erosion from a standardized watershed, and EXAMS estimates environmental fate and transport of pesticides in surface waters. The linkage program shell (PE5v01.pl) that incorporates the site-specific scenarios was used to run these models. The input parameters were selected based on current input parameter guidance.

The PRZM/EXAMS model was used to calculate concentrations using the standard ecological water body scenario in EXAMS. Weather and agricultural practices were simulated over 30 years so that the 1 in 10 year exceedance probability at the site was estimated for the standard ecological water body.

The appropriate PRZM input parameters were selected from the environmental fate data submitted by the registrant and in accordance with US EPA-OPP EFED water model parameter selection guidelines, Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides, Version 2.1, October 22, 2009.

Standard assumptions of 1% spray drift for ground application and 0% drift for granular application are used. The date of first application was set at January 1 for a crop with three growing seasons per year and March 1 for crops with one or two growing seasons per year in PRZM/EXAMS modeling based on the bensulide usage report (USEPA, 2012). The selection of the January 1 application data also accommodates the model's limitation of a 120-day application interval for three growing seasons of a crop. The environmental fate input parameters are listed in **Table 3-1**. A total toxic residue (TTR) approach was used to calculate the combined half-life for bensulide and bensulide oxon.

Table 3-1. Summary of PRZM/EXAMS Environmental Fate Data Used for Aquatic Exposure Estimation for Bensulide and Bensulide Oxon (Total Toxic Residues)		
Input variable (Units)	**Input value and calculations**	**Source**
Crop name	See **Table 3-3**	Product labels
Application method	See **Table 3-3**	Product labels
Application rate (lb a.i./acre)	See **Table 3-3**	Product labels
Application interval (days)	See **Table 3-3**	Product labels
Application efficiency Ground application	0.99	EFED input parameters guideline (EFED guideline) (10/22/2009)
Spray drift fraction	0.01	EFED guideline
Molecular Weight (g/mole)	397.5	MRID 45761801 (Value for parent)
Henry's Law Constant ($atm.m^3$/mole)	7.10×10^{-12}	EPI Suite (v 4.10)
Vapor pressure @ 25^oC (mm Hg)	$2.48\ 10^{-8}$	EPI Suite (v 4.10)
Solubility in Water (mg/L)	5.6	(Value for parent)
Aquatic photolysis $t_{1/2}$ (day)	0	Based on parent and oxon the data from MRID# 40513401
Aerobic soil met. $t_{1/2}$(day)	2,247	749 (Re-calculated for parent and oxon from original data) x 3 (EFED guideline)
Hydrolysis $t_{1/2}$(day) @ 25 ^{0}C	230 (pH 5) 220 (pH 7) 220 (pH 9)	MRID# 00160074 (Value for parent - bensulide oxon not formed)
Aerobic aquatic met. $t_{1/2}$(day)	4,494	No data; (soil aerobic met. half-life x 2; EFED guideline)
Anaerobic soil met. $t_{1/2}$(day)	0	Stable (no ending point)
K_{oc} ml/g (mean)	557	(Lowest Koc of available data)
Application rate, date, frequency, intervals, chemical application method (CAM), efficiency and spray drift	Same values used for the pesticide from the label and as per the parameters guidance document	

3.2.4. Aquatic EEC Results

Table 3-2 includes the results of the PRZM/EXAMS modeling, based on the total toxic residue approach. An example of the full output from PRZM/EXAMS can be found in **Appendix D**.

Table 3-2. Estimated Environmental Concentrations (EECs) for Surface Waters from the Labeled Uses of Bensulide in California, Based on the Total Toxic Residue Approach				
PRZM Scenario (crops represented by scenario)	**Application Rate (Interval) Formulation Type**	**Peak EEC (µg/L)**	**21-day EEC (µg/L)**	**60-day EEC (µg/L)**
CA Turf RLF[1] (golf course turf for use on tees, greens, and bentgrass fairways only)	2 apps @ 16 lb a.i./acre (120 days) Granular	30.44	29.19	26.21
CA Turf RLF (ornamental lawns and turf)	2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	79.48	75.44	70.49
CA Turf RLF[1] (golf course turf)	2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	27.02	25.65	23.97
CA Residential RLF[2] (residential lawns)	2 apps @ 12.6 lb a.i./acre (120 days) Granular	19.48	18.46	17.41
	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	16.63	15.48	14.42
CA Wheat (canola)	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	227.30	215.40	199.30
	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	127.10	124.90	120.80
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	78.59	76.14	71.99
CA Cole Crop RLF (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage)	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	463.70	427.00	378.40
	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	254.20	238.30	228.00
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	125.90	120.20	111.20
CA Lettuce No-irrig. (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula))	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	297.50	277.00	248.50
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	151.30	142.00	129.60
CA Row Crop RLF (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas)	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	218.50	207.60	192.00
	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	104.38	96.39	91.80
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	46.04	42.74	40.11

Table 3-2. Estimated Environmental Concentrations (EECs) for Surface Waters from the Labeled Uses of Bensulide in California, Based on the Total Toxic Residue Approach				
PRZM Scenario (crops represented by scenario)	**Application Rate (Interval) Formulation Type**	**Peak EEC (µg/L)**	**21-day EEC (µg/L)**	**60-day EEC (µg/L)**
CA Melon RLF (cantaloupe, chayote, cucumber, cucurbit vegetables, cucuzzi, gherkin, gourds, gourd (wax), melons (bitter, honeydew, citron, mango, musk, water, winter melons), pepino, pumpkin, squash (butternut, summer, zucchini squash))	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	115.10	109.82	102.63
	1 app @ 9 lb a.i./acre (Not applicable) Emulsifiable Concentrate	111.20	105.88	98.70
CA Tomato No-irrig. (bell pepper, eggplant, groundcherry (strawberry tomato/tomatillo), pepper, pepper (chili), pimento)	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	30.88	29.35	27.45
CA Onion No-Irrig. (garlic, onion (dry bulb and green), radish, shallot)	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	64.21	60.87	56.74
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	10.88	9.86	9.17

[1]Because golf course uses are for tees, greens, and bentgrass fairways only, EECs were adjusted by a factor of 0.34 according to Agency guidance: http://www.epa.gov/oppefed1/models/water/golf_course_adjustment_factors.htm
[2]Residential lawns scenarios were adjusted to account for the inclusion of impervious areas. See text below this table.

Post-processing of Residential Scenarios

This assessment adapted the residential scenarios that were developed specifically for the San Francisco Bay region using the conceptual approach developed for the Barton Springs salamander atrazine endangered species risk assessment (U.S. EPA, 2006). The San Francisco Bay area was selected to be representative of urbanized areas with 11 listed species' habitat present in the general vicinity. This scenario represents general impervious surfaces within a watershed not part of the ¼ acre lot and includes roads, parking lots, and buildings among others where overspray from residential lots is expected to be minimal. The ¼ acre lot, by comparison, was developed with a curve number reflective of the fact that the lot is covered with both pervious surfaces (grass and landscaped gardens) and impervious surfaces (driveways, sidewalks, and buildings). The conceptual model for both scenarios integrates simultaneous modeling of the individual use with both pervious and impervious scenarios assuming the watershed is represented by equal portions (50% of each surface). The final EEC of the residential uses was a summation of the PRZM/EXAM estimation for both pervious and impervious scenarios. The pervious surface was modeled using "CAresidentialRLF" scenario. It is assumed 50% area will be treated. Therefore, the model input application rate was adjusted as: label application rate × 0.5 (amount pervious surface) × 0.5 (area treated).

It is likely that some overspray may reach impervious surfaces in the residential setting. It is assumed that a typical house has a driveway of approximately 25 by 30 feet or 750 square feet and roughly 250 square feet of sidewalk in addition to a typical house. The impervious surface was modeled by "CAimperviousRLF" scenario using two separate assumptions: 1) it is assumed that 50% of the ¼ acre lot is treated with bensulide and 2) it is also assumed that 1% of the application rate could reach the impervious surfaces surrounding each residential lot. Therefore, the model input application rate for impervious surface will be adjusted as: label application rate × 0.5 (amount impervious surface) × 0.01 (amount reached impervious surface).

The second assumption may result in an underestimation of exposure, given that more overspray of impervious surfaces is possible. In order to account for the variability in overspray, the residential scenario was modeled assuming two alternate scenarios of 0% and 10% overspray to impervious surfaces. The alternate assumptions are intended to provide a bound on the 1% assumption. Because both the residential and rights-of-way scenarios were modeled using the paired pervious/impervious approach, the alternate scenarios were modeled for both scenarios (residential was modeled for both granular and liquid formulations). The conservativeness of these assumptions is unknown due to the lack of data on this phenomenon. However, given that the impervious scenario is intended to represent nontarget surfaces such as roads, parking lots and buildings, it is seems reasonable to assume that 10% overspray is an over-estimation of what would likely occur to these off-site areas, while 0% may be an under-estimation.

Two categories of formulations are currently registered for bensulide use on residential sites, including granular and emulsifiable liquid formulations. Both formulations were modeled separately because application rates are different and the standard assumption for modeling granular formulations is different from liquid formulations. Granular formulations are typically modeled as soil broadcast (CAM 1) with 0% spray drift while the emulsifiable liquid (CAM 1) assumes the standard spray drift of 1% for ground applications.

3.2.5. Existing Monitoring Data

There are no available monitoring data for bensulide or its degradate bensulide oxon from California to allow for comparison with modeled EECs. Therefore, the assessment is based on modeled concentrations, as included in **Table 3-2**.

3.3. Terrestrial Animal Exposure Assessment

3.3.1. Exposure to Residues in Terrestrial Food Items: Model Scenarios

T-REX (Version 1.5) is used to calculate dietary and dose-based EECs of bensulide for birds (including terrestrial-phase amphibians and reptiles), mammals, and terrestrial invertebrates. T-REX simulates a 1-year time period. T-HERPS may be used as a refinement of dietary and dose-based EECs for snakes and amphibians when avian risk quotients from T-REX are higher than LOCs. T-HERPS was also set up to simulate a 1-year time period. For this assessment, spray and granular applications of bensulide are considered. Terrestrial EECs were derived for the uses previously summarized in **Table 2-2**. Crops with similar use patterns were grouped together with one crop chosen as a surrogate for the group for the purpose of data presentation. Exposure estimates generated using T-REX and T-HERPS account for both the parent bensulide and the degradate bensulide oxon; because available data show detectable residues of parent and oxon for *Brassica* leafy vegetables at 33 days but no detectable levels in vegetables at more protracted intervals, it is believed that the use of a 35-day dissipation half-life is a conservative way to account for the role of both parent (as an endogenous source of oxon when consumed) and oxon produced in the environment (see **Section 2.2.1** for more information).

Use specific input values, including number of applications, application rate, foliar half-life and application interval are provided in **Table 3-3**. These uses were chosen to illustrate the effects of bensulide on terrestrial species over the full range of uses while minimizing redundancy in the results. An example output from T-REX and T-HERPS is available in **Appendix E**.

Willis and McDowell (1987) was consulted for data on bensulide persistence on foliage to replace the default value of 35 days in the T-REX and T-HERPS models. However, due to the persistence of bensulide in the environment, the default 35 day foliar dissipation rate was assumed to be protective for this assessment.

Table 3-3. Input Parameters Used to Derive Terrestrial EECs for Bensulide from T-REX and T-HERPS

Use	Application Rate (Interval) Formulation Type	Foliar Dissipation Half-Life
golf course turf	2 apps @ 16 lb a.i./acre (120 days) Granular	35 days
golf course turf and ornamental lawns and turf	2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	35 days
residential lawns	2 apps @ 12.6 lb a.i./acre (120 days) Granular	35 days
	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Bulb crops** (garlic, onion (dry bulb and green), radish, shallot) **Canola/rape**	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	35 days
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Leafy vegetable crops** (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula))	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	35 days

<table>
<tr><th colspan="3">Table 3-3. Input Parameters Used to Derive Terrestrial EECs for Bensulide from T-REX and T-HERPS</th></tr>
<tr><th>Use</th><th>Application Rate
(Interval)
Formulation Type</th><th>Foliar
Dissipation
Half-Life</th></tr>
<tr><td>Canola/rape</td><td></td><td></td></tr>
<tr><td>Cole crops (Brassica (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage)
Row crops (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas)
Bulb crops (garlic, onion (dry bulb and green), radish, shallot)
Leafy vegetable crops (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula))
Fruiting vegetable crops (bell pepper, eggplant, groundcherry (strawberry tomato/tomatillo), pepper, pepper (chili), pimento)
Canola/rape</td><td>1 app @ 6 lb a.i./acre
(Not applicable)
Emulsifiable Concentrate</td><td>35 days</td></tr>
<tr><td rowspan="2">Cucurbit/melon crops (cantaloupe, chayote, cucumber, cucurbit vegetables, cucuzzi, gherkin, gourds, gourd (wax), melons (bitter, honeydew, citron, mango, musk, water, winter melons), pepino, pumpkin, squash (butternut, summer, zucchini squash))</td><td>2 apps @ 9 lb a.i./acre
(120 days)
Emulsifiable Concentrate</td><td rowspan="2">35 days</td></tr>
<tr><td>1 app @ 9 lb a.i./acre
(Not applicable)
Emulsifiable Concentrate</td></tr>
</table>

Organisms consume a variety of dietary items and may exist in a variety of sizes at different life stages. T-REX estimates exposure for the following dietary items: short grass, tall grass, broadleaf plants, and fruits/pods, seeds, and arthropods. Birds, including the CCR, and mammals consume all of these items. The size classes of birds represented in T-REX are small (20 g), medium (100 g), and large (1000 g). The size classes for mammals are small (15 g), medium (35 g), and large (1000 g). The dietary items with the highest EECs are reported for birds (surrogate for amphibians and reptiles) and mammals. For mammals and birds, the highest EECs are for the smallest size class consuming short grass. The percentages of the EECs for the different dietary items are discussed in the discussion on uncertainties (**Section 6.1.1.a**).

T-HERPS estimates exposure for the following dietary items: broadleaf plants, fruits/pods/seeds, arthropods, small herbivore mammals, small insectivore mammals, and small amphibians. Snakes and amphibians may consume all of these items. The default size classes of amphibians represented in T-HERPS are small (2 g), medium (20 g), and large (200 g). The default vertebrate prey size that the medium and large amphibians can consume is 13 g and 133 g, respectively (small amphibians are not expected to eat vertebrate prey). The default size classes for snakes are small (2 g), medium (20 g), and large (800 g). The default vertebrate prey size that medium and large snakes can consume is 25 g and 1286 g, respectively (small snakes are not expected to eat vertebrate prey). The dietary items with the highest EECs are reported for amphibians and snakes. For both amphibians and reptiles, the highest EECs and RQs are for a 20-gram animal that consumes small herbivore mammals. If dietary-based RQs are higher than acute dose based RQs for acute exposures, they are shown as well. Dietary-based EECs and RQs are used to characterize risk from chronic exposure. The percentages of the EECs for the different dietary items are discussed in the section on uncertainties (**Section 6.1.1.b**).

T-REX also includes the capability to calculate LD_{50}/ft^2 risk values and specialized risk analyses for granular applications. Conceptually, an LD_{50}/ft^2 is the amount of a pesticide estimated to kill 50% of exposed animals in each square foot of applied area. Although a square foot does not have defined ecological relevance, and any unit area could be used, risk presumably increases as the number of $LD_{50}s/ft^2$ increases. The LD_{50}/ft^2 is used to estimate risk for granular formulations. The LD_{50}/ft^2 is calculated using a toxicity value (adjusted LD_{50}) and the EEC (mg a.i./ft^2) and is directly compared with the Agency's LOCs. LD_{50}/ft^2 risk values were calculated for the uses summarized in **Table 3-4**. Similar to the spray uses analyzed, these uses were chosen to illustrate the effects of bensulide on terrestrial species over the full range of uses while minimizing redundancy in the results.

Table 3-4. Input Parameters and EECs for Applications Used to Derive LD_{50}/ft^2 Risk Values for Bensulide with T- REX

Use	Application Rate	Application Media – Type	Row Spacing (in)	Bandwidth (in)	% Incorp-oration	EEC (mg a.i./ft^2)
golf course turf	2 apps @ 16 lb a.i./acre (120 days)	Granular – Broadcast	NA	NA	0	166.61
residential lawns	2 apps @ 12.6 lb a.i./acre (120 days)	Granular – Broadcast	NA	NA	0	131.20

3.3.1.a. Dietary Exposure to Mammals, Birds, and Amphibians Derived Using T-REX

Upper-bound Kenaga nomogram values reported by T-REX are used for derivation of dietary EECs for the BCB, CCR, CFWS, CTS (all DPS), SFGS, and VELB and their potential prey (**Table 3-5**).

EECs in T-REX that are applicable to direct effects to the CCR are for small (20 g, juveniles) and medium (100 g, adult) birds consuming a variety of dietary items. The highest EEC for the CCR is for the small bird consuming short grass. EECs in T-REX that are applicable to assess direct effect to the terrestrial-phase CTS and SFGS are for small birds (20g) consuming short grass[6]. For birds (surrogates for terrestrial-phase amphibians and reptiles), EECs and RQs for acute dose-based and chronic dietary-based exposure are calculated as these are the most sensitive values. For mammals, acute dose-based and chronic dose-based EECs and RQs are

[6] The short grass EECs and RQs are used for reptiles and amphibians to represent a conservative screen. It is not being assumed that amphibians and snakes eat short grass, the result of modeling the 20 gram bird consuming short grass is more conservative than modeling an alternative diet for amphibians and snakes and is therefore, a valid conservative screen and is protective of these species. If the short grass assessment does not result in LOC exceedances, there is a high confidence that effects are unlikely to occur.

calculated as these are typically the most sensitive values. If the dietary assessment results in higher RQs than the dose-based assessment, the highest dietary RQs are shown as well.

Table 3-5. Upper-bound Kenaga Nomogram EECs for Dietary- and Dose-based Exposures of Birds and Mammals Derived Using T-REX for Bensulide					
Use(s), Type of Application	**App Rate (lb a.i./A, # Apps, Interval (days)**	**EECs for CCR, CTS (all DPS), SFGS and Birds (small birds [20 g] consuming short grass)**		**EECs for Mammals (small mammals [15 g] consuming short grass)**	
		Dietary-based EEC (mg/kg-diet)	**Dose-based EEC (mg/kg-bw)**	**Dietary-based EEC (mg/kg-diet)**	**Dose-based EEC (mg/kg-bw)**
golf course turf	2 apps @ 16 lb a.i./acre (120 days) Granular	4196.64	4779.55	4196.64	4001.17
golf course turf and ornamental lawns and turf	2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	3278.62	3734.02	3278.62	3125.92
residential lawns	2 apps @ 12.6 lb a.i./acre (120 days) Granular	3304.85	3763.90	3304.85	3150.92
	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	2360.61	2688.50	2360.61	2250.66
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Bulb crops** (garlic, onion (dry bulb and green), radish, shallot) **Canola/rape**	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	1586.16	1806.48	1586.16	1512.28
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Leafy vegetable crops** (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	1573.74	1792.33	1573.74	1500.44

Table 3-5. Upper-bound Kenaga Nomogram EECs for Dietary- and Dose-based Exposures of Birds and Mammals Derived Using T-REX for Bensulide					
Use(s), Type of Application	**App Rate (lb a.i./A, # Apps, Interval (days)**	**EECs for CCR, CTS (all DPS), SFGS and Birds (small birds [20 g] consuming short grass)**		**EECs for Mammals (small mammals [15 g] consuming short grass)**	
		Dietary-based EEC (mg/kg-diet)	**Dose-based EEC (mg/kg-bw)**	**Dietary-based EEC (mg/kg-diet)**	**Dose-based EEC (mg/kg-bw)**
(sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula)) **Canola/rape**					
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Bulb crops** (garlic, onion (dry bulb and green), radish, shallot) **Leafy vegetable crops** (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula)) **Fruiting vegetable crops** (bell pepper, eggplant, groundcherry (strawberry tomato/tomatillo), pepper, pepper (chili), pimento) **Canola/rape**	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	1440.00	1640.02	1440.00	1372.93
Cucurbit/melon crops (cantaloupe, chayote, cucumber, cucurbit vegetables, cucuzzi, gherkin, gourds, gourd (wax), melons (bitter, honeydew, citron, mango, musk, water, winter melons), pepino, pumpkin, squash (butternut, summer, zucchini squash))	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	2360.61	2688.50	2360.61	2250.66
	1 app @ 9 lb a.i./acre (Not applicable) Emulsifiable Concentrate	2160.00	2460.02	2160.00	2059.39
NA = not applicable; App = Application					

3.3.1.b. Dietary Exposure to Amphibians and Reptiles Derived Using T-HERPS

Birds were used as surrogate species for terrestrial-phase CTS and SFGS. Terrestrial-phase amphibians and reptiles are poikilotherms indicating that their body temperature varies with environmental temperature. Birds are homeotherms indicating that their temperature is regulated, constant, and largely independent of environmental temperatures. As a consequence, the caloric requirements of terrestrial-phase amphibians and reptiles are markedly lower than birds. Therefore, on a daily dietary intake basis, birds consume more food than terrestrial-phase amphibians. This can be seen when comparing the caloric requirements for free living iguanid lizards (used in this case as a surrogate for terrestrial phase amphibians) to song birds (USEPA, 1993):

$$\text{iguanid FMR (kcal/day)} = 0.0535\ (\text{bw g})^{0.799}$$

$$\text{passerine FMR (kcal/day)} = 2.123\ (\text{bw g})^{0.749}$$

With relatively comparable slopes to the allometric functions and comparable body weights, the free-living metabolic rate (FMR) of birds can be 40 times higher than that of reptiles, though the requirement differences narrow with greater body weights.

Because the existing risk assessment process is driven by the dietary route of exposure, a finding of safety for birds, with their much higher feeding rates and, therefore, higher potential dietary exposure is reasoned to be protective of terrestrial-phase amphibians consuming similar dietary items. For this not to be the case, terrestrial-phase amphibians would have to be 40 times more sensitive than birds for the differences in dietary uptake to be negated. However, there are no existing toxicity studies in terrestrial-phase amphibians for bensulide. To quantify the potential differences in food intake between birds and terrestrial-phase CTS and amphibians, food intake equations for the iguanid lizard were used to replace the food intake equation in T-REX for birds, and additional food items of the CTS and amphibians were evaluated. These functions were encompassed in a model called T-HERPS. T-HERPS is available at: http://www.epa.gov/oppefed1/models/terrestrial/index.htm. EECs calculated using T-HERPS are shown in this section and potential risk is further discussed in the risk characterization.

EECs in T-HERPS that are applicable to the CTS are small (2 g, juveniles) amphibians consuming small and large insects and medium (20 g) amphibians consuming small and large insects, small herbivorous and insectivorous mammals, and amphibians. The dietary item that results in the highest EEC for CTS (all DPS) is the small herbivore mammal. EECs calculated using T-HERPS for the CTS are shown in **Table 3-6**.

Table 3-6. Upper-bound Kenaga Nomogram EECs for Dietary- and Dose-based Exposures of Amphibians Derived Using T-HERPS for Bensulide			
Use(s), Type of Application	App Rate (lb a.i./A, # Apps, Interval (days)	EEC for Medium CTS (medium birds [20 g] consuming herbivorous mammals [13 g])	
		Dietary-based EEC (mg/kg-diet)	Dose-based EEC (mg/kg-bw)
golf course turf	2 apps @ 16 lb a.i./acre (120 days) Granular	4258.77	2768.20
golf course turf and ornamental lawns and turf	2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	3327.16	2162.66
residential lawns	2 apps @ 12.6 lb a.i./acre (120 days) Granular	3353.78	2179.96
	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	2395.56	1557.11
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Bulb crops** (garlic, onion (dry bulb and green), radish, shallot) **Canola/rape**	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	1609.64	1046.27
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Leafy vegetable crops** (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula)) **Canola/rape**	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	1597.04	1038.07
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli	1 app @ 6 lb a.i./acre (Not applicable)	1461.32	949.86

Table 3-6. Upper-bound Kenaga Nomogram EECs for Dietary- and Dose-based Exposures of Amphibians Derived Using T-HERPS for Bensulide			
Use(s), Type of Application	App Rate (lb a.i./A, # Apps, Interval (days)	EEC for Medium CTS (medium birds [20 g] consuming herbivorous mammals [13 g])	
		Dietary-based EEC (mg/kg-diet)	Dose-based EEC (mg/kg-bw)
raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Bulb crops** (garlic, onion (dry bulb and green), radish, shallot) **Leafy vegetable crops** (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula)) **Fruiting vegetable crops** (bell pepper, eggplant, groundcherry (strawberry tomato/tomatillo), pepper, pepper (chili), pimento) **Canola/rape**	Emulsifiable Concentrate		
Cucurbit/melon crops (cantaloupe, chayote, cucumber, cucurbit vegetables, cucuzzi, gherkin, gourds, gourd (wax), melons (bitter, honeydew, citron, mango, musk, water, winter melons), pepino, pumpkin, squash (butternut, summer, zucchini squash))	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	2395.56	1557.11
	1 app @ 9 lb a.i./acre (Not applicable) Emulsifiable Concentrate	2191.98	1424.79
NA = not applicable; App = Application			

T-REX may underestimate exposure to snakes when birds are used as a surrogate and are assumed to eat similar dietary items because of the large meal size a snake may consume on a single day.[7] That is why birds consuming short grass in T-REX are used as the screen to determine whether further refinement in T-HERPS is needed for snakes. T-HERPS was modified (version 1.1) to estimate exposure to snakes based on the maximum size prey item they could consume and is used to refine a risk estimate when LOCs are exceeded for small birds consuming short grass based on RQs estimated in T-REX. The following allometric equation

[7] When examining the same application rates and types, RQs calculated in T-REX for small birds consuming short grass are higher than or equal to the highest RQs estimated in T-HERPs for medium snakes consuming small herbivore mammals. Therefore, RQs calculated in T-REX for the small birds consuming short grass may be used as a screen for examining risk to snakes.

developed by King 2002 was used to estimate the maximum size prey items for snakes (King, 2002).

$$\text{Prey Size} = \text{Snake Mass}^{1.015}$$

The 95% confidence limits on the coefficient are 0.959 and 1.071 (King, 2002). The upper limit was used in T-HERPS to estimate exposure to snakes.

EECs in T-HERPS that are applicable to the SFGS are small (2 g, juveniles) snakes consuming small and large insects and medium (20 g) snakes consuming small and large insects, small herbivorous and insectivorous mammals, and amphibians. The highest EECs for SFGS are for the medium animal consuming small herbivorous mammals. EECs calculated using T-HERPS for the SFGS are shown in **Table 3-7**.

Table 3-7. Upper-bound Kenaga Nomogram EECs for Dietary- and Dose-based Exposures of Reptiles Derived Using T-HERPS for Bensulide

Use(s), Type of Application	App Rate (lb a.i./A, # Apps, Interval (days)	EEC for Small SFGS (small bird [2 g] consuming small insects)		EEC for Medium SFGS (medium birds [20 g] consuming herbivorous mammals [25 g])	
		Dietary-based EEC (mg/kg-diet)	Dose-based EEC (mg/kg-bw)	Dietary-based EEC (mg/kg-diet)	Dose-based EEC (mg/kg-bw)
golf course turf	2 apps @ 16 lb a.i./acre (120 days) Granular	131.10	131.10	3202.29	4002.87
golf course turf and ornamental lawns and turf	2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	102.42	102.42	2501.79	3127.24
residential lawns	2 apps @ 12.6 lb a.i./acre (120 days) Granular	103.24	103.24	2521.81	3152.26
	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	73.74	73.74	1801.29	2251.61
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Bulb crops** (garlic, onion (dry bulb and green), radish, shallot) **Canola/rape**	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	49.55	49.55	1210.34	1512.92
Cole crops (*Brassica* (head and	2 apps @ 6 lb a.i./acre	49.16	49.16	1200.86	1501.08

Table 3-7. Upper-bound Kenaga Nomogram EECs for Dietary- and Dose-based Exposures of Reptiles Derived Using T-HERPS for Bensulide					
Use(s), Type of Application	**App Rate (lb a.i./A, # Apps, Interval (days)**	**EEC for Small SFGS (small bird [2 g] consuming small insects)**		**EEC for Medium SFGS (medium birds [20 g] consuming herbivorous mammals [25 g])**	
		Dietary-based EEC (mg/kg-diet)	**Dose-based EEC (mg/kg-bw)**	**Dietary-based EEC (mg/kg-diet)**	**Dose-based EEC (mg/kg-bw)**
stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Leafy vegetable crops** (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula)) **Canola/rape**	(120 days) Emulsifiable Concentrate				
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Bulb crops** (garlic, onion (dry bulb and green), radish, shallot) **Leafy vegetable crops** (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula)) **Fruiting vegetable crops** (bell pepper, eggplant, groundcherry (strawberry tomato/tomatillo), pepper, pepper (chili), pimento) **Canola/rape**	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	44.98	44.98	1098.81	1373.51

Table 3-7. Upper-bound Kenaga Nomogram EECs for Dietary- and Dose-based Exposures of Reptiles Derived Using T-HERPS for Bensulide					
Use(s), Type of Application	**App Rate (lb a.i./A, # Apps, Interval (days)**	**EEC for Small SFGS (small bird [2 g] consuming small insects)**		**EEC for Medium SFGS (medium birds [20 g] consuming herbivorous mammals [25 g])**	
		Dietary-based EEC (mg/kg-diet)	**Dose-based EEC (mg/kg-bw)**	**Dietary-based EEC (mg/kg-diet)**	**Dose-based EEC (mg/kg-bw)**
Cucurbit/melon crops (cantaloupe, chayote, cucumber, cucurbit vegetables, cucuzzi, gherkin, gourds, gourd (wax), melons (bitter, honeydew, citron, mango, musk, water, winter melons), pepino, pumpkin, squash (butternut, summer, zucchini squash))	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	73.74	73.74	1801.29	2251.61
	1 app @ 9 lb a.i./acre (Not applicable) Emulsifiable Concentrate	67.48	67.48	1648.21	2060.27
NA = not applicable; App = Application					

3.3.2. Exposure to Terrestrial Invertebrates Derived Using T-REX

T-REX is also used to calculate EECs for terrestrial invertebrates exposed to bensulide (**Table 3-8**). Available acute contact toxicity data for bees exposed to bensulide (in units of µg a.i./bee), are converted to µg a.i./g (of bee) by multiplying by 1 bee/0.128 g. Dietary-based EECs calculated by T-REX for arthropods (units of µg a.i./g) are used to estimate exposure to terrestrial invertebrates. The EECs are later compared to the adjusted acute contact toxicity data for bees in order to derive RQs to determine the direct effects to the BCB and VELB and indirect effects based on reduction in prey to the CCR, CTS, and SFGS. An example output from T-REX v. 1.5.1 is available in **Appendix E**.

Table 3-8. Summary EECs Used for Estimating Risk to Terrestrial Invertebrates and Derived Using T-REX for Bensulide		
Use(s), Type of Application	**App Rate (lb a.i./A, # Apps, Interval (days)**	**Arthropod EEC (µg a.i./g)**
golf course turf	2 apps @ 16 lb a.i./acre (120 days) Granular	1643.68
golf course turf and ornamental lawns and turf	2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	1284.13
residential lawns	2 apps @ 12.6 lb a.i./acre (120 days) Granular	1294.40
	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	924.57
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower,	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	621.25

Table 3-8. Summary EECs Used for Estimating Risk to Terrestrial Invertebrates and Derived Using T-REX for Bensulide		
Use(s), Type of Application	**App Rate (lb a.i./A, # Apps, Interval (days)**	**Arthropod EEC (μg a.i./g)**
cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Bulb crops** (garlic, onion (dry bulb and green), radish, shallot) **Canola/rape**		
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Leafy vegetable crops** (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula)) **Canola/rape**	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	616.38
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Bulb crops** (garlic, onion (dry bulb and green), radish, shallot) **Leafy vegetable crops** (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula)) **Fruiting vegetable crops** (bell pepper, eggplant, groundcherry (strawberry tomato/tomatillo), pepper, pepper (chili), pimento) **Canola/rape**	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	564.00
Cucurbit/melon crops (cantaloupe,	2 apps @ 9 lb a.i./acre	924.57

Table 3-8. Summary EECs Used for Estimating Risk to Terrestrial Invertebrates and Derived Using T-REX for Bensulide		
Use(s), Type of Application	**App Rate (lb a.i./A, # Apps, Interval (days)**	**Arthropod EEC (μg a.i./g)**
chayote, cucumber, cucurbit vegetables, cucuzzi, gherkin, gourds, gourd (wax), melons (bitter, honeydew, citron, mango, musk, water, winter melons), pepino, pumpkin, squash (butternut, summer, zucchini squash))	(120 days) Emulsifiable Concentrate	
	1 app @ 9 lb a.i./acre (Not applicable) Emulsifiable Concentrate	846.00
NA = not applicable; App = Application		

3.4. Terrestrial Plant Exposure Assessment

TerrPlant (Version 1.2.2) is used to calculate EECs for non-target plant species inhabiting dry and semi-aquatic areas. Parameter values for application rate, drift assumption, and incorporation depth are based on the use and related application method (**Table 3-3**). A runoff value of 0.01 is utilized based on bensulide's solubility, which is classified by TerrPlant as <10 mg/L for all scenarios. The default incorporation value of 1 is used for all scenarios. For ground spray application methods, drift is assumed to be 1%. For granular applications, drift is assumed to be 0%. EECs relevant to terrestrial plants consider pesticide concentrations in drift and in runoff. These EECs are listed by use in **Table 3-9**. An example output from TerrPlant v.1.2.2 is available in **Appendix F**. TerrPlant models only a single application even though many bensulide products may be applied multiple times.

Table 3-9. TerrPlant Inputs and Resulting EECs for Plants Inhabiting Dry and Semi-aquatic Areas Exposed to Bensulide via Runoff and Drift					
Use	**Application rate (lbs a.i./A)**	**Drift Value (%)**	**Spray drift EEC (lb a.i./A)**	**Dry area EEC (lb a.i./A)**	**Semi-aquatic area EEC (lb a.i./A)**
golf course turf	16 lb a.i./acre Granular	0	0	0.16	1.6
golf course turf and ornamental lawns and turf	12.5 lb a.i./acre Emulsifiable Concentrate	1	0.125	0.25	1.375
residential lawns	12.6 lb a.i./acre Granular	0	0	0.126	1.26
residential lawns **Cucurbit/melon crops** (cantaloupe, chayote, cucumber, cucurbit vegetables, cucuzzi, gherkin, gourds, gourd (wax), melons (bitter, honeydew, citron, mango, musk, water, winter melons), pepino, pumpkin, squash (butternut, summer, zucchini squash))	9 lb a.i./acre Emulsifiable Concentrate	1	0.09	0.18	0.99
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden,	6 lb a.i./acre Emulsifiable Concentrate	1	0.06	0.12	0.66

Table 3-9. TerrPlant Inputs and Resulting EECs for Plants Inhabiting Dry and Semi-aquatic Areas Exposed to Bensulide via Runoff and Drift					
Use	**Application rate (lbs a.i./A)**	**Drift Value (%)**	**Spray drift EEC (lb a.i./A)**	**Dry area EEC (lb a.i./A)**	**Semi-aquatic area EEC (lb a.i./A)**
upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Bulb crops** (garlic, onion (dry bulb and green), radish, shallot) **Leafy vegetable crops** (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula)) **Fruiting vegetable crops** (bell pepper, eggplant, groundcherry (strawberry tomato/tomatillo), pepper, pepper (chili), pimento) **Canola/rape**					

4. Effects Assessment

This assessment evaluates the potential for bensulide to directly or indirectly affect the BCB, CCR, CFWS, CTS (all DPS), DS, SFGS, TG and VELB or modify their designated critical habitat. Assessment endpoints for the effects determination for each assessed species include direct toxic effects on the survival, reproduction, and growth, as well as indirect effects, such as reduction of the prey base or modification of habitat. In addition, potential modification of critical habitat is assessed by evaluating effects to the PCEs, which are components of the critical habitat areas that provide essential life cycle needs of each assessed species. Direct effects to the aquatic-phase CTS are based on toxicity information for fish, while terrestrial-phase amphibian (CTS) and reptile (SFGS) effects are based on avian toxicity data, given that birds are generally used as a surrogate for terrestrial-phase amphibians and reptiles.

As described in the Agency's Overview Document (USEPA, 2004), the most sensitive endpoint for each taxon is used for risk estimation. For this assessment, evaluated taxa include freshwater fish, freshwater invertebrates, estuarine/marine fish, estuarine/marine invertebrates, aquatic plants, birds (also used as a surrogate for terrestrial-phase amphibians and reptiles), mammals, terrestrial invertebrates, and terrestrial plants. Acute (short-term) and chronic (long-term) toxicity information is characterized based on registrant-submitted studies and a comprehensive review of the open literature on bensulide.

4.1. Ecotoxicity Data Sources

Toxicity endpoints are established based on data generated from guideline studies submitted by the registrant, and from open literature studies that meet the criteria for inclusion into the ECOTOX database maintained by EPA/Office of Research and Development (ORD) (USEPA, 2004). Open literature data presented in this assessment were obtained from previous bensulide assessments as well as ECOTOX information obtained in December 2011 (see **Appendix H**). In order to be included in the ECOTOX database, papers must meet the following minimum criteria:

(1) the toxic effects are related to single chemical exposure;
(2) the toxic effects are on an aquatic or terrestrial plant or animal species;
(3) there is a biological effect on live, whole organisms;
(4) a concurrent environmental chemical concentration/dose or application rate is reported; and
(5) there is an explicit duration of exposure.

Most of the accepted studies in the ECOTOX refresh were either efficacy studies for plants or not more sensitive than the registrant-submitted data. There were three acceptable animal studies included in the report, but they were either not more sensitive or the same as registrant-submitted studies (see **Appendix I**). Therefore, toxicity endpoints used in this assessment rely primarily on registrant-submitted studies.

Efficacy studies do not typically provide endpoint values that are useful for risk assessment (*e.g.*, NOAEC, EC_{50}, *etc.*), but rather are intended to identify a dose that maximizes a particular effect (*e.g.*, EC_{100}). The list of citations including toxicological and/or efficacy data on target plant species not considered in this assessment is provided in **Appendix H**.

Data that pass the ECOTOX screen are evaluated along with the registrant-submitted data and may be incorporated qualitatively or quantitatively into this effects determination, as specified by the Agency’s guidance on the evaluation of open literature (USEPA, 2011b). In general, effects data in the open literature that are more conservative than the registrant-submitted data are considered. The degree to which open literature data are quantitatively or qualitatively characterized for the effects determination is dependent on whether the information is relevant to the assessment endpoints (*i.e.*, survival, reproduction, and growth) identified in **Section 2.8**. For example, endpoints such as behavior modifications are likely to be qualitatively evaluated, because quantitative relationships between behavior modifications and reduction in species survival, reproduction, and/or growth are not available. Although the effects determination relies on endpoints that are relevant to the assessment endpoints of survival, growth, or reproduction, it is important to note that the full suite of sublethal endpoints potentially available in the effects literature (regardless of their significance to the assessment endpoints) are considered, as they are relevant to the understanding of the area with potential effects, as defined for the action area.

Citations of all open literature not considered as part of this assessment because they were either rejected by the ECOTOX screen or accepted by ECOTOX but not used (*e.g.*, the endpoint is less sensitive) are included in **Appendix H**. **Appendix H** also includes a rationale for rejection of those studies that did not pass the ECOTOX screen and those that were not evaluated as part of this effects determination.

A detailed spreadsheet of the available ECOTOX open literature data, including the full suite of lethal and sublethal endpoints, is presented in **Appendix I**. **Appendix J** includes a summary of the human health effects data for bensulide.

In addition to registrant-submitted and open literature toxicity information, other sources of information, including use of the acute probit dose response relationship to establish the probability of an individual effect and reviews of ecological incident data, are considered to further refine the characterization of potential ecological effects associated with exposure to bensulide. A summary of the available aquatic and terrestrial ecotoxicity information and the incident information for bensulide are provided in **Sections 4.2** through **4.4**.

4.2. Toxicity of Bensulide to Aquatic Organisms

Table 4-1 summarizes the most sensitive aquatic toxicity endpoints for bensulide, based on an evaluation of both the submitted studies and the available open literature data, as previously discussed. No toxicity data are available for the degradate bensulide oxon. However, the toxicity of the degradate bensulide oxon is assumed to be similar to the parent (see **Section 2.2.1**). No data were available to evaluate chronic effects to benthic organisms, which may serve as prey items for the assessed species. Additional information is provided in **Appendix G**. All endpoints are expressed in terms of the active ingredient (a.i.) unless otherwise specified.

Table 4-1. Aquatic Toxicity Profile for Bensulide (Most Sensitive Endpoints)

Assessment Endpoint	Acute/ Chronic	Species	Toxicity Value Used in Risk Assessment (slope included when available)	MRID (Author, Date)	Study Classification and Comments
Freshwater fish (surrogate for aquatic-phase amphibians for chronic toxicity)	Acute	Rainbow trout (*Oncorhynchus mykiss*)	96-hr LC_{50} = 0.72 mg a.i./L	400980-01 (Mayer and Ellersiek, 1986)	Supplemental . Toxicity value from a compilation study report in which no raw data was included.
	Chronic	Fathead minnow (*Pimephales promelas*)	NOAEC = 0.374 mg a.i./L LOAEC = 0.789 mg a.i./L (based on larval growth and survival)	447204-08 (Kranzfelder, 1998)	Acceptable
Freshwater invertebrates	Acute	Water flea (*Daphnia magna*)	48-hr EC_{50} = 0.58 mg a.i./L slope = 3.78 NOAEC = 0.10 mg a.i./L	471166-01 (McCann, 1978)	Supplemental. Dissolved oxygen concentrations were unacceptably low (27.2%-48.9%) in the four highest test concentrations.
	Chronic	Water flea (*Daphnia*	NOAEC < 0.0042 mg a.i./L	450634-01 (Kranzfelder,	Supplemental. A NOAEC could not be determined due

Table 4-1. Aquatic Toxicity Profile for Bensulide (Most Sensitive Endpoints)					
Assessment Endpoint	**Acute/ Chronic**	**Species**	**Toxicity Value Used in Risk Assessment (slope included when available)**	**MRID (Author, Date)**	**Study Classification and Comments**
		magna)	(based on growth and reproduction)	1998)	to effects occurring at the lowest concentration tested.
Estuarine/ marine fish	Acute	Spot (*Leiostomus xanthurus*)	96-hr LC_{50} = 0.32 mg a.i./L	402284-01 (Mayer, 1986)	Supplemental
Estuarine/ marine invertebrates	Acute	Mysid (*Americamysis bahia*)	96-hr LC_{50} = 0.0624 mg a.i./L 48-hr LC_{50} = 0.085 mg a.i./L NOAEC = 0.0373 mg a.i./L	427502-03 (Morrow and Ward, 1993)	Acceptable
	Acute	Eastern oyster (*Crassostrea virginica*)	96-hr EC_{50} = 0.25 mg a.i./L NOAEC < 0.178 mg a.i./L	427502-02 (Morrow and Ward, 1993)	Acceptable
	Chronic	Mysid (*Americamysis bahia*)	48-hr NOAEC = 0.0485 mg a.i./L LOAEC > 0.0485 mg a.i./L (no effects)	484245-01 (Gerke, 2011)	Supplemental. There was a significant difference between the solvent control and the negative control for the 14-day male length endpoints. However, at 28 days, this difference was not observed.
Aquatic plants	Vascular	Duckweed (*Lemna gibba*)	14-day EC_{50} = 0.14 mg a.i./L NOAEC < 0.0421 mg a.i./L	447204-06 (Kranzfelder, 1998)	Supplemental
	Non-vascular	Marine diatom (*Skeletonema costatum*)	5-day EC_{50} = 0.78 mg a.i./L NOAEC = 0.635 mg a.i./L	447204-05 (Kranzfelder, 1998)	Acceptable

Toxicity to fish and aquatic invertebrates is categorized using the system shown in **Table 4-2** (USEPA, 2004). Toxicity categories for aquatic plants have not been defined.

Table 4-2. Categories of Acute Toxicity for Fish and Aquatic Invertebrates	
LC_{50} (mg/L)	Toxicity Category
< 0.1	Very highly toxic
> 0.1 - 1	Highly toxic
> 1 - 10	Moderately toxic
> 10 - 100	Slightly toxic
> 100	Practically nontoxic

4.2.1. Toxicity to Freshwater Fish

Freshwater fish toxicity data were used to assess potential direct effects of bensulide on CTS (all DPS), DS, SFGS, and TG, as well as indirect effects of bensulide to the CCR, CTS (all DPS), SFGS, and via effects to prey.

A summary of acute and chronic freshwater fish is provided below in **Sections 4.2.1.a** through **4.2.1.b**.

4.2.1.a. Freshwater Fish: Acute Exposure (Mortality) Studies

The most sensitive acute fish toxicity study utilized the rainbow trout. The study was classified as supplemental (due to the lack of raw data), and the LC_{50} was 0.72 mg a.i./L. (MRID 400980-01). This study showed bensulide to be highly toxic to freshwater fish. The two other freshwater fish LC50s were 1.1 mg a.i./L (rainbow trout; MRID 157315) and 0.81 mg a.i./L (bluegill sunfish; MRID 400980-01).

4.2.1.b. Freshwater Fish: Chronic Exposure (Growth/Reproduction) Studies

There is one acceptable freshwater fish chronic toxicity study available (MRID 447204-08). The results of the study demonstrated a NOAEC of 0.374 mg a.i./L. based on larval growth and survival.

4.2.2. Toxicity to Freshwater Invertebrates

Freshwater aquatic invertebrate toxicity data were used to assess potential direct effects of bensulide to the CFWS and indirect effects of bensulide to the CCR, CTS (all DPS), CFWS, DS, SFGS, and TG via effects on prey.

A summary of acute and chronic freshwater invertebrate data is provided below in **Sections 4.2.2.a** through **4.2.2.b**.

4.2.2.a. Freshwater Invertebrates: Acute Exposure Studies

There most sensitive acute toxicity study for freshwater invertebrates utilized the daphnid. The study was classified as supplemental (due to unacceptably low dissolved oxygen concentrations) and showed that bensulide was very highly toxic to freshwater invertebrates with an EC_{50} value of 0.58 mg a.i./L (MRID 471166-01).

4.2.2.b. Freshwater Invertebrates: Chronic Exposure Studies

A supplemental study evaluating the chronic toxicity of bensulide on daphnids indicated that bensulide concentrations of 0.0042 mg a.i./L (lowest concentration tested) could reduce the growth and reproduction of freshwater invertebrates (MRID 450634-01). The study was classified as supplemental due to effects occurring at the lowest concentration tested (NOAEC non-definitive).

4.2.3. Toxicity to Estuarine/Marine Fish

Estuarine/marine fish toxicity data were used to assess potential direct effects of bensulide on DS and TG, as well as indirect effects to the CCR via effects on prey.

A summary of acute and chronic estuarine/marine fish data is provided below in **Sections 4.2.3.a** through **4.2.3.b**.

4.2.3.a. Estuarine/Marine Fish: Acute Exposure Studies

There are two registrant-submitted study testing bensulide, TGAI, toxicity to marine estuarine fish. The study that yielded the most sensitive endpoint used the spot, *Leiostomus xanthurus* (MRID 402284-01). The Agency's review of the study deemed it as supplemental. Based on the results of the study, bensulide is classified as highly toxic to marine estuarine fish (LC_{50} = 0.32 mg a.i./L).

4.2.3.b. Estuarine/Marine Fish: Chronic Exposure Studies

Currently, no data have been submitted to the Agency on the chronic effects of bensulide to estuarine/marine fish.

4.2.4. Toxicity to Estuarine/Marine Invertebrates

Estuarine/marine aquatic invertebrate toxicity data were used to assess potential indirect effects of bensulide to the CCR, DS, and TG via effects on prey.

A summary of acute and chronic estuarine/marine invertebrate data, including data published in the open literature, is provided below in **Sections 4.2.4.a** through **4.2.4.b**.

4.2.4.a. Estuarine/Marine Invertebrates: Acute Exposure Studies

An acute toxicity study evaluating the effects of bensulide to mysid shrimp determined that bensulide is very highly toxic to estuarine/marine invertebrates with an LC_{50} of 0.0624 mg a.i./L (MRID 427502-03). This study was classified as acceptable.

4.2.4.b. Estuarine/Marine Invertebrates: Chronic Exposure Studies

A chronic life cycle toxicity study (MRID 484245-01) that evaluated the effects of bensulide on the mysid (*Americamysis bahia*) was submitted in 2011. The study was determined to be supplemental based on potential solvent interference at 14 days. However, the solvent effect was not observed at 28 days, and no effects were observed at 28 days. Therefore, the NOAEC for the study was 0.0485 mg a.i./L and the LOAEC was >0.0485 mg a.i./L. The NOAEC determined from this study will be used for quantitative risk assessment.

4.2.5. Toxicity to Aquatic Plants

Aquatic plant toxicity studies are used as one of the measures of effect to evaluate whether bensulide may affect primary production. Aquatic plants may also serve as dietary items of CCR, CTS (all DPS), CFWS, DS, and TG and habitat components for the SFGS, CCR, CTS (all DPS), CFWS, DS and TG. In addition, freshwater vascular and non-vascular plant data are used to evaluate a number of the PCEs associated with the critical habitat impact analysis for the CTS-CC, CTS-SB, DS and TG, while estuarine/marine plant data are used to evaluate a number of the PCEs associated with DS and TG.

The registrant has submitted three acceptable aquatic nonvascular plant studies and one supplemental vascular plant study testing bensulide, TGAI. The three acceptable studies tested three species of nonvascular plants including green algae, (*Pseudokirchneriella subcapitata*), marine diatom (*Skeletonema costatum*), blue-green algae (*Anabaena flos-aquae*) and duckweed (*Lemna gibba*) (MRID 447204-02, MRID 447204-05, MRID 447204-03, and MRID 447204-06, respectively). The endpoints of these studies were EC_{50s} of 1.8 mg a.i./L, 0.78 mg a.i./L, >3.58 mg a.i./L and 0.14 mg a.i./L, respectively.

4.3. Toxicity of Bensulide to Terrestrial Organisms

Table 4-3 summarizes the most sensitive terrestrial toxicity endpoints for bensulide, based on an evaluation of both the submitted studies and the open literature. No toxicity data are available for the degradate bensulide oxon. However, the toxicity of the degradate bensulide oxon is assumed to be similar to the parent (see **Section 2.2.1**). Additional information is provided in **Appendix G**.

Table 4-3. Terrestrial Toxicity Profile for Bensulide (Most Sensitive Endpoints)

Endpoint	Acute/ Chronic	Species	Toxicity Value Used in Risk Assessment (slope included when available)	MRID (Author, Date)	Study Classification
Birds (also surrogate for terrestrial-phase amphibians and reptiles)	Acute	Bobwhite quail (*Colinus virginianus*)	LD_{50} = 1386 mg a.i./kg bw slope = 2.92	158455 (Grimes, 1986)	Acceptable
	Subacute Dietary	Bobwhite quail (*Colinus virginianus*) and Mallard duck (*Anas	LC_{50} > 5620 mg a.i./kg diet NOAEC < 562 mg a.i./kg-diet (based on reduced food	158456 (Grimes, 1986)	Acceptable

Table 4-3. Terrestrial Toxicity Profile for Bensulide (Most Sensitive Endpoints)					
Endpoint	**Acute/ Chronic**	**Species**	**Toxicity Value Used in Risk Assessment (slope included when available)**	**MRID (Author, Date)**	**Study Classification**
		platyrhynchos)	consumption at all treatment levels)		
	Chronic	Mallard duck (*Anas platyrhynchos*)	NOAEC = 2.5 mg a.i./kg diet LOAEC = 25 mg a.i./kg-diet (based on reduction in eggshell thickness)	444869-01 (Mansell, 1998)	Acceptable
Mammals	Acute	Rat (*Rattus norvegicus*)	LD_{50} = 270 mg a.i./kg bw	920050-11 (Velez, 1990)	Acceptable
	Chronic	Rat (*Rattus norvegicus*)	NOAEC = 150 mg a.i./kg diet (based on F2 pup survival)	00146585	Acceptable
Terrestrial invertebrates	Acute Contact	Honey bee (*Apis mellifera*)	LD_{50} = 234.38 µg a.i./g bee	Tomlin, 1997	Not applicable. Based on piperophos endpoint (see **Section 4.3.3.b**).
Terrestrial plants	NA	Seedling Emergence Monocots	Ryegrass EC_{25} = 1.9 lb a.i./A NOAEC = 0.38 lb a.i./A	447463-01 (Schwab, 1998)	Acceptable
	NA	Seedling Emergence Dicots	All species similar EC_{25} > 6 lb a.i./A NOAEC = 6.0 lb a.i./A	447463-01 (Schwab, 1998)	Acceptable
	NA	Vegetative Vigor Monocots	Corn EC_{25} > 6 lb a.i./A NOAEC = 0.75 lb a.i./A	447463-01 (Schwab, 1998)	Acceptable
	NA	Vegetative Vigor Dicots	Cucumber EC_{25} = 1.3 lb a.i./A NOAEC = 0.38 lb a.i./A	447463-01 (Schwab, 1998)	Acceptable

Acute toxicity to terrestrial animals is categorized using the classification system shown in **Table 4-4** (USEPA, 2004). Toxicity categories for terrestrial plants have not been defined.

Table 4-4. Categories of Acute Toxicity for Avian and Mammalian Studies		
Oral LD_{50}	**Dietary LC_{50}**	**Toxicity Category**
< 10 mg/kg	< 50 mg/kg-diet	Very highly toxic
10 - 50 mg/kg	50 - 500 mg/kg-diet	Highly toxic
51 - 500 mg/kg	501 - 1000 mg/kg-diet	Moderately toxic
501 - 2000 mg/kg	1001 - 5000 mg/kg-diet	Slightly toxic
> 2000 mg/kg	> 5000 mg/kg-diet	Practically non-toxic

4.3.1. Toxicity to Birds, Reptiles, and Terrestrial-Phase Amphibians

Avian toxicity data were used to assess potential direct effects of bensulide to the SFGS, CCR, and terrestrial-phase CTS (all DPS) as well as indirect effects of bensulide to the SFGS and CCR via effects on prey. As specified in the Overview Document, the Agency uses birds as a surrogate for reptiles and terrestrial-phase amphibians when toxicity data for each specific taxon are not available (USEPA, 2004). The available open literature has no information on bensulide toxicity to reptiles or terrestrial-phase amphibians.

A summary of acute and chronic avian data, including sublethal effects, is provided below in **Sections 4.3.1.a** through **4.3.1.b**.

4.3.1.a. Birds: Acute Exposure (Mortality) Studies

The registrant submitted three avian acute toxicity studies testing bensulide, technical grade active ingredient (TGAI). These studies included two acceptable sub-acute dietary toxicity studies testing bobwhite quail and mallard duck respectively (MRIDs 158456 and 158457) and a single acceptable acute oral dose toxicity study (MRID 158455).

The avian acute toxicity studies indicate that bensulide is practically nontoxic to birds on an acute dietary basis (LC_{50} > 5620 ppm) and slightly toxic on an acute oral toxicity basis (LD_{50} = 1386).

4.3.1.b. Birds: Chronic Exposure (Growth, Reproduction) Studies

Three reproductive toxicity studies testing mallard duck and northern bobwhite quail including two acceptable studies and one supplemental study **(**MRIDs 444869-01, MRID 436160-02, and MRID 43616-00) were submitted. The avian reproductive toxicity studies showed that bensulide can impair avian reproduction at relatively low dietary concentrations. The most serious effect appears to be a reduction of eggshell thickness, which begins to occur at dietary concentrations between 2.5 and 25 ppm a.i. At 250 ppm a.i., the reduction in eggshell thickness was severe **(**11% reduction in MRID 444869-01 and 15% in MRID 436160-02**)** which resulted in a significant increase in the number of cracked eggs. Cracking of eggs usually causes the embryo to die before hatching. Additionally, a dietary concentration of 250 ppm a.i. fed to mallards reduced the percentage of eggs hatched and the percent survival to the 3-week embryo and 14-day-old chick stages.

4.3.2. Toxicity to Mammals

Mammalian toxicity data were used to determine the indirect effects of bensulide to the SFGS, CCR, and CTS (all DPS) via effects on prey and to the SFGS and CTS (all DPS) via effects on habitat or rearing sites.

A summary of acute and chronic mammalian data is provided below in **Sections 4.3.2.a** through **4.3.2.b**. A more complete analysis of toxicity data to mammals is available in **Appendix J**, which is a copy of the Health Effects Division (HED) chapter prepared in support of the re-registration eligibility decision (RED) document finalized in 1999.

4.3.2.a. Mammals: Acute Exposure (Mortality) Studies

The registrant submitted mammalian ecotoxicity studies testing bensulide, TGAI, include a rat single-dose oral LD_{50} study (MRID 920050-11). The mammalian acute toxicity study demonstrates that bensulide is moderately toxic to mammals (LD_{50} = 270 mg a.i./kg-bw).

4.3.2.b. Mammals: Chronic Exposure (Growth, Reproduction) Studies

The mammalian multigenerational reproductive toxicity study results showed a NOAEC of 150 ppm a.i. and the LOAEC is 900 ppm a.i. Rats fed 900 ppm a.i. of bensulide had decreased pup survival, whereas rats fed 150 ppm a.i. had no effects on reproduction. Plasma cholinesterase activity was significantly reduced compared to control at dietary concentrations as low as 23 mg a.i./kg/day. No developmental effects were observed in rats administered oral doses as great as 95 mg a.i./kg/day, which is approximately equivalent to 1900 ppm in the diet (MRID 00146585).

4.3.3. Toxicity to Terrestrial Invertebrates

Terrestrial invertebrate toxicity data were used to assess potential direct effects of bensulide to the BCB and VELB, as well as indirect effects of bensulide to the SFGS, CCR, and CTS (all DPS) via effects on prey.

A summary of acute terrestrial invertebrate data, including data published in the open literature, is provided below in **Sections 4.3.3.a** through **4.3.3.b**.

4.3.3.a. Terrestrial Invertebrates: Acute Exposure (Mortality) Studies

A bensulide honey bee acute contact toxicity study demonstrated a contact LD_{50} of >24.17 µg a.i./bee (only 1.6% of bees died at the limit dose of 24.17 µg a.i./bee) (MRID 00018842). This result indicates that bensulide is practically non-toxic to bees on an acute contact basis. This non-definitive toxicity value was converted to µg/g bee by dividing by 0.128 g (the approximate weight of an adult bee) in order to compare it to EECs (24.17/0.128 = 188.83 µg a.i./g bee). Since EECs are much higher than this non-definitive LD_{50}, there is a great deal of uncertainty in using this value for a quantitative risk assessment.

4.3.3.b. Terrestrial Invertebrates: Sublethal Effects and Additional Open Literature Information

Due to EECs being much higher than the non-definitive $LD_{50,}$ structures of other organophosphate herbicides were studied to determine whether surrogate data could be used to quantitatively estimate risk to terrestrial invertebrates. The organophosphate herbicide piperophos (CAS No. 24151-93-7; no PC code) was most similar to bensulide, as the two chemicals are both phosphorodithioates. The acute contact LD_{50} for piperophos is 30 µg a.i./bee

(Tomlin, 1997). Converted to µg a.i./g bee (30/0.128), the LD_{50} used for risk quantification is 234.38 µg a.i./g bee.

4.3.4. Toxicity to Terrestrial Plants

Terrestrial plants may serve as dietary items of BCB, CCR, CFWS, and VELB and habitat components for the BCB, CCR, CTS (all DPS), CFWS, DS, SFGS, TG, and VELB. In addition, terrestrial plant data are used to evaluate a number of the PCEs associated with the critical habitat impact analysis for the BCB, CTS-CC, CTS-SB, DS, TG, and VELB. The BCB and VELB have obligate relationships with dicot plants.

Plant toxicity data from both registrant-submitted studies and studies in the scientific literature were reviewed for this assessment. Registrant-submitted studies are conducted under conditions and with species defined in EPA toxicity test guidelines. Sublethal endpoints such as plant growth, dry weight, and biomass are evaluated for both monocots and dicots, and effects are evaluated at both seedling emergence and vegetative life stages. Guideline studies generally evaluate toxicity to ten crop species. These tests are conducted on herbaceous crop species only, and extrapolation of effects to other species, such as the woody shrubs and trees and wild herbaceous species, contributes uncertainty to risk conclusions.

Commercial crop species have been selectively bred and may be more or less resistant to particular stressors than wild herbs and forbs. The direction of this uncertainty for specific plants and stressors, including bensulide, is largely unknown. Homogenous test plant seed lots also lack the genetic variation that occurs in natural populations; so, the range of effects seen from tests is likely to be smaller than would be expected from wild populations.

The registrant submitted a vegetative vigor and seedling emergence study testing a formulation containing 45% of bensulide as the active ingredient (MRID 447463-01). The results of the vegetative vigor study demonstrated that cucumber was the most sensitive dicot tested. The cucumber yielded an EC_{25} of 1.3 lb a.i./A and a NOAEC of 0.38 lb a.i./A (based on phytotoxicity). The most sensitive monocot tested in the vegetative vigor study was corn with an EC_{25} of >6.0 lb a.i./A and a NOAEC of 0.75 lb a.i./A (based on shoot fresh weight). The results of the seedling emergence study demonstrate that the most sensitive monocot was ryegrass. Ryegrass yielded an EC_{25} of 1.9 lb a.i./A. and a NOAEC of 0.38 lb a.i./A (based on phytotoxicity). There was not a most sensitive dicot in the seedling emergence study, as all species yielded similar results with EC_{25}s of >6.0 lb a.i./A and NOAECs of 6 lb a.i./A
.

4.4. Incident Database Review

A review of the Ecological Incident Information System (EIIS, version 2.1), the ‘Aggregate Incident Reports’ (v. 1.0) database, and the Avian Incident Monitoring System (AIMS) for ecological incidents involving bensulide was completed on May 17, 2012. No incidents were found in EIIS or AIMS. The Aggregate Incident Reports database contained 57 minor plant incidents (P-B) that occurred from 1997 to 2006. It should be noted that a lack of reported incidents does not imply that no incidents have occurred.

4.5. Use of Probit Slope Response Relationship to Provide Information on the Endangered Species Levels of Concern

The Agency uses the probit dose response relationship as a tool for providing additional information on the potential for acute direct effects to individual listed species and aquatic animals that may indirectly affect the listed species of concern (USEPA, 2004). As part of the risk characterization, an interpretation of acute RQs for listed species is discussed. This interpretation is presented in terms of the chance of an individual event (*i.e.*, mortality or immobilization) should exposure at the EEC actually occur for a species with sensitivity to bensulide on par with the acute toxicity endpoint selected for RQ calculation. To accomplish this interpretation, the Agency uses the slope of the dose response relationship available from the toxicity study used to establish the acute toxicity measures of effect for each taxonomic group that is relevant to this assessment. The individual effects probability associated with the acute RQ is based on the mean estimate of the slope and an assumption of a probit dose response relationship. In addition to a single effects probability estimate based on the mean, upper and lower estimates of the effects probability are also provided to account for variance in the slope, if available.

Individual effect probabilities are calculated based on an Excel spreadsheet tool IECV1.1 (Individual Effect Chance Model Version 1.1) developed by the U.S. EPA, OPP, Environmental Fate and Effects Division (June 22, 2004). The model allows for such calculations by entering the mean slope estimate (and the 95% confidence bounds of that estimate) as the slope parameter for the spreadsheet. In addition, the acute RQ is entered as the desired threshold. Results of the IECV1.1 calculations for the individual effect probabilities for a variety of use scenarios based on bensulide toxicity data are presented in **Table 4-5**.

Table 4-5. Individual Effect Probabilities for Bensulide Exposure at the LOC and for Scenarios that Produce RQs that Exceed the LOC

Exposure Scenario	Taxa	Acute RQ	Probit Slope	Chance of Effect (1 in…)
Listed Species LOC	Terrestrial Invertebrate LD_{50} = 234.38 µg a.i./g bee	0.05	4.5 (Default slope)	418,000,000
golf course turf (2 apps @ 16 lb a.i./acre)		7.01		1
golf course turf and ornamental lawns and turf (2 apps @ 12.5 lb a.i./acre)		5.48		1
residential lawns (2 apps @ 12.6 lb a.i./acre)		5.52		1
residential lawns (2 apps @ 9 lb a.i./acre)		3.94		1
Crops (3 apps @ 6 lb a.i./acre)		2.65		1.03
Crops (2 apps @ 6 lb a.i./acre)		2.63		1.03
Crops (1 app @ 6 lb a.i./acre)		2.41		1.04
Crops (2 apps @ 9 lb a.i/acre)		3.94		1

Table 4-5. Individual Effect Probabilities for Bensulide Exposure at the LOC and for Scenarios that Produce RQs that Exceed the LOC				
Exposure Scenario	**Taxa**	**Acute RQ**	**Probit Slope**	**Chance of Effect (1 in…)**
Crops (1 app @ 9 lb a.i/acre)		3.61		1.01
Listed Species LOC	Small Bird LD_{50} = 1386 mg/kg-bw	0.1	2.92	571
golf course turf (2 apps @ 16 lb a.i./acre)		4.79		1.02
golf course turf and ornamental lawns and turf (2 apps @ 12.5 lb a.i./acre)		3.74		1.05
residential lawns (2 apps @ 12.6 lb a.i./acre)		3.77		1.05
residential lawns (2 apps @ 9 lb a.i./acre)		2.69		1.12
Crops (3 apps @ 6 lb a.i./acre)		1.81		1.29
Crops (2 apps @ 6 lb a.i./acre)		1.79		1.30
Crops (1 app @ 6 lb a.i./acre)		1.64		1.36
Crops (2 apps @ 9 lb a.i/acre)		2.69		1.12
Crops (1 app @ 9 lb a.i/acre)		2.46		1.15
Listed Species LOC	Small Mammal LD_{50} = 270 mg/kg-bw	0.1	4.5 (Default slope)	294,000
golf course turf (2 apps @ 16 lb a.i./acre)		6.74		1
golf course turf and ornamental lawns and turf (2 apps @ 12.5 lb a.i./acre)		5.27		1
residential lawns (2 apps @ 12.6 lb a.i./acre)		5.31		1
residential lawns (2 apps @ 9 lb a.i./acre)		3.79		1
Crops (3 apps @ 6 lb a.i./acre)		2.55		1.03
Crops (2 apps @ 6 lb a.i./acre)		2.53		1.04
Crops (1 app @ 6 lb a.i./acre)		2.31		1.05
Crops (2 apps @ 9 lb a.i/acre)		3.79		1
Crops (1 app @ 9 lb a.i/acre)		3.47		1.01
Listed Species LOC	FW Fish LC_{50} = 0.72 mg/L	0.05	4.5 (Default slope)	418,000,000
CA Turf RLF (2 apps @ 12.5 lb a.i./acre)		0.11		125,000
CA Wheat (3 apps @ 6 lb a.i./acre)		0.32		77.0
CA Wheat (2 apps @ 6		0.18		2,490

Table 4-5. Individual Effect Probabilities for Bensulide Exposure at the LOC and for Scenarios that Produce RQs that Exceed the LOC				
Exposure Scenario	**Taxa**	**Acute RQ**	**Probit Slope**	**Chance of Effect (1 in…)**
lb a.i./acre)				
CA Wheat (1 app @ 6 lb a.i./acre)		0.11		125,000
CA Cole Crop RLF (3 apps @ 6 lb a.i./acre)		0.64		5.22
CA Cole Crop RLF (2 apps @ 6 lb a.i./acre)		0.35		49.8
CA Cole Crop RLF (1 app @ 6 lb a.i./acre)		0.17		3,740
CA Lettuce No-irrig. (2 apps @ 6 lb a.i./acre)		0.41		24.6
CA Lettuce No-irrig. (1 app @ 6 lb a.i./acre)		0.21		874
CA Row Crop RLF (3 apps @ 6 lb a.i./acre)		0.30		107
CA Row Crop RLF (2 apps @ 6 lb a.i./acre)		0.14		16,400
CA Row Crop RLF (1 app @ 6 lb a.i./acre)		0.06		52,200,000
CA Melon RLF (2 apps @ 9 lb a.i./acre)		0.16		5,850
CA Melon RLF (1 app @ 9 lb a.i./acre)		0.15		9,560
CA Onion No-irrig. (3 apps @ 6 lb a.i./acre)		0.09		791,000
Listed Species LOC	FW Invertebrate EC_{50} = 0.58 mg/L	0.05	3.78	2,290,000
CA Turf RLF (2 apps @ 16 lb a.i./acre)		0.05		2,290,000
CA Turf RLF (2 apps @ 12.5 lb a.i./acre)		0.14		1,600
CA Turf RLF (2 apps @ 12.5 lb a.i./acre)		0.05		2,290,000
CA Wheat (3 apps @ 6 lb a.i./acre)		0.39		16.4
CA Wheat (2 apps @ 6 lb a.i./acre)		0.22		155
CA Wheat (1 app @ 6 lb a.i./acre)		0.14		1,600
CA Cole Crop RLF (3 apps @ 6 lb a.i./acre)		0.80		2.80
CA Cole Crop RLF (2 apps @ 6 lb a.i./acre)		0.44		11.3
CA Cole Crop RLF (1 app @ 6 lb a.i./acre)		0.22		155
CA Lettuce No-irrig. (2 apps @ 6 lb a.i./acre)		0.51		7.44
CA Lettuce No-irrig. (1 app @ 6 lb a.i./acre)		0.26		74.1
CA Row Crop RLF (3 apps @ 6 lb a.i./acre)		0.38		17.8

Table 4-5. Individual Effect Probabilities for Bensulide Exposure at the LOC and for Scenarios that Produce RQs that Exceed the LOC				
Exposure Scenario	**Taxa**	**Acute RQ**	**Probit Slope**	**Chance of Effect (1 in…)**
CA Row Crop RLF (2 apps @ 6 lb a.i./acre)		0.18		410
CA Row Crop RLF (1 app @ 6 lb a.i./acre)		0.08		59,200
CA Melon RLF (2 apps @ 9 lb a.i./acre)		0.20		243
CA Melon RLF (1 app @ 9 lb a.i./acre)		0.19		312
CA Tomato No-irrig. (1 app @ 6 lb a.i./acre)		0.05		2,290,000
CA Onion No-irrig. (3 apps @ 6 lb a.i./acre)		0.11		6,880
Listed Species LOC	E/M Fish LC_{50} = 0.32 mg/L	0.05	4.5 (Default slope)	418,000,000
CA Turf RLF (2 apps @ 16 lb a.i./acre)		0.10		294,000
CA Turf RLF (2 apps @ 12.5 lb a.i./acre)		0.25		297
CA Turf RLF (2 apps @ 12.5 lb a.i./acre)		0.08		2,510,000
CA Residential RLF (2 apps @ 12.6 lb a.i./acre)		0.06		52,200,000
CA Residential RLF (2 apps @ 9 lb a.i./acre)		0.05		418,000,000
CA Wheat RLF (3 apps @ 6 lb a.i./acre)		0.71		3.97
CA Wheat RLF (2 apps @ 6 lb a.i./acre)		0.40		27.3
CA Wheat RLF (1 app @ 6 lb a.i./acre)		0.25		297
CA Cole Crop RLF (3 apps @ 6 lb a.i./acre)		1.45		1.31
CA Cole Crop RLF (2 apps @ 6 lb a.i./acre)		0.79		3.10
CA Cole Crop RLF (1 app @ 6 lb a.i/acre)		0.39		30.4
CA Lettuce No-irrig. (2 apps @ 6 lb a.i./acre)		0.93		2.25
CA Lettuce No-irrig. (1 app @ 6 lb a.i./acre)		0.47		14.3
CA Row Crop RLF (3 apps @ 6 lb a.i./acre)		0.68		4.43
CA Row Crop RLF (2 apps @ 6 lb a.i./acre)		0.33		66.1
CA Row Crop RLF (1 app @ 6 lb a.i./acre)		0.14		16,400
CA Melon RLF (2 apps @ 9 lb a.i./acre)		0.36		43.6
CA Melon RLF (1 app @ 9 lb a.i./acre)		0.35		49.8
CA Tomato No-irrig. (1		0.10		294,000

Table 4-5. Individual Effect Probabilities for Bensulide Exposure at the LOC and for Scenarios that Produce RQs that Exceed the LOC				
Exposure Scenario	**Taxa**	**Acute RQ**	**Probit Slope**	**Chance of Effect (1 in…)**
app @ 6 lb a.i./acre)				
CA Onion No-irrig. (3 apps @ 6 lb a.i./acre)		0.20		1,210
Listed Species LOC	E/M Invertebrate LC_{50} = 0.0624 mg/L	0.05	4.5 (Default slope)	418,000,000
CA Turf RLF (2 apps @ 16 lb a.i./acre)		0.49		12.2
CA Turf RLF (2 apps @ 12.5 lb a.i./acre)		1.27		1.47
CA Turf RLF (2 apps @ 12.5 lb a.i./acre)		0.43		20.2
CA Residential RLF (2 apps @ 12.6 lb a.i./acre)		0.31		90.6
CA Residential RLF (2 apps @ 9 lb a.i./acre)		0.27		190
CA Wheat (3 apps @ 6 lb a.i/acre)		3.64		1.01
CA Wheat (2 apps @ 6 lb a.i/acre)		2.04		1.09
CA Wheat (1 app @ 6 lb a.i/acre)		1.26		1.48
CA Cole Crop RLF (3 apps @ 6 lb a.i./acre)		7.43		1
CA Cole Crop RLF (2 apps @ 6 lb a.i./acre)		4.07		1
CA Cole Crop RLF (1 app @ 6 lb a.i/acre)		2.02		1.09
CA Lettuce No-irrig. (2 apps @ 6 lb a.i./acre)		4.77		1
CA Lettuce No-irrig. (1 app @ 6 lb a.i./acre)		2.42		1.04
CA Row Crop RLF (3 apps @ 6 lb a.i./acre)		3.50		1.01
CA Row Crop RLF (2 apps @ 6 lb a.i./acre)		1.67		1.19
CA Row Crop RLF (1 app @ 6 lb a.i./acre)		0.74		3.6
CA Melon RLF (2 apps @ 9 lb a.i./acre)		1.84		1.13
CA Melon RLF (1 app @ 9 lb a.i./acre)		1.78		1.15
CA Tomato No-irrig. (1 app @ 6 lb a.i./acre)		0.49		12.2
CA Onion No-irrig. (3 apps @ 6 lb a.i./acre)		1.03		1.91
CA Onion No-irrig. (1 app @ 6 lb a.i./acre)		0.17		3,740

5. Risk Characterization

Risk characterization is the integration of the exposure and effects characterizations. Risk characterization is used to determine the potential for direct and/or indirect effects to the BCB, CCR, CFWS, CTS (all DPS), DS, SFGS, TG, and VELB or for modification to their designated critical habitat from the use of bensulide in California. The risk characterization provides an estimation (**Section 5.1**) and a description (**Section 5.2**) of the likelihood of adverse effects; articulates risk assessment assumptions, limitations, and uncertainties; and synthesizes an overall conclusion regarding the likelihood of adverse effects to the assessed species or their designated critical habitat (*i.e*., "no effect," "likely to adversely affect," or "may affect, but not likely to adversely affect"). In the risk estimation section, risk quotients are calculated using standard EFED procedures and models. In the risk description section, additional analyses may be conducted to help characterize the potential for risk.

5.1. Risk Estimation

Risk is estimated by calculating the ratio of exposure to toxicity. This ratio is the risk quotient (RQ), which is then compared to pre-established acute and chronic levels of concern (LOCs) for each category evaluated (see **Appendix C**). For acute exposures to listed aquatic animals and terrestrial invertebrates, the LOC is 0.05. For acute exposures to listed birds (and, thus, reptiles and terrestrial-phase amphibians) and mammals, the LOC is 0.1. The LOC for chronic exposures to animals and acute exposures to plants is 1.0.

5.1.1. Potential Risk in the Aquatic Habitat

5.1.1.a. Freshwater and Estuarine/Marine Fish and Aquatic-phase Amphibians

Acute risk to freshwater fish and aquatic-phase amphibians and reptiles is based on 1 in 10 year peak EECs in the standard pond and the lowest acute toxicity value for freshwater fish. Chronic risk is based on the 1 in 10 year 60-day EECs and the lowest chronic toxicity value for freshwater fish. Bensulide total toxic residue risk quotients are shown in **Table 5-1** for freshwater fish (no data were available for aquatic-phase amphibians). **Table 5-2** includes RQs for acute risk to estuarine/marine fish. Since a chronic toxicity value was not available for estuarine/marine fish, RQs were not calculated.

For freshwater fish, the acute listed species LOC (0.05) was exceeded for the following use groups: ornamental lawns and turf, canola, cole crops, leafy vegetables, row crops, melons/cucurbits, and onion/bulb vegetables (high rate only). Golf course turf uses, residential lawns, the low rate for onion/bulb vegetables, and fruiting vegetables use groups did not produce RQs that exceeded the acute listed species LOC. The acute non-listed species LOC (0.5) was also exceeded by the cole crops use group (high rate only). Only the high rate (3 applications at 6 lb a.i./acre) for the cole crops group exceeded the chronic LOC.

Table 5-1. Acute and Chronic RQs for Freshwater Fish and Aquatic-phase Amphibians Exposure to Bensulide					
PRZM Scenario (crops represented by scenario)	**Application Rate (Interval) Formulation Type**	**Peak EEC (µg/L)**	**Acute RQ**	**60-day EEC (µg/L)**	**Chronic RQ**
CA Turf RLF (golf course turf for use on tees, greens, and bentgrass fairways only)	2 apps @ 16 lb a.i./acre (120 days) Granular	30.44	0.04	26.21	0.07
CA Turf RLF (ornamental lawns and turf)	2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	79.48	**0.11**	70.49	0.19
CA Turf RLF (golf course turf for use on tees, greens, and bentgrass fairways only)	2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	27.02	0.04	23.97	0.06
CA Residential RLF (residential lawns)	2 apps @ 12.6 lb a.i./acre (120 days) Granular	19.48	0.03	17.41	0.05
	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	16.63	0.02	14.42	0.04
CA Wheat (canola	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	227.30	**0.32**	199.30	0.53
	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	127.10	**0.18**	120.80	0.32
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	78.59	**0.11**	71.99	0.19
CA Cole Crop RLF (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage)	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	463.70	**0.64***	378.40	**1.01**
	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	254.20	**0.35**	228.00	0.61
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	125.90	**0.17**	111.20	0.30
CA Lettuce No-irrig. (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula))	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	297.50	**0.41**	248.50	0.66
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	151.30	**0.21**	129.60	0.35
CA Row Crop RLF (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas)	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	218.50	**0.30**	192.00	0.51
	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	104.38	**0.14**	91.80	0.25
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	46.04	**0.06**	40.11	0.11

Table 5-1. Acute and Chronic RQs for Freshwater Fish and Aquatic-phase Amphibians Exposure to Bensulide					
PRZM Scenario (crops represented by scenario)	**Application Rate (Interval) Formulation Type**	**Peak EEC (µg/L)**	**Acute RQ**	**60-day EEC (µg/L)**	**Chronic RQ**
CA Melon RLF (cantaloupe, chayote, cucumber, cucurbit vegetables, cucuzzi, gherkin, gourds, gourd (wax), melons (bitter, honeydew, citron, mango, musk, water, winter melons), pepino, pumpkin, squash (butternut, summer, zucchini squash))	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	115.10	**0.16**	102.63	0.27
	1 app @ 9 lb a.i./acre (Not applicable) Emulsifiable Concentrate	111.20	**0.15**	98.70	0.26
CA Tomato No-irrig. (bell pepper, eggplant, groundcherry (strawberry tomato/tomatillo), pepper, pepper (chili), pimento)	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	30.88	0.04	27.45	0.07
CA Onion No-Irrig. (garlic, onion (dry bulb and green), radish, shallot)	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	64.21	**0.09**	56.74	0.15
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	10.88	0.02	9.17	0.02
Listed species LOC exceedances (acute RQ $\geq$ 0.05; chronic RQ $\geq$ 1.0) are bolded. *Also exceeds acute non-listed species LOC (0.5). Acute RQ = use-specific peak EEC/LC_{50} (720 µg/L). Chronic RQ = use-specific 60-day EEC/estimated NOAEC (374 µg/L).					

For acute risk to estuarine/marine fish, the acute listed species LOC (0.05) was exceeded for all uses except the low rate for onion/bulb vegetable uses (1 application at 6 lb a.i./acre) (see **Table 5-2**). The following use groups also exceeded the acute non-listed species LOC (0.5): canola (high rate only), cole crops (high and medium rate only), leafy vegetables (high rate only), and row crops (high rate only). Chronic RQs for estuarine/marine fish could not be calculated since a chronic study was not submitted. The acute-to-chronic ratio (ACR) could not be used as the freshwater species studies used two different species for the acute and chronic tests. Although only one use group exceeded the chronic RQ for freshwater fish, due to the slight increased toxicity to estuarine/marine fish on an acute basis and due to the lack of submitted data, chronic risks to estuarine/marine fish cannot be precluded, and the Agency conservatively assumes that all chronic estuarine/marine fish RQs would exceed the LOC.

Table 5-2. Acute RQs for Estuarine/marine Fish Exposure to Bensulide			
PRZM Scenario (crops represented by scenario)	**Application Rate (Interval) Formulation Type**	**Peak EEC (µg/L)**	**Acute RQ**
CA Turf RLF (golf course turf for use on tees, greens, and bentgrass fairways only)	2 apps @ 16 lb a.i./acre (120 days) Granular	30.44	**0.10**
CA Turf RLF (ornamental lawns and turf)	2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	79.48	**0.25**
CA Turf RLF (golf course turf for use on tees, greens, and	2 apps @ 12.5 lb a.i./acre (120 days)	27.02	**0.08**

Table 5-2. Acute RQs for Estuarine/marine Fish Exposure to Bensulide			
PRZM Scenario (crops represented by scenario)	**Application Rate (Interval) Formulation Type**	**Peak EEC (µg/L)**	**Acute RQ**
bentgrass fairways only)	Emulsifiable Concentrate		
CA Residential RLF (residential lawns)	2 apps @ 12.6 lb a.i./acre (120 days) Granular	19.48	**0.06**
	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	16.63	**0.05**
CA Wheat (canola)	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	227.30	**0.71***
	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	127.10	**0.40**
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	78.59	**0.25**
CA Cole Crop RLF (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage)	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	463.70	**1.45***
	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	254.20	**0.79***
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	125.90	**0.39**
CA Lettuce No-irrig. (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula))	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	297.50	**0.93***
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	151.30	**0.47**
CA Row Crop RLF (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas)	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	218.50	**0.68***
	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	104.38	**0.33**
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	46.04	**0.14**
CA Melon RLF (cantaloupe, chayote, cucumber, cucurbit vegetables, cucuzzi, gherkin, gourds, gourd (wax), melons (bitter, honeydew, citron, mango, musk, water, winter melons), pepino, pumpkin, squash (butternut, summer, zucchini squash))	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	115.10	**0.36**
	1 app @ 9 lb a.i./acre (Not applicable) Emulsifiable Concentrate	111.20	**0.35**
CA Tomato No-irrig. (bell pepper, eggplant, groundcherry (strawberry tomato/tomatillo), pepper, pepper (chili), pimento)	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	30.88	**0.10**

Table 5-2. Acute RQs for Estuarine/marine Fish Exposure to Bensulide			
PRZM Scenario (crops represented by scenario)	**Application Rate (Interval) Formulation Type**	**Peak EEC (µg/L)**	**Acute RQ**
CA Onion No-Irrig. (garlic, onion (dry bulb and green), radish, shallot)	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	64.21	**0.20**
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	10.88	0.03
Listed species LOC exceedances (acute RQ ≥ 0.05) are bolded. *Also exceeds acute non-listed species LOC (0.5). Acute RQ = use-specific peak EEC/LC_{50} (320 µg/L).			

5.1.1.b. Freshwater and Estuarine/Marine Invertebrates

Acute risk to freshwater invertebrates is based on 1 in 10 year peak EECs in the standard pond and the lowest acute toxicity value for freshwater invertebrates. Chronic risk is based on 1 in 10 year 21-day EECs and the lowest chronic toxicity value for freshwater invertebrates. Bensulide RQs for freshwater invertebrates are shown in **Table 5-3**. It should be noted that the chronic toxicity value for freshwater invertebrates (NOAEC < 4.2 µg a.i./L) was non-definitive due to effects occurring at all treatment levels. However, RQs were calculated based on this value to show that every scenario produced RQs that exceeded the LOC. **Table 5-4** includes RQs for acute and chronic risk to estuarine/marine invertebrates.

For freshwater invertebrates, the acute listed species LOC (0.05) was exceeded for the following use groups: turf, canola, cole crops, leafy vegetables, row crops, melons/cucurbits, fruiting vegetables, and onion/bulb vegetables (high rate only). The acute listed species LOC was not exceeded for residential lawns and onion/bulb vegetables (low rate only). The acute non-listed species LOC (0.5) was also exceeded for cole crops (high rate only) and leafy vegetables (high rate only). Chronic RQs for freshwater invertebrates were based on a non-definitive RQ and, thus, are not conservative risk estimates. However, all chronic RQs exceeded the LOC based on the non-definitive NOAEC.

Table 5-3. Acute and Chronic RQs for Freshwater Invertebrates Exposure to Bensulide					
PRZM Scenario (crops represented by scenario)	**Application Rate (Interval) Formulation Type**	**Peak EEC (µg/L)**	**Acute RQ**	**21-day EEC (µg/L)**	**Chronic RQ**
CA Turf RLF (golf course turf for use on tees, greens, and bentgrass fairways only)	2 apps @ 16 lb a.i./acre (120 days) Granular	30.44	**0.05**	29.19	**>6.95**
CA Turf RLF (ornamental lawns and turf)	2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	79.48	**0.14**	75.44	**>17.96**
CA Turf RLF (golf course turf for use on tees, greens, and bentgrass fairways only)	2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	27.02	**0.05**	25.65	**>6.11**
CA Residential RLF (residential lawns)	2 apps @ 12.6 lb a.i./acre (120 days) Granular	19.48	0.03	18.46	**>4.40**

Table 5-3. Acute and Chronic RQs for Freshwater Invertebrates Exposure to Bensulide						
PRZM Scenario (crops represented by scenario)	**Application Rate (Interval) Formulation Type**	**Peak EEC (µg/L)**	**Acute RQ**	**21-day EEC (µg/L)**	**Chronic RQ**
	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	16.63	0.03	15.48	**>3.69**
CA Wheat (canola	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	227.30	**0.39**	215.40	**>51.29**
	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	127.10	**0.22**	124.90	**>29.74**
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	78.59	**0.14**	76.14	**>18.13**
CA Cole Crop RLF (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage)	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	463.70	**0.80***	427.00	**>101.67**
	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	254.20	**0.44**	238.30	**>56.74**
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	125.90	**0.22**	120.20	**>28.62**
CA Lettuce No-irrig. (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula))	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	297.50	**0.51***	277.00	**>65.95**
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	151.30	**0.26**	142.00	**>33.81**
CA Row Crop RLF (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas)	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	218.50	**0.38**	207.60	**>49.43**
	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	104.38	**0.18**	96.39	**>22.95**
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	46.04	**0.08**	42.74	**>10.18**
CA Melon RLF (cantaloupe, chayote, cucumber, cucurbit vegetables, cucuzzi, gherkin, gourds, gourd (wax), melons (bitter, honeydew, citron, mango, musk, water, winter melons), pepino, pumpkin, squash (butternut, summer, zucchini squash))	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	115.10	**0.20**	109.82	**>26.15**
	1 app @ 9 lb a.i./acre (Not applicable) Emulsifiable Concentrate	111.20	**0.19**	105.88	**>25.21**
CA Tomato No-irrig. (bell pepper, eggplant, groundcherry (strawberry tomato/tomatillo), pepper, pepper (chili), pimento)	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	30.88	**0.05**	29.35	**>6.99**
CA Onion No-Irrig. (garlic, onion (dry bulb and green),	3 apps @ 6 lb a.i./acre (120 days)	64.21	**0.11**	60.87	**>14.49**

Table 5-3. Acute and Chronic RQs for Freshwater Invertebrates Exposure to Bensulide					
PRZM Scenario (crops represented by scenario)	**Application Rate (Interval) Formulation Type**	**Peak EEC (µg/L)**	**Acute RQ**	**21-day EEC (µg/L)**	**Chronic RQ**
radish, shallot)	Emulsifiable Concentrate				
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	10.88	0.02	9.86	**>2.35**
Listed species LOC exceedances (acute RQ ≥ 0.05; chronic RQ ≥ 1.0) are bolded. *Also exceeds acute non-listed species LOC (0.5). Acute RQ = use-specific peak EEC/LC_{50} (580 µg/L). Chronic RQ = use-specific 21-day EEC/estimated NOAEC (<4.2 µg/L).					

For estuarine/marine invertebrates, the acute listed species LOC (0.05) was exceeded for all use groups (see **Table 5-4**). The acute non-listed species LOC (0.5) was exceeded for the following use groups: ornamental lawns and turf, canola, cole crops, leafy vegetables, row crops, melons, and onions/bulb vegetables (high rate only). Chronic RQs exceeded the LOC (1.0) for estuarine/marine invertebrates for all use groups except golf course turf, residential lawns, row crops (low rate only), fruiting vegetables, and onions/bulb vegetables (low rate only).

Table 5-4. Acute RQs for Estuarine/marine Invertebrates Exposure to Bensulide					
PRZM Scenario (crops represented by scenario)	**Application Rate (Interval) Formulation Type**	**Peak EEC (µg/L)**	**Acute RQ**	**21-day EEC (µg/L)**	**Chronic RQ**
CA Turf RLF (golf course turf for use on tees, greens, and bentgrass fairways only)	2 apps @ 16 lb a.i./acre (120 days) Granular	30.44	**0.49**	29.19	0.60
CA Turf RLF (ornamental lawns and turf)	2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	79.48	**1.27***	75.44	**1.56+**
CA Turf RLF (golf course turf for use on tees, greens, and bentgrass fairways only)	2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	27.02	**0.43**	25.65	0.53
CA Residential RLF (residential lawns)	2 apps @ 12.6 lb a.i./acre (120 days) Granular	19.48	**0.31**	18.46	0.38
	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	16.63	**0.27**	15.48	0.32
CA Wheat (canola	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	227.30	**3.64***	215.40	**4.44+**

Table 5-4. Acute RQs for Estuarine/marine Invertebrates Exposure to Bensulide					
PRZM Scenario (crops represented by scenario)	**Application Rate (Interval) Formulation Type**	**Peak EEC (µg/L)**	**Acute RQ**	**21-day EEC (µg/L)**	**Chronic RQ**
	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	127.10	**2.04***	124.90	**2.58+**
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	78.59	**1.26***	76.14	**1.57+**
CA Cole Crop RLF (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage)	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	463.70	**7.43***	427.00	**8.80+**
	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	254.20	**4.07***	238.30	**4.91+**
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	125.90	**2.02***	120.20	**2.48+**
CA Lettuce No-irrig. (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula))	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	297.50	**4.77***	277.00	**5.72+**
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	151.30	**2.42***	142.00	**2.93+**
CA Row Crop RLF (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas)	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	218.50	**3.50***	207.60	**4.28+**
	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	104.38	**1.67***	96.39	**1.99+**
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	46.04	**0.74***	42.74	0.88
CA Melon RLF (cantaloupe, chayote, cucumber, cucurbit vegetables, cucuzzi, gherkin, gourds, gourd (wax), melons (bitter, honeydew, citron, mango, musk,	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	115.10	**1.84***	109.82	**2.26+**

Table 5-4. Acute RQs for Estuarine/marine Invertebrates Exposure to Bensulide					
PRZM Scenario (crops represented by scenario)	**Application Rate (Interval) Formulation Type**	**Peak EEC (µg/L)**	**Acute RQ**	**21-day EEC (µg/L)**	**Chronic RQ**
water, winter melons), pepino, pumpkin, squash (butternut, summer, zucchini squash))	1 app @ 9 lb a.i./acre (Not applicable) Emulsifiable Concentrate	111.20	**1.78***	105.88	**2.18+**
CA Tomato No-irrig. (bell pepper, eggplant, groundcherry (strawberry tomato/tomatillo), pepper, pepper (chili), pimento)	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	30.88	**0.49**	29.35	0.60
CA Onion No-Irrig. (garlic, onion (dry bulb and green), radish, shallot)	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	64.21	**1.03***	60.87	**1.26+**
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	10.88	**0.17**	9.86	0.20
Listed species LOC exceedances (acute RQ ≥ 0.05) are bolded. *Also exceeds acute non-listed species LOC (0.5). Acute RQ = use-specific peak EEC/LC_{50} (62.4µg/L). +Exceeds chronic LOC (1.0). Chronic RQ = use-specific 21-day EEC/NOAEC (48.54µg/L).					

5.1.1.c. Aquatic Plants

Acute risk to aquatic vascular and non-vascular plants is based on 1 in 10 year peak EECs in the standard pond and the lowest acute toxicity value, EC_{50} for non-listed species risk and NOAEC or EC_{05} for listed species risk. No species in this assessment have obligate relationships with aquatic plants, so the listed species risk value is not relevant and RQs based on the NOAEC were not calculated. The LOC is 1 for both acute risk and acute listed species risk. **Table 5-5** includes RQs for vascular aquatic plants, and **Table 5-6** includes RQs for non-vascular aquatic plants.

For vascular aquatic plants, the LOC was exceeded for the following use groups: canola (high rate only), cole crops (high and medium rate only), leafy vegetables, and row crops (high rate only).

Table 5-5. Acute RQs for Vascular Aquatic Plant Exposure to Bensulide			
PRZM Scenario (crops represented by scenario)	**Application Rate (Interval) Formulation Type**	**Peak EEC (µg/L)**	**Acute RQ**
CA Turf RLF (golf course turf for use on tees, greens, and bentgrass fairways only)	2 apps @ 16 lb a.i./acre (120 days) Granular	30.44	0.22
CA Turf RLF (ornamental lawns and turf)	2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	79.48	0.57
CA Turf RLF (golf course turf for use on tees, greens, and	2 apps @ 12.5 lb a.i./acre (120 days)	27.02	0.19

Table 5-5. Acute RQs for Vascular Aquatic Plant Exposure to Bensulide			
PRZM Scenario (crops represented by scenario)	**Application Rate (Interval) Formulation Type**	**Peak EEC (µg/L)**	**Acute RQ**
bentgrass fairways only)	Emulsifiable Concentrate		
CA Residential RLF (residential lawns)	2 apps @ 12.6 lb a.i./acre (120 days) Granular	19.48	0.14
	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	16.63	0.12
CA Wheat (canola	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	227.30	**1.62**
	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	127.10	0.91
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	78.59	0.56
CA Cole Crop RLF (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage)	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	463.70	**3.31**
	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	254.20	**1.82**
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	125.90	0.90
CA Lettuce No-irrig. (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula))	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	297.50	**2.13**
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	151.30	**1.08**
CA Row Crop RLF (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas)	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	218.50	**1.56**
	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	104.38	0.75
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	46.04	0.33
CA Melon RLF (cantaloupe, chayote, cucumber, cucurbit vegetables, cucuzzi, gherkin, gourds, gourd (wax), melons (bitter, honeydew, citron, mango, musk, water, winter melons), pepino, pumpkin, squash (butternut, summer, zucchini squash))	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	115.10	0.82
	1 app @ 9 lb a.i./acre (Not applicable) Emulsifiable Concentrate	111.20	0.79
CA Tomato No-irrig. (bell pepper, eggplant, groundcherry (strawberry tomato/tomatillo), pepper, pepper (chili), pimento)	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	30.88	0.22

Table 5-5. Acute RQs for Vascular Aquatic Plant Exposure to Bensulide			
PRZM Scenario (crops represented by scenario)	**Application Rate (Interval) Formulation Type**	**Peak EEC (μg/L)**	**Acute RQ**
CA Onion No-Irrig. (garlic, onion (dry bulb and green), radish, shallot)	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	64.21	0.46
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	10.88	0.08
LOC exceedances (acute RQ $\geq$ 1.0) are bolded. Acute RQ = use-specific peak EEC/EC_{50} (140 μg/L).			

For non-vascular aquatic plants, the LOC was not exceeded for any use (see **Table 5-6**).

Table 5-6. Acute RQs for Non-vascular Aquatic Plant Exposure to Bensulide			
PRZM Scenario (crops represented by scenario)	**Application Rate (Interval) Formulation Type**	**Peak EEC (μg/L)**	**Acute RQ**
CA Turf RLF (golf course turf for use on tees, greens, and bentgrass fairways only)	2 apps @ 16 lb a.i./acre (120 days) Granular	30.44	0.04
CA Turf RLF (ornamental lawns and turf)	2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	79.48	0.10
CA Turf RLF (golf course turf for use on tees, greens, and bentgrass fairways only)	2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	27.02	0.03
CA Residential RLF (residential lawns)	2 apps @ 12.6 lb a.i./acre (120 days) Granular	19.48	0.02
	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	16.63	0.02
CA Wheat (canola	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	227.30	0.29
	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	127.10	0.16
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	78.59	0.10
CA Cole Crop RLF (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage)	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	463.70	0.59
	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	254.20	0.33
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	125.90	0.16

Table 5-6. Acute RQs for Non-vascular Aquatic Plant Exposure to Bensulide			
PRZM Scenario (crops represented by scenario)	**Application Rate (Interval) Formulation Type**	**Peak EEC (µg/L)**	**Acute RQ**
CA Lettuce No-irrig. (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula))	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	297.50	0.38
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	151.30	0.19
CA Row Crop RLF (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas)	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	218.50	0.28
	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	104.38	0.13
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	46.04	0.06
CA Melon RLF (cantaloupe, chayote, cucumber, cucurbit vegetables, cucuzzi, gherkin, gourds, gourd (wax), melons (bitter, honeydew, citron, mango, musk, water, winter melons), pepino, pumpkin, squash (butternut, summer, zucchini squash))	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	115.10	0.15
	1 app @ 9 lb a.i./acre (Not applicable) Emulsifiable Concentrate	111.20	0.14
CA Tomato No-irrig. (bell pepper, eggplant, groundcherry (strawberry tomato/tomatillo), pepper, pepper (chili), pimento)	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	30.88	0.04
CA Onion No-Irrig. (garlic, onion (dry bulb and green), radish, shallot)	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	64.21	0.08
	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	10.88	0.01
LOC exceedances (acute RQ $\geq$ 1.0) are bolded. Acute RQ = use-specific peak EEC/EC_{50} (780 µg/L).			

5.1.2. Potential Risk in the Terrestrial Habitat

5.1.2.a. Birds (surrogate for Reptiles and Terrestrial-phase Amphibians)

As previously discussed in **Section 3.3**, potential direct effects to terrestrial species are based on spray and granular applications of bensulide. Potential direct acute and chronic effects to birds, the CCR, terrestrial-phase CTS (all DPS), and SFGS are evaluated using dose- and dietary-based EECs modeled in T-REX for small (20 g, juveniles) birds consuming short grass (**Table 3-5**) and acute oral and chronic toxicity endpoints for avian species (**Table 4-3**).

Table 5-7 includes RQs for birds, terrestrial-phase amphibians, and reptiles. All acute dose-based RQs exceeded both the listed and non-listed species LOCs. All chronic dietary-based RQs exceeded the listed and non-listed species LOC. Sub-acute dietary RQs were not calculated due to a lack of a definitive LC_{50} in the highest concentration tested in the bobwhite quail study (MRID 158456). However, reduced food consumption was observed in all concentrations tested; therefore, there is potential for acute dietary risk to birds, the CCR, terrestrial-phase CTS (all DPS), and SFGS.

Potential for indirect effects to the CCR, terrestrial-phase CTS, and SFGS may result from direct acute effects to birds and/or amphibians due to a reduction in prey. RQs for indirect effects are calculated in the same manner as those for direct effects. The highest EECs calculated in T-REX are for small birds consuming short grass.

Table 5-7. Acute and Chronic RQs Derived Using T-REX for Bensulide and Birds, Terrestrial-phase Amphibians, and Reptiles

Use(s), Type of Application	App Rate (lb a.i./A, # Apps, Interval (days)	RQs for Birds and CCR, CTS (all DPS), and SFGS (small bird consuming short grass)*	
		Acute Dose Based[1]	Chronic Dietary Based[2]
golf course turf	2 apps @ 16 lb a.i./acre (120 days) Granular	**4.79***	**1678.66+**
golf course turf and ornamental lawns and turf	2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	**3.74***	**1311.45+**
residential lawns	2 apps @ 12.6 lb a.i./acre (120 days) Granular	**3.77***	**1321.94+**
	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	**2.69***	**944.24+**
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Bulb crops** (garlic, onion (dry bulb and green), radish, shallot) **Canola/rape**	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	**1.81***	**634.46+**
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland),	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	**1.79***	**629.50+**

Table 5-7. Acute and Chronic RQs Derived Using T-REX for Bensulide and Birds, Terrestrial-phase Amphibians, and Reptiles			
Use(s), Type of Application	**App Rate (lb a.i./A, # Apps, Interval (days)**	**RQs for Birds and CCR, CTS (all DPS), and SFGS (small bird consuming short grass)***	
		Acute Dose Based[1]	**Chronic Dietary Based**[2]
fennel, okra, parsley, peas) **Leafy vegetable crops** (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula)) **Canola/rape**			
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Bulb crops** (garlic, onion (dry bulb and green), radish, shallot) **Leafy vegetable crops** (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula)) **Fruiting vegetable crops** (bell pepper, eggplant, groundcherry (strawberry tomato/tomatillo), pepper, pepper (chili), pimento) **Canola/rape**	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	**1.64***	**576.00+**
Cucurbit/melon crops (cantaloupe, chayote, cucumber, cucurbit vegetables, cucuzzi, gherkin, gourds, gourd (wax), melons (bitter, honeydew, citron, mango, musk, water, winter melons), pepino, pumpkin, squash (butternut, summer, zucchini squash))	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	**2.69***	**944.24+**
	1 app @ 9 lb a.i./acre (Not applicable) Emulsifiable Concentrate	**2.46***	**864.00+**
*Exceeds acute risk LOC for listed (0.1) and non-listed species (0.5). +Exceeds chronic risk LOC for listed and non-listed species (1.0). [1] Based on dose-based EEC and Northern bobwhite quail acute oral LD_{50} = 1386 mg/kg-bw [2] Based on dietary-based EEC and Mallard duck NOAEC = 2.5 mg/kg-diet			

T-HERPS is used as a refinement to RQs for snakes and terrestrial-phase amphibians if T-REX indicates potential risk. Small snakes and amphibians only consume insects while medium and large snakes and terrestrial-phase amphibians consume small and large insects, mammals, and amphibians. The highest RQs are for medium reptiles and amphibians consuming small herbivorous mammals. Potential direct acute and chronic effects to the CTS and SFGS are further evaluated by considering dose- and dietary-based EECs modeled in T-HERPS for medium amphibians and snakes, respectively, consuming small herbivorous mammals (**Table 3-6**) and acute oral and chronic toxicity endpoints for avian species (**Table 4-3**). T-HERPS RQs are summarized in **Table 5-8**.

Table 5-8. Acute and Chronic RQs Derived Using T-HERPS for Bensulide and Amphibians and Reptiles

Use(s), Type of Application	App Rate (lb a.i./A, # Apps, Interval (days)	RQs for CTS (all DPS) (medium birds consuming herbivorous mammals)*		RQs for SFGS (medium birds consuming herbivorous mammals)*	
		Acute Dose Based[1]	Chronic Dietary Based[2]	Acute Dose Based[1]	Chronic Dietary Based[2]
golf course turf	2 apps @ 16 lb a.i./acre (120 days) Granular	**2.00***	**1703.51+**	**2.89***	**1280.92+**
golf course turf and ornamental lawns and turf	2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	**1.56***	**1330.86+**	**2.26***	**1000.72+**
residential lawns	2 apps @ 12.6 lb a.i./acre (120 days) Granular	**1.57***	**1341.51+**	**2.27***	**1008.72+**
	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	**1.12***	**958.22+**	**1.62***	**720.52+**
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Bulb crops** (garlic, onion (dry bulb and green), radish, shallot) **Canola/rape**	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	**0.75***	**643.86+**	**1.09***	**484.14+**
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas)	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	**0.75***	**638.82+**	**1.08***	**480.34+**

Table 5-8. Acute and Chronic RQs Derived Using T-HERPS for Bensulide and Amphibians and Reptiles					
Use(s), Type of Application	**App Rate (lb a.i./A, # Apps, Interval (days)**	**RQs for CTS (all DPS) (medium birds consuming herbivorous mammals)***		**RQs for SFGS (medium birds consuming herbivorous mammals)***	
		Acute Dose Based[1]	**Chronic Dietary Based[2]**	**Acute Dose Based[1]**	**Chronic Dietary Based[2]**
Leafy vegetable crops (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula)) **Canola/rape**					
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Bulb crops** (garlic, onion (dry bulb and green), radish, shallot) **Leafy vegetable crops** (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula)) **Fruiting vegetable crops** (bell pepper, eggplant, groundcherry (strawberry tomato/tomatillo), pepper, pepper (chili), pimento) **Canola/rape**	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	**0.69***	**584.53+**	**0.99***	**439.52+**
Cucurbit/melon crops (cantaloupe, chayote, cucumber, cucurbit vegetables, cucuzzi, gherkin, gourds, gourd (wax), melons (bitter, honeydew, citron, mango, musk, water, winter melons), pepino, pumpkin, squash (butternut, summer, zucchini squash))	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	**1.12***	**958.22+**	**1.62***	**720.52+**
	1 app @ 9 lb a.i./acre (Not applicable) Emulsifiable Concentrate	**1.03***	**876.79+**	**1.49***	**659.29+**

*Exceeds acute listed species LOC (0.1) and acute non-listed species LOC (0.5).
+Exceeds chronic listed and non-listed species LOC (1.0).
[1] Based on dose-based EEC and Northern bobwhite quail acute oral LD_{50} = 1386 mg/kg-bw
[2] Based on dietary-based EEC and Mallard duck NOAEC = 2.5 mg/kg-diet
Acute dietary RQs for birds are not calculated because a median lethal concentration was not established at the highest concentration tested (LC_{50} >5260 mg/kg-diet).

Table 5-9 includes LD_{50}/ft^2 values, which are derived by T-REX.

Table 5-9. LD_{50}/ft^2 Values Derived Using T-REX for Bensulide and Birds

Use	Application Rate	Application Media – Type	RQ (birds at application site)*,[1]		
			Small (20 g)	Medium (100 g)	Large (1000 g)
golf course turf	2 apps @ 16 lb a.i./acre (120 days)	Granular – Broadcast	**8.34**	**1.31**	0.09
residential lawns	2 apps @ 12.6 lb a.i./acre (120 days)	Granular – Broadcast	**6.57**	**1.03**	0.07

*LOC exceedances (acute risk to listed species (0.1)) are bolded.
[1] Based on dose-based EEC and Northern bobwhite quail acute oral LD_{50} = 1386 mg/kg-bw

5.1.2.b. Mammals

Potential acute and chronic effects to small mammals are evaluated using dose- and dietary-based EECs modeled in T-REX for a small mammal (15 g) consuming short grass.

Potential for indirect effects to the CCR, CTS (all DPS), and SFGS may result from direct effects to mammals due to a reduction in prey. Potential indirect effects to the CTS (all DPS) and SFGS may result from direct effects to mammals due to effects on habitat or a reduction in rearing sites. RQs for indirect effects are calculated in the same manner as those for direct effects. The highest EECs calculated in T-REX are for small mammals consuming short grass.

Tables 5-10 and **5-11** include RQs for mammals. Acute and chronic RQs exceed the listed and non-listed species LOCs for mammals for bensulide for every scenario. Based on these results, there is a potential for indirect effects to those listed species that rely on mammals as prey items or for habitat during at least some portion of their life-cycle (*i.e.*, CCR, CTS (all DPS), and SFGS).

Table 5-10. Acute and Chronic RQs Derived Using T-REX for Bensulide and Mammals

Use(s), Type of Application	App Rate (lb a.i./A, # Apps, Interval (days)	RQs for Mammals (small mammals consuming short grass)*	
		Acute Dose Based[1]	Chronic Dietary Based[2]
golf course turf	2 apps @ 16 lb a.i./acre (120 days) Granular	**6.74***	**27.98+**
golf course turf and ornamental lawns and turf	2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	**5.27***	**21.86+**
residential lawns	2 apps @ 12.6 lb a.i./acre (120 days) Granular	**5.31***	**22.03+**
	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	**3.79***	**15.74+**

Table 5-10. Acute and Chronic RQs Derived Using T-REX for Bensulide and Mammals			
Use(s), Type of Application	App Rate (lb a.i./A, # Apps, Interval (days)	RQs for Mammals (small mammals consuming short grass)*	
		Acute Dose Based[1]	Chronic Dietary Based[2]
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Bulb crops** (garlic, onion (dry bulb and green), radish, shallot) **Canola/rape**	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	**2.55***	**10.57+**
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Leafy vegetable crops** (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula)) **Canola/rape**	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	**2.53***	**10.49+**
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Bulb crops** (garlic, onion (dry bulb and green), radish, shallot) **Leafy vegetable crops** (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula)) **Fruiting vegetable crops** (bell pepper,	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	**2.31***	**9.60+**

Table 5-10. Acute and Chronic RQs Derived Using T-REX for Bensulide and Mammals			
Use(s), Type of Application	**App Rate (lb a.i./A, # Apps, Interval (days)**	**RQs for Mammals (small mammals consuming short grass)***	
		Acute Dose Based[1]	**Chronic Dietary Based[2]**
eggplant, groundcherry (strawberry tomato/tomatillo), pepper, pepper (chili), pimento) **Canola/rape**			
Cucurbit/melon crops (cantaloupe, chayote, cucumber, cucurbit vegetables, cucuzzi, gherkin, gourds, gourd (wax), melons (bitter, honeydew, citron, mango, musk, water, winter melons), pepino, pumpkin, squash (butternut, summer, zucchini squash))	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	**3.79***	**15.74+**
	1 app @ 9 lb a.i./acre (Not applicable) Emulsifiable Concentrate	**3.47***	**14.40+**
*Exceeds acute risk LOC for listed (0.1) and non-listed species (0.5). +Exceeds chronic risk LOC for listed and non-listed species (1.0). [1] Based on dose-based EEC and acute oral LD_{50} = 270 mg/kg-bw [2] Based on dietary-based EEC and NOAEC = 150 mg/kg-diet			

Table 5-11. LD_{50}/ft^2 Values Derived Using T-REX for Bensulide and Mammals					
Use	**Application Rate**	**Application Media – Type**	**RQ (mammals at application site)*,[1]**		
			Small (15 g)	**Medium (35 g)**	**Large (1000 g)**
golf course turf	2 apps @ 16 lb a.i./acre (120 days)	Granular – Broadcast	**18.72**	**9.91**	**0.80**
residential lawns	2 apps @ 12.6 lb a.i./acre (120 days)	Granular – Broadcast	**14.74**	**7.81**	**0.63**
*LOC exceedances (acute risk to listed species (0.1)) are bolded. [1] Based on dose-based EEC and rat acute oral LD_{50} = 270 mg/kg-bw					

5.1.2.c. Terrestrial Invertebrates

In order to assess the risks of bensulide to terrestrial invertebrates, the honey bee is used as a surrogate for terrestrial invertebrates. EECs (µg a.i./g of bee) calculated by T-REX for arthropods are divided by the calculated toxicity value for terrestrial invertebrates (**Table 4-3**). The honey bee toxicity data for piperophos will be used to assess direct risk to the BCB and VELB, as the bensulide toxicity value was non-definitive.

Acute RQs exceed the listed species LOC (0.05) for terrestrial invertebrates for bensulide for all scenarios and both species (**Table 5-12**). Based on these results, bensulide does have the potential to directly affect the BCB and VELB. Additionally, there is a potential for indirect effects to those listed species that rely on terrestrial invertebrates as prey items during at least some portion of their life-cycle (*i.e.*, CCR, CTS (all DPS), and SFGS).

Table 5-12. Acute RQs for Terrestrial Invertebrate Exposure to Bensulide		
Use(s), Type of Application	**App Rate (lb a.i./A, # Apps, Interval (days)**	**RQs for BCB and VELB (arthropods)*,[1]**
golf course turf	2 apps @ 16 lb a.i./acre (120 days) Granular	**7.01***
golf course turf and ornamental lawns and turf	2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	**5.48***
residential lawns	2 apps @ 12.6 lb a.i./acre (120 days) Granular	**5.52***
	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	**3.94**
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Bulb crops** (garlic, onion (dry bulb and green), radish, shallot) **Canola/rape**	3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	**2.65***
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Leafy vegetable crops** (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula)) **Canola/rape**	2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	**2.63***
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Bulb crops** (garlic, onion (dry bulb and green), radish, shallot) **Leafy vegetable crops** (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula))	1 app @ 6 lb a.i./acre (Not applicable) Emulsifiable Concentrate	**2.41***

Table 5-12. Acute RQs for Terrestrial Invertebrate Exposure to Bensulide		
Use(s), Type of Application	**App Rate (lb a.i./A, # Apps, Interval (days)**	**RQs for BCB and VELB (arthropods)*,1**
Fruiting vegetable crops (bell pepper, eggplant, groundcherry (strawberry tomato/tomatillo), pepper, pepper (chili), pimento) **Canola/rape**		
Cucurbit/melon crops (cantaloupe, chayote, cucumber, cucurbit vegetables, cucuzzi, gherkin, gourds, gourd (wax), melons (bitter, honeydew, citron, mango, musk, water, winter melons), pepino, pumpkin, squash (butternut, summer, zucchini squash))	2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	**3.94***
	1 app @ 9 lb a.i./acre (Not applicable) Emulsifiable Concentrate	**3.61***
*LOC exceedances (RQ $\geq$ 0.05) are bolded. [1] Based on EEC and piperophos honey bee acute contact LD_{50} = 234.38 µg/g-bw (Direct effects to VELB and BCB)		

5.1.2.d. Terrestrial Plants

Generally, for indirect effects, potential effects on terrestrial vegetation are assessed using RQs from terrestrial plant seedling emergence and vegetative vigor EC_{25} data as a screen. Since the BCB and the VELB have an obligate relationship with specific dicot plant species, the seedling emergence and vegetative vigor NOAEC for dicots are used to calculate RQs for indirect effects to these species via potential effects to dicots. EC_{25} values were non-definitive (>6 lb a.i./acre) for seedling emergence for dicots and vegetative vigor for monocots. However, since the studies were not tested up to maximum application rates, it was conservatively assumed that the maximum application rate tested (6 lb a.i./acre) was actually the EC_{25}. RQs for terrestrial plants exposed to bensulide are shown in **Table 5-13**.

Semi-aquatic area RQs exceed the LOC (1.0) for terrestrial plants for all use scenarios. Based on these results, bensulide is not likely to indirectly affect the BCB and VELB because their habitats do not include semi-aquatic areas.

Indirect effects to endangered species with non-obligate relationships with terrestrial plants are generally assessed using EC_{25} data. Based on these RQ values, there may be a potential for indirect effects to those listed species that rely on semi-aquatic plants during at least some portion of their life-cycle (*i.e.*, CCR, CFWS, CTS (all DPS), DS, SFGS, and TG).

Table 5-13. RQs for Terrestrial Plants Inhabiting Dry and Semi-Aquatic Areas Exposed to Bensulide via Runoff and Drift						
Use	**Application rate (lbs a.i./A)**	**Drift Value (%)**	**Plant Type and Listed Status**	**Dry area RQ*,1**	**Semi-aquatic area RQ*,1**	**Spray drift RQ*,1**
golf course turf	16 lb a.i./acre Granular	0	Monocot non-	<0.1	0.84	<0.1

Table 5-13. RQs for Terrestrial Plants Inhabiting Dry and Semi-Aquatic Areas Exposed to Bensulide via Runoff and Drift						
Use	**Application rate (lbs a.i./A)**	**Drift Value (%)**	**Plant Type and Listed Status**	**Dry area RQ*,[1]**	**Semi-aquatic area RQ*,[1]**	**Spray drift RQ*,[1]**
			listed			
			Monocot listed	0.42	**4.21***	<0.1
			Dicot non-listed	<0.1	0.27	<0.1
			Dicot listed	<0.1	0.27	<0.1
golf course turf and ornamental lawns and turf	12.5 lb a.i./acre Emulsifiable Concentrate	1	Monocot non-listed	0.13	0.72	<0.1
			Monocot listed	0.66	**3.62***	0.33
			Dicot non-listed	<0.1	0.23	<0.1
			Dicot listed	<0.1	0.23	<0.1
residential lawns	12.6 lb a.i./acre Granular	0	Monocot non-listed	<0.1	0.66	<0.1
			Monocot listed	0.33	**3.32***	<0.1
			Dicot non-listed	<0.1	0.21	<0.1
			Dicot listed	<0.1	0.21	<0.1
residential lawns **Cucurbit/melon crops** (cantaloupe, chayote, cucumber, cucurbit vegetables, cucuzzi, gherkin, gourds, gourd (wax), melons (bitter, honeydew, citron, mango, musk, water, winter melons), pepino, pumpkin, squash (butternut, summer, zucchini squash))	9 lb a.i./acre Emulsifiable Concentrate	1	Monocot non-listed	<0.1	0.52	<0.1
			Monocot listed	0.47	**2.61***	0.24
			Dicot non-listed	<0.1	0.17	<0.1
			Dicot listed	<0.1	0.17	0.24
Cole crops (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi,	6 lb a.i./acre Emulsifiable Concentrate	1	Monocot non-listed	<0.1	0.35	<0.1

Table 5-13. RQs for Terrestrial Plants Inhabiting Dry and Semi-Aquatic Areas Exposed to Bensulide via Runoff and Drift						
Use	**Application rate (lbs a.i./A)**	**Drift Value (%)**	**Plant Type and Listed Status**	**Dry area RQ*,1**	**Semi-aquatic area RQ*,1**	**Spray drift RQ*,1**
mustard, mustard cabbage) **Row crops** (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) **Bulb crops** (garlic, onion (dry bulb and green), radish, shallot) **Leafy vegetable crops** (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula)) **Fruiting vegetable crops** (bell pepper, eggplant, groundcherry (strawberry tomato/tomatillo), pepper, pepper (chili), pimento) **Canola/rape**			Monocot listed	0.32	**1.74***	0.16
			Dicot non-listed	<0.1	0.11	<0.1
			Dicot listed	<0.1	0.11	0.16
*LOC exceedances (RQ ≥ 1) are bolded and shaded. [1] Based on EEC and monocot and dicot seedling emergence and vegetative vigor						

5.1.3. Primary Constituent Elements of Designated Critical Habitat

For bensulide use, the assessment endpoints for designated critical habitat PCEs involve the same endpoints as those being assessed relative to the potential for direct and indirect effects to the listed species assessed here. Therefore, the effects determinations for direct and indirect effects are used as the basis of the effects determination for potential modification to designated critical habitat.

5.2. Risk Description

The risk description synthesizes overall conclusions regarding the likelihood of adverse impacts leading to a preliminary effects determination (*i.e.*, “no effect,” “may affect, but not likely to adversely affect,” or “likely to adversely affect”) for the assessed species and the potential for modification of their designated critical habitat based on analysis of RQs and a comparison to the LOC. The final No Effect/May Affect determination is made after the spatial analysis is completed at the end of the risk description, **Section 5.2.9**. In **Section 5.2.9**, a discussion of any potential overlap between areas where potential usage may result in an LAA effects determination and areas where species are expected to occur (including any designated critical habitat) is presented. If there is no overlap of the species habitat and occurrence sections with the Potential Area of LAA Effects, a No Effect determination is made.

If the RQs presented in the Risk Estimation (**Section 5.1**) show no direct or indirect effects for the assessed species, and no modification to PCEs of the designated critical habitat, a preliminary "no effect" determination is made, based on bensulide's use within the action area. However, if LOCs for direct or indirect effect are exceeded or effects may modify the PCEs of the critical habitat, the Agency concludes a preliminary "may affect" determination for the FIFRA regulatory action regarding bensulide. Based on this risk estimation process described above, all species in this assessment, the BCB, CCR, CFWS, CTS (all DPS), DS, SFGS, TG, and VELB have a preliminary "may affect" determination. A summary of the risk estimation results are provided in **Table 5-14** for direct and indirect effects to the listed species assessed here, as well as for the PCEs of their designated critical habitat (if any).

Table 5-14. Risk Estimation Summary for Bensulide – Direct and Indirect Effects

Taxa	LOC Exceedances (Yes/No)	Description of Results of Risk Estimation	Assessed Species Potentially Affected	Species Associated with a Designated Critical Habitat that May Be Modified by the Assessed Action
Freshwater Fish and Aquatic-phase Amphibians	Non-listed Species (Yes) Listed Species (Yes)	Acute RQs exceeded the listed species LOC (0.05) for all uses except golf course turf, residential lawns, fruiting vegetables, and the low rate (1 application @ 6 lb a.i./acre) for onions/bulb vegetables. The acute non-listed species LOC (0.5) and chronic LOC (1.0) was exceeded for the high rate for cole crop uses (3 applications @ 6 lb a.i./acre).	<u>Indirect Effects (prey items)</u>: CCR, CTS (all DPS), SFGS <u>Direct Effects</u>: CTS (all DPS), DS, TG	CTS-CC, CTS-SB, DS, TG
Freshwater Invertebrates	Non-listed Species (Yes) Listed Species (Yes)	Acute RQs exceeded the listed species LOC (0.05) for all uses except residential lawns and the low rate for onions/bulb vegetables (1 application @ 6 lb a.i./acre). The acute non-listed species LOC (0.5) was exceeded for the high rate for cole crop uses (3 applications @ 6 lb a.i./acre) and the high rate for leafy vegetable crop uses (2 applications @ 6 lb a.i./acre). The chronic LOC was exceeded for all uses.	<u>Indirect Effects (prey items)</u>: CCR, CFWS, CTS (all DPS), DS, SFGS, TG <u>Direct Effects</u>: CFWS	CTS-CC, CTS-SB, DS, TG
Estuarine/Marine Fish	Non-listed Species (Yes) Listed Species (Yes)	Acute RQs exceeded the listed species LOC (0.05) for all uses except the low rate for onions/bulb vegetables (1 application @ 6 lb a.i./acre). The acute non-listed species LOC (0.5) was exceeded for the high rate for canola (3	<u>Indirect Effects (prey items)</u>: CCR	DS, TG

Table 5-14. Risk Estimation Summary for Bensulide – Direct and Indirect Effects				
Taxa	**LOC Exceedances (Yes/No)**	**Description of Results of Risk Estimation**	**Assessed Species Potentially Affected**	**Species Associated with a Designated Critical Habitat that May Be Modified by the Assessed Action**
		applications @ 6 lb a.i./acre), the high and medium rates for cole crop uses (2 & 3 applications @ 6 lb a.i./acre), the high rate for leafy vegetable uses (2 applications @ 6 lb a.i./acre), and the high rate for row crop uses (3 applications @ 6 lb a.i./acre). Although no chronic toxicity data for estuarine/marine fish were available, due to the slight increased toxicity of bensulide to estuarine/marine fish on an acute basis and one crop group use exceeding the chronic LOC for freshwater fish, risks to estuarine/marine fish cannot be precluded, and the Agency conservatively assumes that chronic estuarine/marine fish RQs would exceed the LOC.	Direct Effects: DS, TG	
Estuarine/Marine Invertebrates	Non-listed Species (Yes) Listed Species (Yes)	Acute RQs exceeded the listed species LOC (0.05) for all uses. The acute non-listed species LOC (0.5) was exceeded for ornamental lawns and turf, canola, cole crops, leafy vegetables, row crops, melons, and the high rate for onions/bulb vegetables (3 applications @ 6 lb a.i./acre). Chronic RQs exceeded the LOC (1.0) for estuarine/marine invertebrates for all use groups except golf course turf, residential lawns, row crops (low rate only), fruiting vegetables, and onions/bulb vegetables (low rate only).	Indirect Effects (prey items): CCR, DS, TG	DS, TG
Vascular Aquatic Plants	Non-listed Species (Yes)	RQs exceeded the LOC (1.0) for the high rate for canola (3 applications @ 6 lb a.i./acre), the high and medium rates for cole crop uses (2 & 3 applications @ 6 lb a.i./acre), leafy vegetable uses, the high rate for row crop uses (3 applications @ 6 lb a.i./acre).	Indirect Effects (habitat only): SFGS Indirect Effects (habitat and food): CCR, CFWS, CTS (all DPS), DS, TG	CTS-CC, CTS-SB, DS, TG
Non-Vascular Aquatic Plants	Non-listed Species (No)	None of the RQs exceeded the LOC (1.0) for any use.	Indirect Effects (habitat and/or food): None	None

Table 5-14. Risk Estimation Summary for Bensulide – Direct and Indirect Effects				
Taxa	**LOC Exceedances (Yes/No)**	**Description of Results of Risk Estimation**	**Assessed Species Potentially Affected**	**Species Associated with a Designated Critical Habitat that May Be Modified by the Assessed Action**
Birds, Reptiles, and Terrestrial-Phase Amphibians	Non-listed Species (Yes) Listed Species (Yes)	Based on T-REX modeling and T-HERPS refinements, acute RQs exceeded the listed and non-listed species LOCs (0.1 and 0.5, respectively) for all uses, as did chronic RQs.	<u>Indirect Effects (prey items)</u>: CCR, CTS (all DPS), SFGS <u>Direct Effects</u>: CCR, CTS (all DPS), SFGS	CTS-CC, CTS-SB,
Mammals	Non-listed Species (Yes) Listed Species (Yes)	Acute RQs exceed the listed and non-listed species LOCs (0.1 and 0.5, respectively) for all uses, as did chronic RQs.	<u>Indirect Effects (prey items)</u>: CCR Indirect Effects (prey items and habitat): CTS (all DPS), SFGS	CTS-CC, CTS-SB
Terrestrial Invertebrates	Listed Species (Yes)	RQs exceeded the listed species LOC (0.05) for all uses.	<u>Indirect Effects (prey items)</u>: CCR, CTS (all DPS), SFGS	CTS-CC, CTS-SB
			<u>Direct Effects</u>: BCB, VELB	BCB, VELB
Terrestrial Plants - Monocots	Non-listed Species (No) Listed Species (Yes)	Semi-aquatic area RQs exceeded the LOC (1.0) for listed monocots only (obligate relationships) for all uses.	<u>Indirect Effects (habitat only)</u>: CTS (all DPS), DS, SFGS, TG <u>Indirect Effects (habitat and food)</u>: CCR, CFWS (Note: BCB and VELB do not have obligate relationships with plants found in semi-aquatic areas.)	CTS-CC, CTS-SB, DS, TG
Terrestrial Plants - Dicots	Non-listed Species (No) Listed Species (No)			

Following a preliminary "may affect" determination, additional information is considered to refine the potential for exposure at the predicted levels based on the life history characteristics (*i.e.*, habitat range, feeding preferences, *etc*.) of the assessed species. Based on the best available information, the Agency uses the refined evaluation to distinguish those actions that "may affect, but are not likely to adversely affect" from those actions that are "likely to adversely affect" the assessed species and its designated critical habitat.

The criteria used to make determinations that the effects of an action are "not likely to adversely affect" the assessed species or modify its designated critical habitat include the following:

- Significance of Effect: Insignificant effects are those that cannot be meaningfully measured, detected, or evaluated in the context of a level of effect where "take" occurs for even a single individual. "Take" in this context means to harass or harm, defined as the following:
    - Harm includes significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering.
    - Harass is defined as actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering.
- Likelihood of the Effect Occurring: Discountable effects are those that are extremely unlikely to occur.
- Adverse Nature of Effect: Effects that are wholly beneficial without any adverse effects are not considered adverse.

A description of the risk and effects determination for each of the established assessment endpoints for the assessed species and their designated critical habitat is provided in **Section 5.2.1** through **Section 5.2.8**. The effects determination section for each listed species assessed will follow a similar pattern. Each will start with a discussion of the potential for direct effects, followed by a discussion of the potential for indirect effects. These discussions do not consider the spatial analysis. For those listed species that have designated critical habitat, the section will end with a discussion on the potential for modification to the critical habitat from the use of bensulide. Finally, in **Section 5.2.9**, a discussion of any potential overlap between areas of concern and the species (including any designated critical habitat) is presented. If there is no overlap of the species habitat and occurrence sections with the Potential Area of LAA Effects, a No Effect determination is made.

5.2.1. Bay Checkerspot Butterfly

5.2.1.a. Direct Effects

RQs for all bensulide uses exceed the LOC (0.05) for direct effects to the BCB, resulting in a preliminary "may affect" determination. However, it should be noted that the toxicity value used to derive the RQs was based on surrogate data for piperophos since the bensulide data was non-definitive (*i.e.*, 50% mortality was not observed and the one dose tested; the LD_{50} > 24.17 µg a.i./bee). In addition, there is uncertainty regarding the use of honey bee data as a surrogate for Lepidoptera species. EECs, calculated using T-REX for arthropods, would have to be about 2.4 times lower than the EEC for the lowest use rate of bensulide and about 7 times lower based on the highest use rate to alleviate concerns of direct effects to listed Lepidoptera species.

No incidents involving terrestrial invertebrates were reported for bensulide, and no open literature studies were available either.

The probability of an individual effect for a BCB is high: between 1 in 1 (100%) and 1 in 1.04 (96%) for the full range of bensulide application rates (**Table 4-5**). These probabilities are calculated based on the acute RQs and the default probit slope of 4.5.

Based on the weight of evidence presented here, there is a potential for direct effects to the BCB as a result of bensulide uses.

5.2.1.b. Indirect Effects

The BCB relies on terrestrial dicot plants exclusively for both food and habitat and has an obligate relationship with dicots. Eggs are laid on a native plantain, which the larvae feed upon; if this food is not sufficient for development the larvae may move onto owl's clover. The adult butterflies live on nectar, feeding on a variety of plants. The BCB inhabits grasslands on serpentine soils, such as the Montara soil series; populations now remain only in San Mateo and Santa Clara counties.

RQs exceeded the LOC for listed monocots in semi-aquatic areas only for all use scenarios. None of the listed or non-listed dicot and non-listed monocot RQs exceeded the LOC. Based on these results, bensulide is not likely to indirectly affect the BCB because its habitat does not include semi-aquatic areas. RQs are based on seedling emergence and vegetative vigor studies with bensulide using monocots and dicots. However, it should be noted that the studies were not conducted with the maximum single application rate.

The Aggregate Incident Reports database contained 57 minor plant incidents (P-B) that occurred from 1997 to 2006. No details regarding these incidents are available. Therefore, although plant damage may occur, effects to non-target plants are not expected to result in indirect effects to the BCB.

5.2.1.c. Modification of Designated Critical Habitat

Based on the assessment of direct effects to the BCB above, there is potential for modification of designated critical habitat for the BCB.

5.2.2. California Clapper Rail

5.2.2.a. Direct Effects

Acute and chronic RQ values representing all uses of bensulide exceed the LOCs for direct effects to the CCR, resulting in a preliminary “may affect” determination.

No incidents involving birds have been reported. No open literature studies on the effects of bensulide on birds or terrestrial-phase amphibians have been identified.

The probability of an individual effect for a CCR based on avian toxicity data is between 1 in 1.02 (98%) and 1 in 1.36 (74%) for the full range of bensulide application rates (**Table 4-5**). These probabilities are calculated based on acute RQs and the associated probit slope of 2.92.

Based on the weight of evidence presented here, there is a potential for direct effects to the CCR as a result of bensulide uses.

5.2.2.b. Indirect Effects

The CCR are generalist and opportunistic feeders that forage at the upper end of marshes, along the ecotone between mudflat and higher vegetated zones, and in tidal sloughs. Mussels, clams, arthropods, snails, worms and small fish are its preferred foods, which it retrieves by probing and scavenging the surface while walking. The bird will only forage on mudflats or very shallow water where there is taller plant material nearby to provide protection at high tide. Although CCRs typically consume invertebrates, they have also been known to occasionally consume small birds and mammals, including the salt marsh harvest mouse. The CCR diet may contain up to 15% plant material.

Indirect effects to the CCR via loss of prey species and plant foods are evaluated using toxicity data and other information gathered on freshwater fish, freshwater invertebrates, estuarine/marine fish, estuarine/marine invertebrates, aquatic plants, birds, small mammals, terrestrial invertebrates, and terrestrial plants.

The CCR inhabits cordgrass marshes around San Francisco Bay. CCR juveniles can disperse a sufficient distance to be found in both residential and agricultural areas east of SF Bay and along the open coast.

Freshwater Fish

Only one scenario (high rate for cole crops use group) yielded acute and chronic RQs that exceed the non-listed species LOCs (0.5 for acute, 1.0 for chronic). The probability of an individual effect for non-listed freshwater fish was 1 in 5.22 (19%). Other uses that yielded acute RQs that exceeded the acute listed species LOC (0.05) yielded probabilities of an individual effect between 1 in 24.6 (4%) to 1 in 52,200,000. These probabilities were calculated based on acute RQs and the default probit slope (4.5). Although no incidents were reported, indirect effects to the CCR are possible based on this prey component.

Freshwater Invertebrates

Acute RQs exceed the non-listed species LOC (0.5) for a couple uses, and chronic RQs exceed the non-listed species LOC (1.0) for all uses. The probability of an individual effect for non-listed freshwater invertebrates ranged from 1 in 7.44 (13%) to 1 in 2.80 (36%). Other uses that yielded acute RQs that exceeded the listed species LOC (0.05) yielded probabilities of an individual effect between 1 in 11.3 (9%) and 1 in 2,290,000. These probabilities were calculated based on acute RQs and the probit slope of 3.78. Therefore, indirect effects to the CCR are possible based on this prey component.

Estuarine/Marine Fish

Acute RQs exceed the non-listed species LOC (0.5) for five different uses. Chronic RQs were not calculated due to lack of data but were assumed to exceed the LOC (1.0) for all uses. The probability of an individual effect for a non-listed estuarine/marine fish ranged from 1 in 4.43 (23%) to 1 in 1.31 (76%). Other uses that yielded acute RQs that exceeded the listed species LOC (0.05) yielded probabilities of an individual effect between 1 in 14.3 (7%) and 1 in 418,000,000. These probabilities were calculated based on acute RQs and the default probit slope of 4.5. Based on the weight of evidence presented here, indirect effects to the CCR are possible based on this prey component.

Estuarine/Marine Invertebrates

Acute RQs exceed the non-listed species LOC (0.5) for estuarine/marine invertebrates for almost all of the use scenarios. Chronic RQs exceeded the chronic LOC (1.0) for estuarine/marine invertebrates for most use scenarios. The probability of an individual effect for a non-listed estuarine/marine invertebrate is between 1 in 3.6 (28%) and 1 in 1 (100%) for the full range of bensulide application rates (**Table 4-5**). Other uses that yielded acute RQs that exceeded the listed species LOC (0.05) yielded probabilities of an individual effect between 1 in 12.2 (8%) and 1 in 3,740. These probabilities are calculated based on the acute RQs and the default probit slope of 4.5.

There are no incident reports or open literature studies available on the effects of bensulide on estuarine/marine invertebrates; however, incidents on invertebrates are unlikely to be noticed and reported to the Agency.

Based on the weight of evidence, indirect effects to the CCR based on this prey component are possible.

Aquatic Plants

None of the use scenarios produced an RQ that exceed the LOC for non-vascular plants. A few of the scenarios produced RQs that exceed the LOC for vascular plants. Therefore, indirect effects to the CCR based on this food and habitat component are possible.

Birds

For the same reasons that are detailed in the CCR direct effects section, indirect effects to the CCR are possible based on risk to small avian prey.

Small Mammals

All use scenarios produced acute and chronic RQs that exceed both the listed and non-listed species LOC. The probability of an individual effect is close to 100% for all uses. These probabilities are based on acute LOCs and the default probit slope (4.5). Therefore, indirect effects to the CCR are possible based on risk to small mammalian prey.

Terrestrial Invertebrates

For the same reasons that are detailed in the BCB and VELB direct effects sections, indirect effects to the CCR are possible based on risk to terrestrial invertebrate prey.

Terrestrial Plants

There are 57 minor plant incidents reported as aggregate incidents for which no information is available. Because RQs exceeded the LOC for listed dicots in semi-aquatic areas, indirect effects to the CCR are possible based on this food and habitat component.

5.2.3. California Freshwater Shrimp

5.2.3.a. Direct Effects

Acute RQs exceeded the listed species LOC (0.05) for almost all use scenarios, and chronic RQs exceeded the listed and non-listed species LOC (1.0) for all uses, resulting in a preliminary "may affect" determination. The probability of an individual effect for listed freshwater invertebrates ranged from 1 in 2,290,000 to 1 in 2.80 (36%). These probabilities were calculated based on acute RQs and the probit slope of 3.78. Therefore, direct effects are possible to the CFWS based on this prey component.

5.2.3.b. Indirect Effects

The CFWS relies on aquatic and terrestrial plants for both food and habitat. The CFWS feeds on decomposing vegetation and other detritus, consuming minute diverse particles conveyed by currents to downstream pools, which includes zooplankton. The CFWS is found only in low elevation perennial streams or intermittent streams with perennial pools in the northern San Francisco Bay Area. Freshwater shrimp require low gradient streams with diverse habitat structure including undercut banks, exposed roots, woody debris and overhanging vegetation. Indirect effects to the CFWS via loss of food and habitat are evaluated using toxicity data and other information gathered on freshwater invertebrates, aquatic plants, and terrestrial plants.

Freshwater Invertebrates

For the same reasons that are detailed in the CFWS direct effects section, indirect effects to the CFWS are possible based on risk to freshwater invertebrate prey items.

Aquatic Plants

None of the use scenarios produced an RQ that exceeded the LOC for non-vascular plants. A few of the scenarios produced RQs that exceeded the LOC for vascular plants. Therefore, indirect effects to the CFWS based on this food and habitat component are possible.

Terrestrial Plants

There are 57 minor plant incidents reported as aggregate incidents for which no information is available. Because RQs exceeded the LOC for listed dicots in semi-aquatic areas, indirect effects to the CFWS are possible based on this food and habitat component.

5.2.4. California Tiger Salamander (All DPS)

5.2.4.a. Direct Effects

Aquatic-phase

The aquatic-phase includes life stages of the CTS that are obligatory aquatic organisms, including eggs and larvae. It also includes submerged terrestrial-phase juveniles and adults, which spend a portion of their time in water bodies that may receive runoff and spray drift containing bensulide.

Almost all use scenarios yield acute RQs that exceed the listed species LOC for direct effects to the aquatic-phase CTS, resulting in a preliminary “may affect” determination. Only one scenario yields a chronic RQ that exceeds the LOC. The probability of an individual effect for an aquatic-phase CTS is between 1 in 52,200,000 and 1 in 5.22 (19%) for the full range of bensulide application rates (**Table 4-5**). These probabilities are calculated based on the acute RQs and the default probit slope of 4.5. Therefore, direct effects to the aquatic-phase CTS are possible.

Terrestrial-phase

Potential for direct effects to the terrestrial-phase CTS are assessed based on direct acute and chronic toxicity effects to birds as a surrogate due to a lack of toxicity data for terrestrial-phase amphibians. Acute and chronic RQs representing all uses of bensulide exceed the listed species LOC for direct effects to the terrestrial-phase CTS, resulting in a preliminary “may affect” determination.

A refinement of the acute and chronic risks posed to the terrestrial-phase CTS was performed using the T-HERPS model. Avian RQ values used as screening surrogates for terrestrial-phase amphibians likely overestimate risks to amphibians. Overestimation is due to the higher energy requirements of birds over amphibians of the same body weight, which results in a higher daily food intake rate value and a resultant higher dose-based exposure for birds than would occur for an amphibian of the same body weight. The T-HERPS model refines the EEC and RQ values based on dietary intake rate of an amphibian, rather than a dietary intake rate of a bird. Acute and chronic RQs show a slight decrease when modeled in T-HERPS, but remain above the listed species LOC for all use scenarios. Model results from T-HERPS are from the most sensitive RQs, medium amphibians (20 g) consuming herbivorous mammals.

The probability of an individual effect for a CTS based on avian toxicity data is between 1 in 1.02 (98%) and 1 in 1.36 (74%) for the full range of bensulide application rates (**Table 4-5**). These probabilities are calculated based on acute RQs and the associated probit slope of 2.92.

Based on the weight of evidence presented here, direct effects to the terrestrial-phase CTS as a result of bensulide uses are possible.

5.2.4.b. Indirect Effects

CTS larvae are only able to eat small crustaceans, algae, and mosquito larvae. When they are large enough, they begin to consume aquatic insects, invertebrates and tadpoles of Pacific treefrogs, California red-legged frogs, western toads, and spadefoot toads. The terrestrial-phase CTS feeds on terrestrial invertebrates, insects, frogs, worms, and small mammals. Indirect effects to the CTS via loss of prey species are evaluated using toxicity data and other information gathered on freshwater invertebrates, freshwater fish, terrestrial invertebrates, and small mammals.

The CTS inhabits low elevation vernal pools and seasonal ponds and associated grassland, oak savannah, and coastal scrub plant communities. Juvenile and adult CTS spend the dry summer and fall months in the burrows of California ground squirrels (*Spermophilus beecheyi*) and Botta's pocket gopher (*Thomomys bottae*). The CTS cannot dig their own burrows; as a result, their presence is associated with active burrows of these small mammals. Indirect effects to the CTS through potential modification of habitat are evaluated based on impacts of bensulide on aquatic plants, terrestrial plants, and small mammals.

Freshwater Invertebrates

Acute RQs exceeded the non-listed species LOC (0.5) for a couple uses, and chronic RQs exceed the non-listed species LOC (1.0) for all uses. The probability of an individual effect for non-listed freshwater invertebrates ranged from 1 in 7.44 (13%) to 1 in 2.80 (36%). Other uses that yielded acute RQs that exceeded the listed species LOC (0.05) yielded probabilities of an individual effect between 1 in 11.3 (9%) and 1 in 2,290,000. These probabilities were calculated based on acute RQs and the probit slope of 3.78. Therefore, indirect effects to the CTS are possible based on this prey component.

Freshwater Fish

Only one scenario (high rate for cole crops use group) yielded acute and chronic RQs that exceed the non-listed species LOCs (0.5 for acute, 1.0 for chronic). The probability of an individual effect for non-listed freshwater fish was 1 in 5.22 (19%). Other uses that yielded acute RQs that exceeded the acute listed species LOC (0.05) yielded probabilities of an individual effect between 1 in 24.6 (4%) to 1 in 52,200,000. These probabilities were calculated based on acute RQs and the default probit slope (4.5). Although no incidents were reported, indirect effects to the CTS are possible based on this prey component.

Terrestrial Invertebrates

For the same reasons that are detailed in the BCB and VELB direct effects sections, indirect effects to the CTS are possible based on risk to terrestrial invertebrate prey.

Small Mammals

All use scenarios produced acute and chronic RQs that exceed both the listed and non-listed species LOC. The probability of an individual effect is close to 100% for all uses. These probabilities are based on acute LOCs and the default probit slope (4.5). Therefore, indirect effects are anticipated to the CTS based on risk to small mammalian prey. In addition, juvenile and adult CTS rely on the burrows of small mammals for habitat in the dry summer and fall months. Therefore, indirect effects are anticipated to the CTS based on modification of habitat caused by the reduction of small mammals and, consequently, their burrows.

Aquatic Plants

Aquatic plants serve several important functions in aquatic ecosystems. Non-vascular aquatic plants are primary producers and provide the autochthonous energy base for aquatic ecosystems. Vascular plants provide structure, rather than energy, to the system, as attachment sites for many aquatic invertebrates, and refugia for juvenile organisms, such as fish and frogs. Emergent plants help reduce sediment loading and provide stability to nearshore areas and lower streambanks. In addition, vascular aquatic plants are important as attachment sites for egg masses of aquatic species.

None of the use scenarios produced an RQ that exceeded the LOC for non-vascular plants. A few of the scenarios produced RQs that exceeded the LOC for vascular plants. Therefore, indirect effects to the CTS based on this food and habitat component are possible.

Terrestrial Plants

Terrestrial plants serve several important habitat-related functions for the listed assessed species. In addition to providing habitat and cover for invertebrate and vertebrate prey items of the listed assessed species, terrestrial vegetation also provides shelter and cover from predators while foraging. Upland vegetation including grassland and woodlands provides cover during dispersal. Riparian vegetation helps to maintain the integrity of aquatic systems by providing bank and thermal stability, serving as a buffer to filter out sediment, nutrients, and contaminants before they reach the watershed, and serving as an energy source.

There are 57 minor plant incidents reported as aggregate incidents for which no information is available. Because RQs exceeded the LOC for listed dicots in semi-aquatic areas, indirect effects to the CTS are possible based on modification of habitat.

5.2.4.c. Modification of Designated Critical Habitat

Based on the assessment of direct and indirect effects to the CTS, the modification of designated critical habitat for the CTS-CC and CTS-SB may occur. There is no designated critical habitat for the CTS-SC.

5.2.5. Delta Smelt

5.2.5.a. Direct Effects

Acute RQs for almost all uses of bensulide exceed the listed species LOC for freshwater fish. Only one scenario yielded a chronic RQ that exceeded the chronic LOC for freshwater fish. All but one of the use scenarios yielded acute RQs that exceeded the listed species LOC for estuarine/marine fish. Although chronic estuarine/marine fish data were not available, due to the slight increased acute toxicity of bensulide to estuarine/marine fish compared to freshwater fish, the Agency conservatively concluded that all chronic RQs would exceed the LOC for estuarine/marine fish. The probability of an individual effect for freshwater fish ranged from 1 in 52,200,000 to 1 in 5.22 (19%). The probability of an individual effect for estuarine/marine fish ranged from 1 in 418,000,000 to 1 in 1.31 (76%). These probabilities were calculated based on acute RQs and the default probit slope (4.5). Although no incidents were reported, direct effects to the DS are possible; therefore, a preliminary "may affect" determination is made.

5.2.5.b. Indirect Effects

As discussed in **Attachment II**, the diet of DS is composed primarily of zooplankton, particularly copepods. Therefore, freshwater and estuarine/marine invertebrates as well as unicellular aquatic plants are considered as prey groups for determining indirect effects to the DS caused by direct effects to its prey.

Freshwater Invertebrates

Acute RQs exceeded the non-listed species LOC (0.5) for a couple uses, and chronic RQs exceeded the non-listed species LOC (1.0) for all uses. The probability of an individual effect for non-listed freshwater invertebrates ranged from 1 in 7.44 (13%) to 1 in 2.80 (36%). Other uses that yielded acute RQs that exceeded the listed species LOC (0.05) yielded probabilities of an individual effect between 1 in 11.3 (9%) and 1 in 2,290,000. These probabilities were calculated based on acute RQs and the probit slope of 3.78. Therefore, indirect effects to the DS are possible based on this prey component.

Estuarine/Marine Invertebrates

Acute RQs exceeded the non-listed species LOC (0.5) for estuarine/marine invertebrates for almost all of the use scenarios. Chronic RQs exceeded the chronic LOC (1.0) for estuarine/marine invertebrates for most use scenarios. The probability of an individual effect for a non-listed estuarine/marine invertebrate is between 1 in 3.6 (28%) and 1 in 1 (100%) for the full range of bensulide application rates (**Table 4-5**). Other uses that yielded acute RQs that exceeded the listed species LOC (0.05) yielded probabilities of an individual effect between 1 in 12.2 (8%) and 1 in 3,740. These probabilities are calculated based on the acute RQs and the default probit slope of 4.5.

There are no incident reports or open literature studies available on the effects of bensulide on estuarine/marine invertebrates; however, incidents on invertebrates are unlikely to be noticed and reported to the Agency.

Based on the weight of evidence, indirect effects to the DS based on this prey component are possible.

Aquatic Plants

None of the use scenarios produced an RQ that exceeded the LOC for non-vascular plants. A few of the scenarios produced RQs that exceeded the LOC for vascular plants. Therefore, indirect effects to the DS based on this food and habitat component are possible.

Terrestrial Plants

There are 57 minor plant incidents reported as aggregate incidents for which no information is available. Because RQs exceeded the LOC for listed dicots in semi-aquatic areas, indirect effects to the DS are possible based on modification of habitat.

5.2.5.c. Modification of Designated Critical Habitat

Based on the assessment of direct and indirect effects to the DS, the modification of designated critical habitat for the DS may occur.

5.2.6. San Francisco Garter Snake

5.2.6.a. Direct Effects

Potential for direct effects to the SFGS are assessed based on direct acute and chronic toxicity effects to birds as a surrogate due to a lack of toxicity data for reptiles. Acute and chronic RQs representing all uses of bensulide exceed the LOCs for direct effects to the SFGS, resulting in a preliminary “may affect” determination.

See **Section 5.2.4.a** for a description of the refinement of terrestrial acute and chronic risks conducted using the T-HERPS model.

The probability of an individual effect for a SFGS based on avian toxicity data is between 1 in 1.02 (98%) and 1 in 1.36 (74%) for the full range of bensulide application rates (**Table 4-5**). These probabilities are calculated based on acute RQs and the associated probit slope of 2.92.

Based on the weight of evidence presented here, direct effects to the SFGS as a result of bensulide uses are possible.

5.2.6.b. Indirect Effects

Adult SFGS feed primarily on California red-legged frogs and juvenile bullfrogs. Newborn and juvenile snakes prey upon Pacific tree frogs. Small mammals, reptiles, amphibians, terrestrial and aquatic invertebrates, and some fish species may also be consumed by the SFGS if they can be captured in shallow water. Indirect effects to the SFGS via loss of prey species are evaluated using toxicity data and other information gathered on freshwater fish, freshwater invertebrates, birds, small mammals, and terrestrial invertebrates.

The SFGS inhabits densely vegetated ponds near open hillsides where it can sun, feed, and find cover in rodent burrows as well as forage extensively in aquatic habitats. Freshwater habitats include natural and manmade (*e.g.* stock) ponds, slow moving streams, vernal pools and other ephemeral or permanent water bodies which typically support inundation during winter rains. Upland habitats are within 200 ft of the mean high water mark of such aquatic habitats.

Freshwater Fish and Aquatic-phase Amphibians

Only one scenario (high rate for cole crops use group) yielded acute and chronic RQs that exceeded the non-listed species LOCs (0.5 for acute, 1.0 for chronic). The probability of an individual effect for non-listed freshwater fish was 1 in 5.22 (19%). Other uses that yielded acute RQs that exceeded the acute listed species LOC (0.05) yielded probabilities of an individual effect between 1 in 24.6 (4%) to 1 in 52,200,000. These probabilities were calculated based on acute RQs and the default probit slope (4.5). Although no incidents were reported, indirect effects to the SFGS are possible based on this prey component.

Freshwater Invertebrates

Acute RQs exceeded the non-listed species LOC (0.5) for a couple uses, and chronic RQs exceeded the non-listed species LOC (1.0) for all uses. The probability of an individual effect for non-listed freshwater invertebrates ranged from 1 in 7.44 (13%) to 1 in 2.80 (36%). Other uses that yielded acute RQs that exceeded the listed species LOC (0.05) yielded probabilities of an individual effect between 1 in 11.3 (9%) and 1 in 2,290,000. These probabilities were calculated based on acute RQs and the probit slope of 3.78. Therefore, indirect effects to the SFGS are possible based on this prey component.

Birds, Terrestrial-phase Amphibians, and Reptiles

For the same reasons that are detailed in the SFGS and terrestrial-phase CTS direct effects sections, indirect effects to the SFGS are possible based on this prey component.

Small Mammals

All use scenarios produced acute and chronic RQs that exceed both the listed and non-listed species LOC. The probability of an individual effect is close to 100% for all uses. These probabilities are based on acute LOCs and the default probit slope (4.5). Therefore, indirect effects are anticipated to the SFGS based on risk to small mammalian prey. In addition, SFGS rely on the burrows of small mammals for shelter and aestivation when ponds become dry. SFGSs may also forage for amphibians in the rodent burrows during the summer.

Therefore, indirect effects are anticipated to the SFGS based on modification of habitat caused by the reduction of small mammals and, consequently, their burrows.

Terrestrial Invertebrates

For the same reasons that are detailed in the BCB and VELB direct effects sections, indirect effects to the SFGS are possible based on risk to terrestrial invertebrate prey.

Aquatic Plants

None of the use scenarios produced an RQ that exceeded the LOC for non-vascular plants. A few of the scenarios produced RQs that exceeded the LOC for vascular plants. Therefore, indirect effects to the SFGS based on modification of habitat are possible.

Terrestrial Plants

Terrestrial plants serve several important habitat-related functions for the listed assessed species. In addition to providing habitat and cover for invertebrate and vertebrate prey items of the listed assessed species, terrestrial vegetation also provides shelter and cover from predators while foraging. Upland vegetation including grassland and woodlands provides cover during dispersal. Riparian vegetation helps to maintain the integrity of aquatic systems by providing bank and thermal stability, serving as a buffer to filter out sediment, nutrients, and contaminants before they reach the watershed, and serving as an energy source.

There are 57 minor plant incidents reported as aggregate incidents for which no information is available. Because RQs exceeded the LOC for listed dicots in semi-aquatic areas, indirect effects to the SFGS are possible based on modification of habitat.

5.2.7. Tidewater Goby

5.2.7.a. Direct Effects

Acute RQs for almost all uses of bensulide exceed the listed species LOC for freshwater fish. Only one scenario yielded a chronic RQ that exceeded the chronic LOC for freshwater fish. All but one of the use scenarios yield acute RQs that exceeded the listed species LOC for estuarine/marine fish. Although chronic estuarine/marine fish data were not available, due to the slight increased acute toxicity of bensulide to estuarine/marine fish compared to freshwater fish, the Agency conservatively concluded that all chronic RQs would exceed the LOC for estuarine/marine fish. The probability of an individual effect for freshwater fish ranged from 1 in 52,200,000 to 1 in 5.22 (19%). The probability of an individual effect for estuarine/marine fish ranged from 1 in 418,000,000 to 1 in 1.31 (76%). These probabilities were calculated based on acute RQs and the default probit slope (4.5). Although no incidents were reported, direct effects to the TG are possible; therefore, a preliminary “may affect” determination is made.

5.2.7.b. Indirect Effects

As discussed in **Attachment II**, the diet of the TG consists of macroinvertebrates such as mysid, shrimp, gammarid amphipods, ostracods, and aquatic insects. Food items of the smallest TGs, which are 4-8mm (0.2-0.3 in.) in size, have not been examined, but they likely feed on unicellular phytoplankton or zooplankton like many other early stage larval fishes (**Attachment II**). Therefore, freshwater and estuarine/marine invertebrates as well as unicellular aquatic plants are considered as prey groups for determining indirect effects to the TG caused by direct effects to its prey.

Freshwater Invertebrates

Acute RQs exceeded the non-listed species LOC (0.5) for a couple uses, and chronic RQs exceeded the non-listed species LOC (1.0) for all uses. The probability of an individual effect for non-listed freshwater invertebrates ranged from 1 in 7.44 (13%) to 1 in 2.80 (36%). Other uses that yielded acute RQs that exceeded the listed species LOC (0.05) yielded probabilities of an individual effect between 1 in 11.3 (9%) and 1 in 2,290,000. These probabilities were calculated based on acute RQs and the probit slope of 3.78. Therefore, indirect effects to the TG are possible based on this prey component.

Estuarine/Marine Invertebrates

Acute RQs exceeded the non-listed species LOC (0.5) for estuarine/marine invertebrates for almost all of the use scenarios. Chronic RQs exceeded the chronic LOC (1.0) for estuarine/marine invertebrates for most use scenarios. The probability of an individual effect for a non-listed estuarine/marine invertebrate is between 1 in 3.6 (28%) and 1 in 1 (100%) for the full range of bensulide application rates (**Table 4-5**). Other uses that yielded acute RQs that exceeded the listed species LOC (0.05) yielded probabilities of an individual effect between 1 in 12.2 (8%) and 1 in 3,740. These probabilities are calculated based on the acute RQs and the default probit slope of 4.5.

There are no incident reports or open literature studies available on the effects of bensulide on estuarine/marine invertebrates; however, incidents on invertebrates are unlikely to be noticed and reported to the Agency.

Based on the weight of evidence, indirect effects to the TG based on this prey component are possible.

Aquatic Plants

None of the use scenarios produced an RQ that exceeded the LOC for non-vascular plants. A few of the scenarios produced RQs that exceeded the LOC for vascular plants. Therefore, indirect effects to the TG based on this food and habitat component are possible.

Terrestrial Plants

There are 57 minor plant incidents reported as aggregate incidents for which no information is available. Because RQs exceeded the LOC for listed dicots in semi-aquatic areas, indirect effects to the TG are possible based on modification of habitat.

5.2.7.c. Modification of Designated Critical Habitat

Based on the assessment of direct and indirect effects to the TG, the modification of designated critical habitat for the TG may occur.

5.2.8. Valley Elderberry Longhorn Beetle

5.2.8.a. Direct Effects

RQs for all bensulide uses LOC (0.05) for direct effects to the VELB, resulting in a preliminary "may affect" determination. However, it should be noted that the toxicity value used to derive the RQs was based on surrogate data for piperophos since the bensulide data was non-definitive (*i.e.*, 50% mortality was not observed and the one dose tested; the LD_{50} > 24.17 µg a.i./bee). In addition, there is uncertainty regarding the use of honey bee data as a surrogate for Coleoptera species. EECs, calculated using T-REX for arthropods, would have to be about 2.4 times lower than the EEC for the lowest use rate of bensulide and about 7 times lower based on the highest use rate to alleviate concerns of direct effects to listed Coleoptera species.

No incidents involving terrestrial invertebrates were reported for bensulide, and there were no open literature studies available either.

The probability of an individual effect for a VELB is high: between 1 in 1 (100%) and 1 in 1.04 (96%) for the full range of bensulide application rates (**Table 4-5**). These probabilities are calculated based on the acute RQs and the default probit slope of 4.5.

Based on the weight of evidence presented here, there is a potential for direct effects to the VELB as a result of bensulide uses.

5.2.8.b. Indirect Effects

The VELB is associated with riparian elderberry trees during its entire life cycle and relies on these trees for both food and habitat. The VELB has an obligate relationship with the elderberry trees. Females lay their eggs on the bark and larvae hatch and burrow into the stems. The larval stage may last 2 years, after which the larvae enter the pupal stage and transform into adults.

RQs exceeded the LOC for listed monocots in semi-aquatic areas only for all use scenarios. None of the listed or non-listed dicot and non-listed monocot RQs exceeded the LOC. Based on these results, bensulide is not likely to indirectly affect the VELB because its habitat does not include semi-aquatic areas. RQs are based on seedling emergence and vegetative vigor studies with bensulide using monocots and dicots. However, it should be noted that the studies were not conducted with the maximum single application rate.

The Aggregate Incident Reports database contained 57 minor plant incidents (P-B) that occurred from 1997 to 2006. No details regarding these incidents are available. Therefore, although plant damage may occur, effects to non-target plants are not expected to result in indirect effects to the VELB.

5.2.8.c. Modification of Designated Critical Habitat

Based on the assessment of direct effects to the VELB above, there is potential for modification of designated critical habitat for the VELB.

5.2.9. Spatial Extent of Potential Effects

Since LOCs are exceeded, an analysis of the spatial extent of the potential LAA effects determination is needed to determine where effects may occur in relation to the treated site. If the potential area of usage and subsequent Potential Area of LAA Effects overlaps with BCB, CCR, CFWS, CTS (all DPS), DS, SFGS, TG, or VELB, habitat or areas of occurrence or critical habitat of the BCB, CTS-CC, CTS-SB, DS, TG, or VELB, a likely to adversely affect determination is made. If the Potential Area of LAA Effects and the habitat and areas of occurrence or critical habitat do not overlap, a no effect determination is made.

To determine this area, the footprint of bensulide's use pattern is identified, using corresponding land cover data, see **Section 2.7**. This area is defined by all land cover types that represent the labeled outdoor uses of bensulide including agriculture, orchards/vineyards, pasture, and non-agriculture. Actual usage is expected to occur in a smaller area as the chemical is only expected to be used on a portion of the identified area. The spatial extent of the effects determination also includes areas beyond the initial area of concern that may be impacted by runoff and/or spray drift (Use Footprint + distance downstream or downwind from use sites where organisms relevant to the assessed species may be affected). The determination of the buffer distance and downstream dilution for spatial extent of the effects determination is described below.

5.2.9.a. Spray Drift

In order to determine terrestrial and aquatic habitats of concern due to bensulide exposures through spray drift, it is necessary to estimate the distance that spray applications can drift from the treated area and still be present at concentrations that exceed levels of concern. Ground applications of bensulide granular formulations are not expected to result in any spray drift. For the flowable uses, a quantitative analysis of spray drift distances was completed using AgDRIFT (v. 2.1.1) using default inputs for ground applications (*i.e*., high boom, ASABE droplet size distribution = very fine to fine, 90th percentile of the data distribution).

For this assessment, a Tier I spray drift analysis was completed to determine whether a buffer zone could be defined at <1000 ft. The distance of potential impact away from the use sites is determined by the distance required to fall below the LOC. The dissipation distance is expected to increase based on a decrease in droplet size as fine drops will result in more drift. In some cases, topography (such as an intervening ridge) or weather conditions (such as prevailing winds) could affect the estimates. Spray drift buffer distances were calculated for the highest spray application rates for ground applications for terrestrial and aquatic habitats. Registered labels did not specify buffer distances to reduce potential risk due to spray drift.

Buffer distances for terrestrial taxa are provided in **Table 5-15**. For birds and mammals, RQs would exceed the LOC from 3 up to 89 feet from the edge of the field. For arthropods, RQs would exceed the LOC from 121 up to 177 feet from the edge of the field. For plants, RQs would exceed the LOC from 121 up to 440 feet from the edge of the field.

Aquatic buffer distances to no LOC exceedance (presented in **Table 5-16**) were generally 0 feet, indicating that potential risk due to spray drift off of the field is not a concern. However, for listed estuarine/marine invertebrates, RQs would exceed the LOC from 161 up to 259 feet from the edge of the field.

Table 5-15. Spray Drift Dissipation Distances for Terrestrial Taxa to No LOC Exceedance for Bensulide

Taxa	Use (Application Rate)	Terrestrial Buffer (ft)
Birds	1 app @ 6 lb a.i./acre for listed species (T-REX)	43
	1 app @ 6 lb a.i./acre for non-listed species (T-REX)	10
	1 app @ 6 lb a.i./acre for listed species (T-HERPS refinement)	20
	1 app @ 6 lb a.i./acre for non-listed species (T-HERPS refinement)	3
	1 app @ 9 lb a.i./acre for listed species (T-REX)	62
	1 app @ 9 lb a.i./acre for non-listed species (T-REX)	13
	1 app @ 9 lb a.i./acre for listed species (T-HERPS refinement)	30
	1 app @ 9 lb a.i./acre for non-listed species (T-HERPS refinement)	7
Mammals	1 app @ 6 lb a.i./acre for listed species (T-REX)	59
	1 app @ 6 lb a.i./acre for non-listed species (T-REX)	13
	1 app @ 9 lb a.i./acre for listed species (T-REX)	89
	1 app @ 9 lb a.i./acre for non-listed species (T-REX)	20
Arthropods	1 app @ 6 lb a.i./acre (T-REX)	121
	1 app @ 9 lb a.i./acre (T-REX)	177
Plants	1 app @ 6 lb a.i./acre (TerrPlant)	226
	1 app @ 9 lb a.i./acre (TerrPlant)	440
	1 app @ 6 lb a.i./acre (TerrPlant)	121
	1 app @ 9 lb a.i./acre (TerrPlant)	252

Table 5-16. Spray Drift Dissipation Distances for Aquatic Taxa to No LOC Exceedance for Bensulide

Taxa	Use (Application Rate)	Aquatic Buffer (ft)
Freshwater Fish	1 app @ 6 lb a.i./acre for listed species	0
	1 app @ 6 lb a.i./acre for non-listed species	0
	1 app @ 9 lb a.i./acre for listed species	0
	1 app @ 9 lb a.i./acre for non-listed species	0
Estuarine/marine	1 app @ 6 lb a.i./acre for listed species	0

Table 5-16. Spray Drift Dissipation Distances for Aquatic Taxa to No LOC Exceedance for Bensulide		
Taxa	**Use (Application Rate)**	**Aquatic Buffer (ft)**
Fish	1 app @ 6 lb a.i./acre for non-listed species	0
	1 app @ 9 lb a.i./acre for listed species	0
	1 app @ 9 lb a.i./acre for non-listed species	0
Freshwater Invertebrates	1 app @ 6 lb a.i./acre for listed species	0
	1 app @ 6 lb a.i./acre for non-listed species	0
	1 app @ 9 lb a.i./acre for listed species	0
	1 app @ 9 lb a.i./acre for non-listed species	0
Estuarine/marine Invertebrates	1 app @ 6 lb a.i./acre for listed species	161
	1 app @ 6 lb a.i./acre for non-listed species	0
	1 app @ 9 lb a.i./acre for listed species	259
	1 app @ 9 lb a.i./acre for non-listed species	0
Vascular Plants	1 app @ 6 lb a.i./acre	0
	1 app @ 9 lb a.i./acre	0

5.2.9.b. Downstream Dilution Analysis

The downstream extent of exposure in streams and rivers where the EEC could potentially be above levels that would exceed the most sensitive LOC is calculated using the downstream dilution model (highest acute RQ/acute LOC = 7.43/0.05 = 148.6; 1/148.6 = 0.67%). The downstream dilution analysis indicated that the maximum distance downstream where the potential for risk exists is 379.8 km.

5.2.9.c. Overlap of Potential Areas of LAA Effect and Habitat and Occurrence of BCB, CCR, CFWS, CTS, DS, SFGS, TG, and VELB

The spray drift and downstream dilution analyses help to identify areas of potential effect to the BCB, CCR, CFWS, CTS (all DPS), DS, SFGS, TG, and VELB from registered uses of bensulide (see **Appendix L** for overlap maps and more information).

5.3. Effects Determinations

5.3.1. Bay Checkerspot Butterfly

It is possible for bensulide to directly impact the BCB based on RQs exceeding LOCs for terrestrial invertebrates. Indirect effects from impacts on food and habitat are not anticipated due to RQs not exceeding LOCs for terrestrial plants inhabiting areas in which BCB inhabit (*i.e.,* LOCs are only exceeded for plants that inhabit semi-aquatic areas, which the BCB does not inhabit). There is overlap between the areas of the LAA effects determination for bensulide and BCB range.

Therefore, the Agency makes a **may affect, and likely to adversely affect** determination and a **habitat modification determination** for the BCB, based on the potential for direct effects and effects to the PCEs of critical habitat.

5.3.2. California Clapper Rail

It is possible for bensulide to directly impact the CCR based on RQs exceeding LOCs avian species. Indirect effects from impacts on prey are also possible based on RQs exceeding LOCs for birds, mammals, terrestrial invertebrates, aquatic plants, and freshwater invertebrates. Indirect effects from impacts on habitat are possible due to RQs exceeding LOCs for aquatic and terrestrial plants. There is overlap between the areas of the LAA effects determination for bensulide and CCR range.

Therefore, the Agency makes a **may affect, and likely to adversely affect** determination for the CCR. The CCR does not have a designated critical habitat.

5.3.3. California Freshwater Shrimp

It is possible for bensulide to directly impact the CFWS based on RQs exceeding LOCs for freshwater invertebrates. Indirect effects from impacts on prey are also possible based on RQs exceeding LOCs for freshwater invertebrates and aquatic and terrestrial plants. Indirect effects from impacts on habitat are possible due to RQs exceeding LOCs for aquatic and terrestrial plants. There is overlap between the areas of the LAA effects determination for bensulide and CFWS range.

Therefore, the Agency makes a **may affect, and likely to adversely affect** determination for the CFWS. The CFWS does not have a designated critical habitat.

5.3.4. California Tiger Salamander (All 3 DPS)

It is possible for bensulide to directly impact the CTS based on RQs exceeding LOCs for terrestrial-phase amphibians, using avian surrogate species data and based on RQs exceeding LOCs for aquatic-phase amphibians, using freshwater fish surrogate species data. Indirect effects from impacts on prey are also possible based on RQs exceeding LOCs for terrestrial-phase amphibians, using avian surrogate species data, mammals, terrestrial invertebrates, freshwater invertebrates, and aquatic plants. Indirect effects from impacts on habitat are possible due to RQs exceeding LOCs for aquatic and terrestrial plants and mammal burrow availability. Small mammals are essential in creating the underground habitat that juvenile and adult CTS depend upon for food, shelter, and protection from the elements and predation. There is overlap between the areas of the LAA effects determination for bensulide and CTS range.

Therefore, the Agency makes a **may affect, and likely to adversely affect** determination for the CTS (all DPS) and a **habitat modification determination** for the designated critical habitat of the CTS-CC, and CTS-SB based on the potential for direct and indirect effects and effects to the PCEs of critical habitat. The CTS-SC does not have a designated critical habitat.

5.3.5. Delta Smelt

It is possible for bensulide to directly impact the DS based on RQs exceeding LOCs for freshwater and estuarine/marine fish. Indirect effects from impacts on prey and habitat are also possible based on RQs exceeding LOCs for freshwater and estuarine/marine invertebrates and aquatic and terrestrial plants. There is overlap between the areas of the LAA effects determination for bensulide and the DS range.

Therefore, the Agency makes a **may affect, and likely to adversely affect** determination for the DS and a **habitat modification determination** for the designated critical habitat of the DS.

5.3.6. San Francisco Garter Snake

It is possible for bensulide to directly impact the SFGS based on RQs exceeding LOCs for reptiles, using avian surrogate species data. Indirect effects from impacts on prey are also possible based on RQs exceeding LOCs for terrestrial-phase amphibians, using avian surrogate species data, reptiles, mammals, terrestrial invertebrates, and freshwater invertebrates. Indirect effects from impacts on habitat are possible due to RQs exceeding LOCs for aquatic and terrestrial plants and mammal burrow availability. SFGS rely on the burrows of small mammals for shelter and aestivation. There is overlap between the areas of the LAA effects determination for bensulide and SFGS range.

Therefore, the Agency makes a **may affect, and likely to adversely affect** determination for the SFGS. The SFGS does not have a designated critical habitat.

5.3.7. Tidewater Goby

It is possible for bensulide to directly impact the TG based on RQs exceeding LOCs for freshwater and estuarine/marine fish. Indirect effects from impacts on prey and habitat are also possible based on RQs exceeding LOCs for freshwater and estuarine/marine invertebrates and aquatic and terrestrial plants. There is overlap between the areas of the LAA effects determination for bensulide and the TG range.

Therefore, the Agency makes a **may affect, and likely to adversely affect** determination for the TG and a **habitat modification determination** for the designated critical habitat of the TG.

5.3.8. Valley Elderberry Longhorn Beetle

It is possible for bensulide to directly impact the VELB based on RQs exceeding LOCs for terrestrial invertebrates. Indirect effects from impacts on food and habitat are not anticipated due to RQs not exceeding the LOC for terrestrial plants inhabiting areas in which VELB inhabit (*i.e.*, LOCs are only exceeded for plants that inhabit semi-aquatic areas, which the VELB does not inhabit). There is overlap between the areas of the LAA effects determination for bensulide and VELB range.

Therefore, the Agency makes a **may affect, and likely to adversely affect** determination and a **habitat modification determination** for the VELB, based on the potential for direct effects and effects to the PCEs of critical habitat.

5.3.9. Addressing the Risk Hypotheses

In order to conclude this risk assessment, it is necessary to address the risk hypotheses defined in **Section 2.9.1**. Based on the conclusions of this assessment, all of the stated hypotheses represent concerns in terms of direct effects of bensulide on the BCB, CCR, CFWS, CTS, DS, SFGS, TG, and VELB. However, concerns in terms of indirect effects of bensulide are only expected on CCR, CFWS, CTS (all DPS), DS, SFGS, and TG. There is potential for modification of designated critical habitat for BCB, CTS-CC, CTS-SB, DS, TG, and VELB.

The labeled uses of bensulide may:

- directly affect BCB, CCR, CFWS, CTS (all DPS), DS, SFGS, TG, and VELB by causing mortality or by adversely affecting growth or fecundity;
- indirectly affect BCB, CCR, CFWS, CTS (all DPS), DS, SFGS, TG, and VELB and/or modify their designated critical habitat by reducing or changing the composition of food supply;
- indirectly affect CCR, CFWS, CTS (all DPS), DS, SFGS, and TG and/or modify their designated critical habitat by reducing or changing the composition of the aquatic plant community in the species' current range, thus affecting primary productivity and/or cover;
- indirectly affect BCB, CCR, CFWS, CTS (all DPS), DS, SFGS, TG, and VELB and/or modify their designated critical habitat by reducing or changing the composition of the terrestrial plant community in the species' current range;
- indirectly affect CCR, CFWS, CTS (all DPS), DS, SFGS, and TG and/or modify their designated critical habitat by reducing or changing aquatic habitat in their current range (via modification of water quality parameters, habitat morphology, and/or sedimentation);
- indirectly affect CTS (all DPS) and SFGS and/or modify their designated critical habitat by reducing or changing terrestrial habitat in their current range (via reduction in small burrowing mammals leading to reduction in underground refugia/cover).

6. Uncertainties

Uncertainties that apply to most assessments completed for the San Francisco Bay Species Litigation are discussed in **Attachment I**. This section describes additional uncertainties specific to this assessment.

6.1. Exposure Assessment Uncertainties

6.1.1. Terrestrial Exposure Assessment

6.1.1.a. T-REX

Organisms consume a variety of dietary items and may exist in a variety of sizes at different life stages. For foliar applications of liquid formulations, T-REX estimates exposure for the following dietary items: short grass, tall grass, broadleaf plants/small insects, fruits/pods/seeds/large insects, and seeds for granivores. Birds (used as a surrogate for amphibians and reptiles), including the CCR, and mammals consume all of these items. The size classes of birds represented in T-REX are the small (20 g), medium (100 g), and large (1000 g). The size classes for mammals are small (15 g), medium (35 g), and large (1000 g). EECs are calculated for the most sensitive dietary item and size class for birds (surrogate for amphibians and reptiles) and mammals. **Table 6-1** shows the percentages of the EECs and RQs of the various dietary classes for each size class as compared to the most sensitive dietary class (short grass) and size class (small mammal or bird). This information could be used to further characterize potential risk that is specific to the diet of birds and mammals. For example, if a mammal only consumes broadleaf plants and small insects and the RQ was 100 for small mammals consuming short grass, the RQ for small mammals that only consumed broadleaf plants and small insects would be 56 (100 x 0.56).

Table 6-1. Percentage of EEC or RQ for the Specified Dietary Items and Size Classes as Compared to the EEC or RQ for The Most Sensitive Dietary Items (Short Grass) and Size Class (Small Bird or Small Mammal)

Dietary Items	Percentage of EECs or RQs for the Specified Dietary Items and Size Class as compared to the EEC or RQ for Small Birds[1] or Small Mammals Consuming Short Grass					
Birds: Dose Based EECs and RQs						
Size Class	Small, 20 g		Mid, 100 g		Large, 1000 g	
	EEC	RQ	EEC	RQ	EEC	RQ
Short Grass	100%	100%	57%	45%	26%	14%
Tall Grass	46%	46%	26%	21%	12%	7%
Broadleaf plants/small Insects	56%	56%	32%	25%	14%	8%
Fruits/pods/seeds/large insects	6%	6%	4%	3%	2%	1%
Granivores	1%	1%	1%	1%	0.4%	0.2%
Mammals: Dose-Based EECs and RQs						
Size Class	Small, 15 g		Mid, 35 g		Large, 1000 g	
	EEC	RQ	EEC	RQ	EEC	RQ
Short Grass	100%	100%	69%	85%	16%	46%
Tall Grass	46%	46%	32%	39%	7%	21%
Broadleaf plants/small Insects	56%	56%	39%	48%	9%	26%
Fruits/pods/seeds/large insects	6%	6%	4%	5%	1%	3%
Granivores	1%	1%	1%	1%	0.2%	0.6%

Table 6-1. Percentage of EEC or RQ for the Specified Dietary Items and Size Classes as Compared to the EEC or RQ for The Most Sensitive Dietary Items (Short Grass) and Size Class (Small Bird or Small Mammal)	
Dietary Items	**Percentage of EECs or RQs for the Specified Dietary Items and Size Class as compared to the EEC or RQ for Small Birds[1] or Small Mammals Consuming Short Grass**
Mammals and Birds: Dietary-based EECs and RQs for all Size Classes[2]	
Short Grass	100%
Tall Grass	46%
Broadleaf plants/sm Insects	56%
Fruits/pods/seeds/lg insects	6%
[1] The percents of the maximum RQ shown here for birds are based on the Agency's default avian scaling factor of 1.15. [2] Percentages for dose-based chronic EECs and RQs for mammals are equivalent to the acute dose-based EECs and RQs.	

In the risk assessment, RQs were only calculated for the most sensitive dietary class relevant to the organisms assessed. For most organisms, not enough data is available to conclude that birds or mammals may not exclusively feed on a dietary class for at least some time period. However, most birds and mammals consume a variety of dietary items and thus the RQ will overestimate risk to those organisms. For example, the CCR is estimated to consume only 15% plant material (USFWS, 2003). Additionally, some organisms will not feed on all of the dietary classes. For example, many amphibians would only consume insects and not any plant material.

6.1.1.b. T-HERPS

For foliar applications of liquid formulations, T-HERPS estimates exposure for the following dietary items: broadleaf plants/small insects, fruits/pods/seeds/large insects, small herbivore mammals, small insectivore mammals, and small amphibians. Snakes and amphibians may consume all of these items. The default size classes of amphibians represented in T-HERPS are small (2 g), medium (20 g), and large (200 g). The default vertebrate prey size that the medium and large amphibians can consume is 13 g and 133 g, respectively (small amphibians are not expected to eat vertebrate prey). The default size classes for snakes are small (2 g), medium (20 g), and large (800 g). The default vertebrate prey size that medium and large snakes can consume is 25 g and 1,286 g, respectively (small snakes are not expected to eat vertebrate prey). EECs are calculated for the most sensitive dietary item and size class for amphibians and snakes. **Table 6-2** shows the percentages of the EECs and RQs of the various dietary classes for each size class as compared to the most sensitive dietary class (herbivorous mammal) and size class [medium (20 g) amphibian or snake]. This information could be used to further characterize potential risk that is specific to the diet of amphibians and snakes.

Table 6-2. Percentage of EEC or RQ for the Specified Dietary Class as Compared to the EEC or RQ for The Most Sensitive Dietary Class (Small Herbivore Mammals) and Size Class (Medium Amphibian or Snake)

Dietary Items	Percentage of EECs or RQs for the Specified Dietary Items and Size Class as compared to the EEC or RQ for Medium Amphibians or Snakes Consuming Small Herbivore Mammals			
Amphibians: Acute Dose Based EECs and RQs				
Size Class	Small, 2 g	Mid, 20 g	Large, 200 g	
Broadleaf plants/sm Insects	5%	3%	2%	
Fruits/pods/seeds/lg insects	0.5%	0.3%	0.2%	
Small herbivore mammals	NA	100%	37%	
Small insectivore mammals	NA	6%	2%	
Small amphibians	NA	2%	1%	
Snakes: Acute Dose-Based EECs and RQs				
Size Class	Small, 2 g	Mid, 20 g	Mid, 200 g[1]	Large, 800 g
Broadleaf plants/sm Insects	3%	2%	1%	1%
Fruits/pods/seeds/lg insects	0.4%	0.2%	0.1%	0.1%
Small herbivore mammals	NA	100%	40%	23%
Small insectivore mammals	NA	6%	3%	1%
Small amphibians	NA	2%	2%	1%
Amphibians and Snakes: Acute and Chronic Dietary-based EECs and RQs for all Size Classes				
	Amphibians		Snakes	
Broadleaf plants/sm Insects	56%		73%	
Fruits/pods/seeds/lg insects	6%		8%	
Small herbivore mammals	100%		100%	
Small insectivore mammals	6%		6%	
Small amphibians	2%		2%	

[1] To provide more information, a 200 g snake (eating a 291 g prey item) was also modeled (in addition to the default body sizes).

In the risk assessment, RQs were only calculated for the most sensitive dietary class relevant to the organisms assessed. For most organisms, not enough data are available to conclude that amphibians or snakes may not exclusively feed on a dietary class for at least some time period. However, most amphibians and snakes consume a variety of dietary items and thus the RQ will overestimate risk to those organisms. Additionally, some organisms will not feed on all of the dietary classes. For example, many amphibians would only consume insects and not any plant material.

6.1.2. Exposure in Estuarine/Marine Environments

PRZM-EXAMS modeled EECs are intended to represent exposure of aquatic organisms in relatively small ponds and low-order streams. Therefore it is likely that EECs generated from the PRZM-EXAMS model will over-estimate potential concentrations in larger receiving water bodies such as estuaries, embayments, and coastal marine areas because chemicals in runoff water (or spray drift, etc.) should be diluted by a much larger volume of water than would be found in the ‘typical’ EXAMS pond. However, as chemical constituents in water draining from freshwater streams encounter brackish or other near-marine-associated conditions, there is potential for important chemical transformations to occur. Many chemical compounds can undergo changes in mobility, toxicity, or persistence when changes in pH, Eh (redox potential), salinity, dissolved oxygen (DO) content, or temperature are encountered. For example, desorption and re-mobilization of some chemicals from sediments can occur with changes in salinity (Jordan *et al.*, 2008; Means, 1995; Swarzenski *et al.*, 2003), changes in pH (*e.g.*, Wood and Baptista 1993; Parikh et al. 2004; Fernandez et al. 2005), Eh changes (Velde and Church, 1999; Wood and Baptista, 1993), and other factors. Thus, although chemicals in discharging rivers may be diluted by large volumes of water within receiving estuaries and embayments, the hydrochemistry of the marine-influenced water may negate some of the attenuating impact of the greater water volume; for example, the effect of dilution may be confounded by changes in chemical mobility (and/or bioavailability) in brackish water. In addition, freshwater contributions from discharging streams and rivers do not instantaneously mix with more saline water bodies. In these settings, water will commonly remain highly stratified, with fresh water lying atop denser, heavier saline water – meaning that exposure to concentrations found in discharging stream water may propagate some distance beyond the outflow point of the stream (especially near the water surface). Therefore, it is not assumed that discharging water will be rapidly diluted by the entire water volume within an estuary, embayment, or other coastal aquatic environment. PRZM-EXAMS model results should be considered consistent with concentrations that might be found near the head of an estuary unless there is specific information – such as monitoring data – to indicate otherwise. Conditions nearer to the mouth of a bay or estuary, however, may be closer to a marine-type system, and thus more subject to the notable buffering, mixing, and diluting capacities of an open marine environment. Conversely, tidal effects (pressure waves) can propagate much further upstream than the actual estuarine water, so discharging river water may become temporarily partially impounded near the mouth (discharge point) of a channel, and resistant to mixing until tidal forces are reversed.

The Agency does not currently have sufficient information regarding the hydrology and hydrochemistry of estuarine aquatic habitats to develop alternate scenarios for assessed listed species that inhabit these types of ecosystems. The Agency acknowledges that there are unique brackish and estuarine habitats that may not be accurately captured by PRZM-EXAMS modeling results, and may, therefore, under- or over-estimate exposure, depending on the aforementioned variables.

6.1.3. Spray Drift Modeling

It is unlikely that the same organism would be exposed to the maximum amount of spray drift from every application made. In order for an organism to receive the maximum concentration of bensulide from multiple applications, each application of bensulide would have to occur under identical atmospheric conditions (*e.g.*, same wind speed and same wind direction) and the animal or plant being exposed would have to be located in the same location, which receives the maximum amount of spray drift, after each application. Additionally, other factors, including variations in topography, cover, and meteorological conditions over the transport distance are not accounted for by the AgDRIFT model (*i.e.*, it models spray drift from ground applications in a flat area with little to no ground cover and a steady, constant wind speed and direction). Therefore, in most cases, the drift estimates from AgDRIFT may overestimate exposure, especially as the distance increases from the site of application, since the model does not account for potential obstructions (*e.g.*, large hills, berms, buildings, trees, *etc*.).

6.1.4. Degradate Exposure

Bensulide oxon is a major environmental degradate of bensulide. The total toxic residue approach was used for the aquatic exposure assessment, and the 35-day dissipation half-life was used to account for exposure to both the parent bensulide and the degradate bensulide oxon (see **Section 2.2.1**).

6.1.5. Use Patterns

Many labels do not specify parameters such as application interval, total number of applications per year, and maximum amount of bensulide that can be applied per year. In the absence of such label information, the Agency made conservative assumptions of use patterns.

6.2. Effects Assessment Uncertainties

6.2.1. Data Gaps and Uncertainties

The dataset for ecotoxicity was not complete due to missing studies or studies that provided non-definitive endpoints. Conservative assumptions were made in the absence of data for terrestrial invertebrates, chronic effects to estuarine/marine fish, and terrestrial plants. In the absence of toxicity data for the bensulide oxon, toxicity was assumed to be similar to the parent bensulide (see **Section 2.2.1**). In addition, no data were available that evaluated the chronic effects of bensulide on benthic organisms. Due to the potential for chronic risk to aquatic invertebrates inhabiting the water column, it can be assumed that the potential for chronic risk to benthic invertebrates exists as well.

6.2.2. Use of Surrogate Species Effects Data

Guideline toxicity tests and open literature data on bensulide are not available for reptiles or terrestrial-phase amphibians; therefore, birds are used as surrogate species for reptiles, terrestrial-phase amphibians, the SFGS, and the CTS. Reptiles and amphibians are poikilotherms (body temperature varies with environmental temperature) while birds are homeotherms (temperature is regulated, constant, and largely independent of environmental temperatures). Therefore, reptiles and amphibians tend to have much lower metabolic rates and lower caloric intake requirements than birds or mammals. As a consequence, birds are likely to consume more food than amphibians or reptiles. Consequently, use of avian food intake allometric equation as a surrogate for reptile and terrestrial-amphibians is likely to result in an over-estimation of exposure. Therefore, endpoints based on bird ecotoxicity data are assumed to be protective of potential direct effects to reptiles and terrestrial-phase amphibians including the SFGS and CTS, and extrapolation of the risk conclusions from the most sensitive tested species to the SFGS and CTS are likely to overestimate the potential risks to those species. The T-HERPS model attempts to account for this difference and refines the risk estimation for reptiles and terrestrial-phase amphibians.

Efforts are made to select the organisms most likely to be affected by the type of compound and usage pattern; however, there is an inherent uncertainty in extrapolating across phyla. In addition, the Agency's LOCs are intentionally set very low, and conservative estimates are made in the screening level risk assessment to account for these uncertainties.

6.2.3. Sublethal Effects

When assessing acute risk, the screening risk assessment relies on the acute mortality endpoint as well as a suite of sublethal responses to the pesticide, as determined by the testing of species response to chronic exposure conditions and subsequent chronic risk assessment. Consideration of additional sublethal data in the effects determination is exercised on a case-by-case basis and only after careful consideration of the nature of the sublethal effect measured and the extent and quality of available data to support establishing a plausible relationship between the measure of effect (sublethal endpoint) and the assessment endpoints. However, the full suite of sublethal effects from valid open literature studies is considered for the characterization purposes.

To the extent to which sublethal effects are not considered in this assessment, the potential direct and indirect effects of bensulide on listed species may be underestimated.

6.2.4. Acute LOC Assumptions

The risk characterization section of this assessment includes an evaluation of the potential for individual effects. The individual effects probability associated with the acute RQ is based on the assumption that the dose-response curve fits a probit model. It uses the mean estimate of the slope and the LC_{50} to estimate the probability of individual effects. When raw data associated with the LC_{50} is not available, a default value of 4.5 is used for the probit slope.

7. Risk Conclusions

In fulfilling its obligations under Section 7(a)(2) of the Endangered Species Act, the information presented in this endangered species risk assessment represents the best data currently available to assess the potential risks of bensulide and its degradate bensulide oxon to BCB, CCR, CFWS, CTS, DS, SFGS, TG, and VELB and their designated critical habitat.

Based on the best available information, the Agency makes a Likely to Adversely Affect determination for the BCB, CCR, CFWS, CTS (all DPS), DS, SFGS, TG, and VELB. Additionally, the Agency has determined that there is the potential for modification of the designated critical habitat for the BCB, CTS-CC, CTS-SB, DS, TG, and VELB from the use of the chemical. Given the LAA determination for the BCB, CCR, CFWS, CTS (all DPS), DS, SFGS, TG, and VELB and potential modification of designated critical habitat for the BCB, CTS-CC, CTS-SB, DS, TG, and VELB, a description of the baseline status and cumulative effects is provided in **Attachment III**.

A summary of the risk conclusions and effects determinations for the BCB, CCR, CFWS, CTS (all DPS), DS, SFGS, TG, and VELB and their critical habitat, given the uncertainties discussed in **Section 6** and **Attachment I**, is presented in **Table 7-1** and **Error! Reference source not found.**. Use-specific effects potentials are provided in **Table 7-3** and **Table 7-4**.

Table 7-1. Effects Determination Summary for Effects of Bensulide Use on the BCB, CCR, CFWS, CTS, DS, SFGS, TG, and VELB

Species	Effects Determination	Basis for Determination
Bay Checkerspot Butterfly (*Euphydryas editha bayensis*)	May affect, likely to adversely affect (LAA)	**Potential for Direct Effects**
		Terrestrial It is possible for bensulide to directly impact the BCB based on RQs exceeding the LOC for all uses of bensulide.
		Potential for Indirect Effects
		Terrestrial food items, habitat Indirect effects from impacts on food and habitat are not anticipated due RQs not exceeding the LOC for terrestrial plants inhabiting areas in which BCB inhabit (LOCs are only exceeded for plants that inhabit semi-aquatic areas, which the BCB does not inhabit).
Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus)*	May affect, likely to adversely affect (LAA)	**Potential for Direct Effects**
		Terrestrial It is possible for bensulide to directly impact the VELB based on RQs exceeding the LOC for all uses of bensulide
		Potential for Indirect Effects
		Terrestrial food items, habitat Indirect effects from impacts on food and habitat are not anticipated due RQs not exceeding the LOC for terrestrial plants inhabiting areas in which VELB inhabit (LOCs are only exceeded for plants that inhabit semi-aquatic areas, which the VELB does not inhabit).
California Tiger Salamander (All 3 DPS) (*Ambystoma californiense)*	May affect, likely to adversely affect (LAA)	**Potential for Direct Effects**
		Aquatic-phase (Eggs, Larvae, and Adults) & Terrestrial-phase (Juveniles and Adults) It is possible for bensulide to directly impact the CTS based on RQs exceeding LOCs for terrestrial-phase amphibians, using avian surrogate species data, for all uses on an acute and chronic basis. Based on RQs exceeding LOCs for aquatic-phase amphibians, using freshwater fish surrogate species data, it is possible for bensulide to directly impact the CTS on an acute basis for the following use groups: ornamental lawns and turf, canola, cole crops, leafy vegetables, row crops, melons, and the high rate for onions/bulb vegetables. On a chronic basis, it is possible for bensulide to directly impact the CTS based on the RQ for the high rate for cole crops exceeding the LOC.
		Potential for Indirect Effects
		Aquatic prey items, aquatic habitat, cover, and primary productivity & Terrestrial prey items, habitat Indirect effects from impacts on prey are possible based on RQs exceeding LOCs for terrestrial-phase amphibians (for all uses), using avian surrogate species data, mammals (for all uses), terrestrial invertebrates (for all uses), freshwater fish (for ornamental lawns and turf, canola, cole crops, leafy vegetables, row crops, melons, and the high rate for onions/bulb vegetables on an acute basis; for the high rate for cole crops on a chronic basis), freshwater invertebrates (for all uses except residential lawns and the low rate for onions/bulb vegetables on an acute basis; for all uses on a chronic

Table 7-1. Effects Determination Summary for Effects of Bensulide Use on the BCB, CCR, CFWS, CTS, DS, SFGS, TG, and VELB		
Species	**Effects Determination**	**Basis for Determination**
		basis) and aquatic plants (for the high rate for canola, medium and high rate for cole crops, leafy vegetables, and the high rate for row crops). Indirect effects from impacts on habitat are possible due to effects on aquatic and terrestrial plants and mammal burrow availability. Small mammals are essential in creating the underground habitat that juvenile and adult CTS depend upon for food, shelter, and protection from the elements and predation.
California Clapper Rail (*Rallus longirostris obsoletus*)	May affect, likely to adversely affect (LAA)	**Potential for Direct Effects**
		Terrestrial It is possible for bensulide to directly impact the CCR based on RQs exceeding LOCs for avian species for all uses on an acute and chronic basis.
		Potential for Indirect Effects
		Aquatic prey items, aquatic habitat, cover, and primary productivity & Terrestrial prey items, riparian habitat Indirect effects from impacts on prey are possible based on RQs exceeding LOCs for birds, mammals, and terrestrial invertebrates for all uses. Indirect effects from impacts on prey are also possible based on RQs exceeding LOCs for aquatic plants (for the high rate for canola, medium and high rate for cole crops, leafy vegetables, and the high rate for row crops), terrestrial plants (for all uses for monocots), freshwater fish (for ornamental lawns and turf, canola, cole crops, leafy vegetables, row crops, melons, and the high rate for onions/bulb vegetables on an acute basis; for the high rate for cole crops on a chronic basis), estuarine/marine fish (for all uses except the low rate for onions/bulb vegetables on an acute basis; for all uses on a chronic basis), freshwater invertebrates (for all uses except residential lawns and the low rate for onions/bulb vegetables on an acute basis; for all uses on a chronic basis), and estuarine/marine invertebrates (for all uses on an acute basis; for all uses except golf course turf, residential lawns, the low rate for row crops, fruiting vegetables, and the low rate for onions/bulb vegetables on a chronic basis). Indirect effects from impacts on habitat are possible due to RQs exceeding the LOC for aquatic plants (for the high rate for canola, medium and high rate for cole crops, leafy vegetables, and the high rate for row crops) and terrestrial plants (for all uses for monocots).
California Freshwater Shrimp (*Syncaris pacifica*)	May affect, likely to adversely affect (LAA)	**Potential for Direct Effects**
		Aquatic It is possible for bensulide to directly impact the CFWS based on RQs exceeding LOCs for freshwater invertebrates for all uses except residential lawns and the low rate for onions/bulb vegetables on an acute basis and for all uses on a chronic basis
		Potential for Indirect Effects
		Aquatic prey items, habitat, cover, and primary productivity & Terrestrial prey items, riparian habitat Indirect effects from impacts on prey are possible based on RQs exceeding LOCs for freshwater invertebrates (for all uses except residential lawns and the low rate for onions/bulb vegetables on an acute basis; for all uses on a chronic basis), aquatic plants (for the high rate for canola, medium and high rate for cole crops, leafy vegetables, and the high rate for row crops), and terrestrial plants (for all uses for monocots). Indirect effects from impacts on

Table 7-1. Effects Determination Summary for Effects of Bensulide Use on the BCB, CCR, CFWS, CTS, DS, SFGS, TG, and VELB		
Species	**Effects Determination**	**Basis for Determination**
		habitat are also possible due to RQs exceeding the LOC for aquatic plants (for the high rate for canola, medium and high rate for cole crops, leafy vegetables, and the high rate for row crops) and terrestrial plants (for all uses for monocots).
Delta Smelt	May affect, likely to adversely affect (LAA)	**Potential for Direct Effects**
		Aquatic It is possible for bensulide to directly impact the DS based on RQs exceeding LOCs for freshwater fish (for ornamental lawns and turf, canola, cole crops, leafy vegetables, row crops, melons, and the high rate for onions/bulb vegetables on an acute basis; for the high rate for cole crops on a chronic basis) and estuarine/marine fish (for all uses except the low rate for onions/bulb vegetables on an acute basis; for all uses on a chronic basis).
		Potential for Indirect Effects
		Aquatic prey items, habitat, cover, and primary productivity & Terrestrial riparian habitat Indirect effects from impacts on prey are possible based on RQs exceeding LOCs for freshwater invertebrates (for all uses except residential lawns and the low rate for onions/bulb vegetables on an acute basis; for all uses on a chronic basis), estuarine/marine invertebrates (for all uses on an acute basis; for all uses except golf course turf, residential lawns, the low rate for row crops, fruiting vegetables, and the low rate for onions/bulb vegetables on a chronic basis), and aquatic plants (for the high rate for canola, medium and high rate for cole crops, leafy vegetables, and the high rate for row crops). Indirect effects from impacts on habitat are also possible due to RQs exceeding the LOC for aquatic plants (for the high rate for canola, medium and high rate for cole crops, leafy vegetables, and the high rate for row crops) and terrestrial plants (for all uses for monocots).
San Francisco Garter Snake (*Thamnophis sirtalis tetrataenia*)	May affect, likely to adversely affect (LAA)	**Potential for Direct Effects**
		Terrestrial It is possible for bensulide to directly impact the SFGS based on RQs exceeding the LOC for reptiles, using avian surrogate species data, for all uses on an acute and chronic basis.
		Potential for Indirect Effects
		Aquatic prey items, aquatic habitat, cover, and primary productivity& Terrestrial prey items, riparian habitat Indirect effects from impacts on prey are possible based on RQs exceeding LOCs for terrestrial-phase amphibians and reptiles (for all uses), using avian surrogate species data, mammals (for all uses), terrestrial invertebrates (for all uses), freshwater fish and aquatic-phase amphibians (for ornamental lawns and turf, canola, cole crops, leafy vegetables, row crops, melons, and the high rate for onions/bulb vegetables on an acute basis; for the high rate for cole crops on a chronic basis), and freshwater invertebrates (for all uses except residential lawns and the low rate for onions/bulb vegetables on an acute basis; for all uses on a chronic basis). Indirect effects from impacts on habitat are also possible due to effects on aquatic and terrestrial plants and mammal burrow availability. SFGS rely on the burrows of small mammals for shelter and aestivation.
Tidewater Goby		**Potential for Direct Effects**

Table 7-1. Effects Determination Summary for Effects of Bensulide Use on the BCB, CCR, CFWS, CTS, DS, SFGS, TG, and VELB		
Species	**Effects Determination**	**Basis for Determination**
	May affect, likely to adversely affect (LAA)	***Aquatic*** It is possible for bensulide to directly impact the TG based on RQs exceeding LOCs for freshwater fish (for ornamental lawns and turf, canola, cole crops, leafy vegetables, row crops, melons, and the high rate for onions/bulb vegetables on an acute basis; for the high rate for cole crops on a chronic basis) and estuarine/marine fish (for all uses except the low rate for onions/bulb vegetables on an acute basis; for all uses on a chronic basis).
		Potential for Indirect Effects
		Aquatic prey items, aquatic habitat, cover, and primary productivity & Terrestrial riparian habitat Indirect effects from impacts on prey are possible based on RQs exceeding LOCs for freshwater invertebrates (for all uses except residential lawns and the low rate for onions/bulb vegetables on an acute basis; for all uses on a chronic basis), estuarine/marine invertebrates (for all uses on an acute basis; for all uses except golf course turf, residential lawns, the low rate for row crops, fruiting vegetables, and the low rate for onions/bulb vegetables on a chronic basis), and aquatic plants (for the high rate for canola, medium and high rate for cole crops, leafy vegetables, and the high rate for row crops). Indirect effects from impacts on habitat are also possible due to RQs exceeding the LOC for aquatic plants (for the high rate for canola, medium and high rate for cole crops, leafy vegetables, and the high rate for row crops) and terrestrial plants (for all uses for monocots).

Table 7-2. Effects Determination Summary for the Critical Habitat Impact Analysis		
Species with Designated Critical Habitat	**Effects Determination**	**Basis for Determination**
Bay Checkerspot Butterfly	Habitat modification	Impacts on habitat are not anticipated due to RQs not exceeding the LOC for terrestrial plants inhabiting areas in which BCB inhabit (*i.e.*, LOCs are only exceeded for plants that inhabit semi-aquatic areas, which the BCB does not inhabit). However, direct effects to the BCB are possible. There is overlap between the areas of the LAA effects determination for bensulide and BCB range.
California Tiger Salamander Central California Distinct Population Segment	Habitat modification	Impacts on habitat are possible due to RQs exceeding LOCs for aquatic and terrestrial plants and mammal burrow availability. Small mammals are essential in creating the underground habitat that juvenile and adult CTS depend upon for food, shelter, and protection from the elements and predation. There is overlap between the areas of the LAA effects determination for bensulide and CTS range.
California Tiger Salamander Santa Barbara County Distinct Population Segment	Habitat modification	Impacts on habitat are possible due to RQs exceeding LOCs for aquatic and terrestrial plants and mammal burrow availability. Small mammals are essential in creating the underground habitat that juvenile and adult CTS depend upon for food, shelter, and protection from the elements and predation. There is overlap between the areas of the LAA effects determination for bensulide and CTS range.
Delta Smelt	Habitat modification	Impacts on habitat are possible based on RQs exceeding LOCs for aquatic and terrestrial plants. There is overlap between the areas of the LAA effects determination for bensulide and the DS range.

Table 7-2. Effects Determination Summary for the Critical Habitat Impact Analysis		
Species with Designated Critical Habitat	**Effects Determination**	**Basis for Determination**
Tidewater Goby	Habitat modification	Impacts on habitat are possible based on RQs exceeding LOCs for aquatic and terrestrial plants. There is overlap between the areas of the LAA effects determination for bensulide and the TG range.
Valley Elderberry Longhorn Beetle	Habitat modification	Impacts on habitat are not anticipated due to RQs not exceeding the LOC for terrestrial plants inhabiting areas in which VELB inhabit (*i.e.*, LOCs are only exceeded for plants that inhabit semi-aquatic areas, which the VELB does not inhabit). However, direct effects to the VELB are possible. There is overlap between the areas of the LAA effects determination for bensulide and VELB range.

Table 7-3. Use Specific Summary of the Potential for Adverse Effects to Aquatic Taxa

Use & Application Rate	Potential for Effects to Identified Taxa Found in the Aquatic Environment: DS, TG, and Estuarine/Marine Vertebrates[1]		CTS (all DPS), DS, TG, and Freshwater Vertebrates[2]		CFWS and Freshwater Invertebrates[3]		Estuarine/Marine Invertebrates[4]		Vascular Plants[5]	Non-vascular Plants[5]
	Acute	**Chronic**	**Acute**	**Chronic**	**Acute**	**Chronic**	**Acute**	**Chronic**		
CA Turf RLF (golf course turf for use on tees, greens, and bentgrass fairways only) 2 apps @ 16 lb a.i./acre (120 days) Granular	**Yes***	**Yes**	No	No	**Yes***	**Yes**	**Yes***	No	No	No
CA Turf RLF (ornamental lawns and turf) 2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	**Yes***	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	**Yes**	No	No
CA Turf RLF (golf course turf for use on tees, greens, and bentgrass fairways only) 2 apps @ 12.5 lb a.i./acre (120 days) Emulsifiable Concentrate	**Yes***	**Yes**	No	No	**Yes***	**Yes**	**Yes***	No	No	No
CA Residential RLF (residential lawns) 2 apps @ 12.6 lb a.i./acre (120 days) Granular	**Yes***	**Yes**	No	No	No	**Yes**	**Yes***	No	No	No
CA Residential RLF (residential lawns) 2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	**Yes***	**Yes**	No	No	No	**Yes**	**Yes***	No	No	No
CA Wheat (canola) 3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	**Yes**	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	**Yes**	**Yes**	No
CA Wheat (canola) 2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	**Yes***	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	**Yes**	No	No
CA Wheat (canola) 1 app @ 6 lb a.i./acre	**Yes***	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	**Yes**	No	No

Table 7-3. Use Specific Summary of the Potential for Adverse Effects to Aquatic Taxa										
Use & Application Rate	Potential for Effects to Identified Taxa Found in the Aquatic Environment:									
	DS, TG, and Estuarine/Marine Vertebrates[1]		CTS (all DPS), DS, TG, and Freshwater Vertebrates[2]		CFWS and Freshwater Invertebrates[3]		Estuarine/Marine Invertebrates[4]		Vascular Plants[5]	Non-vascular Plants[5]
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic		
Emulsifiable Concentrate										
CA Cole Crop RLF (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) 3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	No
CA Cole Crop RLF (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) 2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	**Yes**	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	**Yes**	**Yes**	No
CA Cole Crop RLF (*Brassica* (head and stem) vegetables, broccoli, broccoli raab, Brussels sprouts, cabbage, cauliflower, cole crops, collards, cress (garden, upland), kale, kohlrabi, mustard, mustard cabbage) 1 app @ 6 lb a.i./acre Emulsifiable Concentrate	**Yes***	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	**Yes**	No	No
CA Lettuce No-irrig. (corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula)) 2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	**Yes**	**Yes**	**Yes***	No	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	No
CA Lettuce No-irrig.	**Yes***	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	**Yes**	**Yes**	No

Table 7-3. Use Specific Summary of the Potential for Adverse Effects to Aquatic Taxa										
Use & Application Rate	Potential for Effects to Identified Taxa Found in the Aquatic Environment:									
	DS, TG, and Estuarine/Marine Vertebrates[1]		CTS (all DPS), DS, TG, and Freshwater Vertebrates[2]		CFWS and Freshwater Invertebrates[3]		Estuarine/Marine Invertebrates[4]		Vascular Plants[5]	Non-vascular Plants[5]
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic		
(corn salad, leafy vegetables, greens, chicory/radicchio, dandelion, dock (sorrel), endive, lettuce (head, leaf), orach (mountain spinach), spinach, Swiss chard, fennel, roquette (arugula)) 1 app @ 6 lb a.i./acre Emulsifiable Concentrate										
CA Row Crop RLF (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) 3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	**Yes**	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	**Yes**	**Yes**	No
CA Row Crop RLF (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) 2 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	**Yes***	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	**Yes**	No	No
CA Row Crop RLF (artichokes, beans, beet, cardoon, celery, celtuce, chervil, chrysanthemum (garland), fennel, okra, parsley, peas) 1 app @ 6 lb a.i./acre Emulsifiable Concentrate	**Yes***	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	No	No	No
CA Melon RLF (cantaloupe, chayote, cucumber, cucurbit vegetables, cucuzzi, gherkin, gourds, gourd (wax), melons (bitter, honeydew, citron, mango, musk, water, winter melons), pepino, pumpkin, squash (butternut, summer, zucchini squash)) 2 apps @ 9 lb a.i./acre (120 days) Emulsifiable Concentrate	**Yes***	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	**Yes**	No	No

Table 7-3. Use Specific Summary of the Potential for Adverse Effects to Aquatic Taxa										
Use & Application Rate	**Potential for Effects to Identified Taxa Found in the Aquatic Environment:**									
	DS, TG, and Estuarine/Marine Vertebrates[1]		**CTS (all DPS), DS, TG, and Freshwater Vertebrates[2]**		**CFWS and Freshwater Invertebrates[3]**		**Estuarine/Marine Invertebrates[4]**		**Vascular Plants[5]**	**Non-vascular Plants[5]**
	Acute	**Chronic**	**Acute**	**Chronic**	**Acute**	**Chronic**	**Acute**	**Chronic**		
CA Melon RLF (cantaloupe, chayote, cucumber, cucurbit vegetables, cucuzzi, gherkin, gourds, gourd (wax), melons (bitter, honeydew, citron, mango, musk, water, winter melons), pepino, pumpkin, squash (butternut, summer, zucchini squash)) 1 app @ 9 lb a.i./acre Emulsifiable Concentrate	**Yes***	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	**Yes**	No	No
CA Tomato No-irrig. (bell pepper, eggplant, groundcherry (strawberry tomato/tomatillo), pepper, pepper (chili), pimento) 1 app @ 6 lb a.i./acre Emulsifiable Concentrate	**Yes***	**Yes**	No	No	**Yes***	**Yes**	**Yes***	No	No	No
CA Onion No-Irrig. (garlic, onion (dry bulb and green), radish, shallot) 3 apps @ 6 lb a.i./acre (120 days) Emulsifiable Concentrate	**Yes***	**Yes**	**Yes***	No	**Yes***	**Yes**	**Yes**	**Yes**	No	No
CA Onion No-Irrig. (garlic, onion (dry bulb and green), radish, shallot) 1 app @ 6 lb a.i./acre Emulsifiable Concentrate	No	**Yes**	No	No	No	**Yes**	**Yes***	No	No	No

[1] A yes in this column also indicates a potential for indirect effects to CCR. Chronic risk conservatively assumed in the absence of data based on one exceeding chronic RQ for freshwater fish and slight increased acute toxicity of bensulide to estuarine/marine fish compared to freshwater fish.
[2] A yes in this column also indicates a potential for indirect effects to CCR, CTS (all DPS), and SFGS.
[3] A yes in this column also indicates a potential for indirect effects to CCR, CFWS, CTS (all DPS), DS, SFGS, and TG.
[4] A yes in this column also indicates a potential for indirect effects to CCR, DS, and TG.
[5] A yes in this column also indicates a potential for indirect effects to CCR, CFWS, CTS (all DPS), DS, SFGS, and TG.
* RQ exceeds the LOC for listed species but not for non-listed species. LOCs are 0.05 for acute risk to listed aquatic species, 0.5 for acute risk to non-listed aquatic species, 1.0 for chronic risk to all aquatic species, and 1.0 for risk to aquatic plants.

Table 7-4. Use Specific Summary of the Potential for Adverse Effects to Terrestrial Taxa											
Uses	**Potential for Effects to Identified Taxa Found in the Terrestrial Environment:**										
	Small Mammals[1]		**CCR and Small Birds[2]**		**CTS (all DPS) and Amphibians[3]**		**SFGS and Reptiles[4]**		**BCB, VELB, and Invertebrates (Acute)[5]**	**Dicots[6]**	**Monocots[6]**
	Acute	**Chronic**	**Acute**	**Chronic**	**Acute**	**Chronic**	**Acute**	**Chronic**			
All Uses	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	No	**Yes+**

[1] A yes in this column indicates a potential for indirect effects to CCR, CTS (all DPS), and SFGS.
[2] A yes in this column also indicates a potential for indirect effects to the CCR, CTS (all DPS), and SFGS.
[3] A yes in this column also indicates a potential indirect effects to CCR, CTS (all DPS), and SFGS. .
[4] A yes in this column also indicates the potential for direct and indirect effects to SFGS.
[5] A yes in this column also indicates a potential for indirect effects to CCR, CTS (all DPS), and SFGS.
[6] A yes in this column indicates a potential for indirect effects to BCB, CCR, CFWS, CTS (all DPS), DS, SFGS, TG, and VELB. For the BCB and VELB, this is based on the listed species LOC because of the obligate relationship with terrestrial monocots and dicots. For other species, the LOC exceedances are evaluated based on the LOC for non-listed species.
*LOCs are 0.05 for acute risk to listed terrestrial invertebrates, 0.1 for acute risk to other listed terrestrial species, 0.5 for acute risk to non-listed terrestrial species, 1.0 for chronic risk to all terrestrial species, and 1.0 for risk to terrestrial plants.
+LOCs exceeded for listed monocots in semi-aquatic areas only.

Based on the conclusions of this assessment, a formal consultation with the U. S. Fish and Wildlife Service under Section 7 of the Endangered Species Act should be initiated.

When evaluating the significance of this risk assessment's direct/indirect and adverse habitat modification effects determinations, it is important to note that pesticide exposures and predicted risks to the listed species and its resources (*i.e.*, food and habitat) are not expected to be uniform across the action area. In fact, given the assumptions of drift and downstream transport (*i.e*., attenuation with distance), pesticide exposure and associated risks to the species and its resources are expected to decrease with increasing distance away from the treated field or site of application. Evaluation of the implication of this non-uniform distribution of risk to the species would require information and assessment techniques that are not currently available. Examples of such information and methodology required for this type of analysis would include the following:

- Enhanced information on the density and distribution of BCB, CCR, CFWS, CTS (all DPS), DS, SFGS, TG, and VELB life stages within the action area and/or applicable designated critical habitat. This information would allow for quantitative extrapolation of the present risk assessment's predictions of individual effects to the proportion of the population extant within geographical areas where those effects are predicted. Furthermore, such population information would allow for a more comprehensive evaluation of the significance of potential resource impairment to individuals of the assessed species.
- Quantitative information on prey base requirements for the assessed species. While existing information provides a preliminary picture of the types of food sources utilized by the assessed species, it does not establish minimal requirements to sustain healthy individuals at varying life stages. Such information could be used to establish biologically relevant thresholds of effects on the prey base, and ultimately establish geographical limits to those effects. This information could be used together with the density data discussed above to characterize the likelihood of adverse effects to individuals.
- Information on population responses of prey base organisms to the pesticide. Currently, methodologies are limited to predicting exposures and likely levels of direct mortality, growth or reproductive impairment immediately following exposure to the pesticide. The degree to which repeated exposure events and the inherent demographic characteristics of the prey population play into the extent to which prey resources may recover is not predictable. An enhanced understanding of long-term prey responses to pesticide exposure would allow for a more refined determination of the magnitude and duration of resource impairment, and together with the information described above, a more complete prediction of effects to individual species and potential modification to critical habitat.

8. References

A bibliography of ECOTOX references, identified by the letter E followed by a number, is located in **Appendix H**.

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