Risks of Diazinon Use to Federally Threatened Delta Smelt (*Hypomesus transpacificus*) and the Federally Endangered Tidewater Goby (*Eucyclogobius newberryi*)

Pesticide Effects Determinations
PC Code: 057801
CAS Number: 333-41-5

Environmental Fate and Effects Division
Office of Pesticide Programs
Washington, D.C. 20460

March 28, 2012

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List of Commonly Used Abbreviations and Nomenclature

μg/kg	Symbol for "micrograms per kilogram"
$\mu g \cdot L^{-1}$	Symbol for "micrograms per liter"
ºC	Symbol for "degrees Celsius"
a.i.	Active Ingredient
AIMS	Avian Information Monitoring System
Acc#	Accession Number
BCF	Bioconcentration Factor
BEAD	Biological and Economic Analysis Division
Bw	Body Weight
CAM	Chemical Application Method
CARB	California Air Resources Board
CBD	Center for Biological Diversity
CDPR	California Department of Pesticide Regulation
CDPR-PUR	California Department of Pesticide Regulation Pesticide Use Reporting Database
CI	Confidence Interval
CL	Confidence Limit
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")
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
Ft	Feet
HPLC	High Pressure Liquid Chromatography

i.e.	Latin for *id est* ("that is")
IECV1.1	Individual Effect Chance Model Version 1.1
Kg	Kilogram(s)
kJ/mole	Kilojoules per mole
Km	Kilometer(s)
K_{AW}	Air-water Partition Coefficient
K_d	Solid-water Distribution Coefficient
K_f	Freundlich Solid-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
LOC	Level of Concern
LOD	Level of Detection
LOEC	Lowest Observable Effect Concentration
LOQ	Level of Quantitation
M	Meter(s)
MA	May Affect
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
n/a	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
NOEC	No Observable Effect Concentration
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
pK_a	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
SLN	Special Local Need
TG	Tidewater Goby
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
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 on the delta smelt (*Hypomesus transpacificus*, DS) and the tidewater goby (*Eucyclogobius newberryi*, TG) arising from FIFRA regulatory actions regarding use of diazinon on agricultural and non-agricultural sites. In addition, this assessment evaluates whether these actions can be expected to result in modification of designated critical habitats for the DS and the TG. This assessment was completed in accordance with the United States 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, 2004c), and consistent with a stipulated injunction ordered by the Federal District Court for the Northern District of California in the case Center for Biological Diversity (CBD) vs. EPA *et al.* (Case No. 07-2794-JCS).

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 TG was listed as endangered on March 7, 1994 (59 FR 5494) by the USFWS. TG are found primarily in waters of coastal lagoons, estuaries, and marshes. 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 occur in freshwater streams up gradient and tributary to brackish habitats (68920 FR Vol 71, No 228).

1.2. Scope of Assessment

1.2.1. Uses Assessed

Diazinon is an organophosphate insecticide. Formulation types registered include wettable powder, emulsifiable concentrate, soluble concentrate, and insecticide cattle tag. Currently, labeled uses of diazinon include several fruit, nut, vegetable crops, ornamental nursery stock, and cattle ear tags. The following uses are considered as part of the federal action evaluated in this assessment:

Agricultural Uses: almonds, apple, cherry, pear, apricot, nectarine, plum, prune, peach, succulent beans, lima beans, beans, snap beans, beets, blackberry, caneberry, boysenberry, dewberry, loganberry, raspberry, blueberry, broccoli, Brussel sprouts, cabbage, cauliflower, collard, kale, mustard, carrot, peas, pepper, fig, endive, spinach, lettuce, garlic, leek, musk melon, water melon, winter melon, honeydew melon, cantaloupe, onion, green onion, scallions, spring onion, radish, shallot, rutabaga, strawberry, tomato, and cattle ear tags.

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

Nursery Stock: herbaceous ornamentals, nonflowering ornamentals, woody shrubs and vines, ornamental trees, and shade trees, and miscellaneous nursery stock to control fruit flies[2]

Uses of diazinon on cranberry, pineapple, filbert, and watercress are not relevant to this assessment, since these crops are not grown in California or diazinon use in California is not allowed on that crop. Use as cattle ear tags are assumed to have minimal releases to the environment.

1.2.2. Environmental Fate Properties of Diazinon

Diazinon is moderately soluble (40 mg/L), semi-volatile (vapor pressure = 6.6×10^{-5} torr), and has a moderate log K_{ow} (3.69 to 3.85) (**Table 2-1**). The primary route of degradation depends on environmental conditions. Hydrolysis in water occurs on the order of weeks to months depending on pH. At pH 5, 7, and 9 the hydrolysis half-lives were 13, 139, and 77 days, respectively. Supplemental data on aqueous and soil photolysis indicate that diazinon is likely to undergo photolysis in aqueous and soil systems. Aerobic and anaerobic metabolism half-lives range from 6 to 39 days. Definitive sorption coefficients are not available; however, EPIWEB version 4.1 predicts a K_{oc} of 2,184 L/kg organic carbon indicating it is slightly mobile according to the FAO classification system (FAO, 2000).[3] Substantial fractions of applied diazinon could be available for runoff for several months post-application. A complete discussion of the environmental fate of diazinon is available in Section 2.5.

The environmental fate properties of diazinon along with monitoring data identifying its presence in surface waters, air, and in precipitation in California indicate that runoff, spray drift, volatilization, atmospheric transport and subsequent deposition represent potential transport mechanisms of diazinon to the aquatic habitats of the DS and TG. In this assessment, transport of diazinon from initial application sites through runoff and spray drift are considered in deriving quantitative estimates of diazinon exposure to DS and TG, their forage and their habitats. Although volatilization of diazinon from treated areas resulting in atmospheric transport and eventual deposition represent relevant transport pathways leading to exposure of the DS and the TG and their habitats, adequate tools are not available at this time to fully estimate exposures through these pathways. These pathways are expected to result in much lower exposure than exposure to diazinon from runoff and spray drift; however, these pathways may still result in exposure at levels that have the potential to be a risk concern (see Section 6.1.1.a). Volatilization, atmospheric transport and wet and dry deposition from the atmosphere are not included in the calculation of risk quotients but are considered in the characterization of risk and in the uncertainties discussion.

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[2] A special local needs label (CA-5002) is registered to the California Department of Food and Agriculture, to be used for fruit fly pests and is subject to State quarantine action on ornamental tree fruit nursery stock and ornamental nursery stock.

[3] For pesticides that do not contain metals, fluorine atoms, 1,2-4-triazole groups, and/or aromatic amines and do not have a pKa between 5 and 9, EPISUITE predicted K_{OC} values are within a factor of ten of experimental values 85% of the time (USEPA 2006a).

1.2.3. Evaluation of Degradates and Stressors of Concern

Degradates of diazinon include:

- oxypyrimidine (2-isopropyl-4-methyl-6-hydroxypyrimidine)
- diazoxon (Diethyl 2-isopropyl-6-methyl-4-pyrimidinyl phosphate)
- GS-3114 (2-(2-Hydroxy-2-propanyl)-6-methyl-4(1H)-pyrimidinone)
- demethyl oxypyrimidine

Comparison of available toxicity information for oxypyrimidine indicates lesser aquatic toxicity than the parent for freshwater and estuarine/marine fish, invertebrates, aquatic plants and birds. Diazinon aquatic acute toxicity endpoints for the rainbow trout, water flea, and green algae range from 0.00021 to 3.7 mg/L while the corresponding endpoints for oxypyrimidine range from >101 to > 109 mg/L (**Table 4-5**). Because oxypyrimidine is not of greater or equal toxicological concern compared to diazinon, concentrations of this degradate are not assessed further. Demethyl oxypyrimidine and GS-3114 have a similar structures to oxypyrimidine and were also assumed to be less toxic than parent diazinon. Additionally, GS-3114 and demethyl oxypyrimidine are minor degradates that were observed intermittently in fate studies and they do not contain the organophosphorus functional group.

Data are not available on diazoxon for fish. Available data indicate that diazoxon is an order of magnitude more toxic to aquatic amphibians than the parent compound (Sparling and Fellers, 2007, E92498). Diazoxon acute and subacute toxicity testing with birds indicate that the compound is minimally as toxic (LD_{50}=4.99 mg a.i./kg bw) (Rodgers 2005e; MRID 46579604) as the parent (LD_{50}= 5.2 mg a.i./kg bw) on an acute oral exposure basis and is more toxic (LC_{50} = 72 mg a.i./kg diet) (Rodgers 2005f; MRID 46579602) than the parent (LC_{50}=245 mg a.i./kg diet) on a subacute dietary exposure basis (**Table 4-5**). Submitted laboratory environmental fate studies for diazinon do not identify diazoxon as a degradate; however, it was detected near the limit of quantitation in some terrestrial field dissipation studies. The diazoxon concentrations detected in the submitted field studies are likely low as the storage stability studies indicated diazoxon was not stable in stored samples. Additionally, diazoxon has been detected in precipitation samples in California, indicating that it is formed in the atmosphere; resulting in the potential for atmospheric deposition of diazoxon to aquatic habitats of the DS and TG. As discussed above, tools are unavailable at this time to quantify exposures through atmospheric transport and deposition. Diazoxon is expected to be transported to DS and TG habitats through atmospheric deposition and possibly through runoff. Due to the limited data available on diazoxon and lack of standard methodologies for assessing exposure due to deposition of semivolatile pesticides, exposures of DS and TG to diazoxon are considered in the uncertainties section of this document. Diazinon alone is considered in quantifying RQs.

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

As described above, DS and TG are aquatic organisms. Tier 2 aquatic exposure models are used to estimate high-end exposures of diazinon in aquatic habitats resulting from runoff and spray drift from different uses. The models used to predict aquatic EECs are the Pesticide Root Zone Model (PRZM) coupled with the Exposure Analysis Model System (EXAMS). Default spray drift values of 5%, 3%, and 1% of the application rate were used for aerial, airblast, and ground applications, respectively. The associated default application efficiency for aerial spray was 95%. The default application efficiency for airblast and ground sprays is 99%. These loadings were used as inputs to EXAMS, added to the run off loads generated by PRZM. As estimated using PRZM and EXAMS, one-in-ten year peak EECs resulting from different diazinon uses range from 0.14 µg/L for figs to 496 µg/L. The highest EECs were estimated for the transplant use of diazinon on a per plant basis for cole crops. These estimates are supplemented with analysis of available California surface water monitoring data from United States Geological Survey's (USGS) National Water Quality Assessment (NAWQA) program and the California Department of Pesticide Regulation (CDPR). Detections of diazinon have occurred throughout the United States, and it is one of the most frequently detected insecticides in surface water in the NAWQA program. Diazinon was detected in every major river basin in the USGS National National Stream Quality Accounting Network (NASQAN) study. Diazinon has also been detected in ground water, precipitation, and sediment (Section 3.4). The maximum concentration of diazinon reported by NAWQA for California surface waters with agricultural watersheds is 3.8 µg/L (0.36 µg/L after 2003), which is within the range of EECs for the different crops evaluated. The maximum concentration of diazinon reported by the CDPR surface water database (46.6 µg/L) is of the same order of magnitude as some of the highest modeled concentrations. After 2003, the highest measured concentration in the CDPR and NAWQA dataset was 4.3 µg/L.

1.3.1.b. Terrestrial Exposures

Terrestrial plants are an important component in all four primary constituent elements (PCEs) of DS and TG critical habitat, particularly for providing shade, and thus, temperature control, and in mitigating runoff and sedimentation, which also affect water quality. The TerrPlant model is used to estimate diazinon exposures to plants inhabiting semi-aquatic and dry areas, resulting from uses involving foliar and granular diazinon applications. Terrestrial EECs for plants range from 0.16 to 0.56 lbs a.i./A for single applications with application rates ranging from 0.77 to 4.10 lbs a.i./A.

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 habitats have been established for the DS and TG. Primary PCEs were used to evaluate whether diazinon has the potential to modify designated critical habitats. The Agency evaluated registrant-submitted studies and data from the open literature to characterize diazinon toxicity. 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 habitats was used.

Section 4 summarizes the ecotoxicity data available on diazinon. Diazinon is very highly toxic to freshwater and estuarine/marine fish and is very highly toxic to aquatic invertebrates on an acute exposure basis. Chronic exposure to diazinon resulted in decreased growth and reproduction in freshwater fish and decreased survival in freshwater invertebrates. No toxicity data are available for determining the effects of diazinon on vascular aquatic plants; however, data on one aquatic nonvascular plant species (EC_{50} of 3,700 µg/L; MRID 40509806) suggests that aquatic plants are not particularly sensitive to diazinon.

1.3.3. Measures of Risk

Acute and chronic risk quotients (RQs) are compared to the Agency's Levels of Concern (LOCs) to identify instances where diazinon 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 diazinon 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 diazinon to DS and TG and their designated critical habitat.

Based on the best available information, the Agency makes a 'Likely to Adversely Affect' determination for the DS and TG. Additionally, the Agency has determined that there is the potential for modification of the designated critical habitat for the DS and TG from the use of the chemical. Given the LAA determination for DS and TG and potential modification of designated critical habitat for this species, a description of the baseline status and cumulative effects is provided in **Attachment III**.

A summary of the risk conclusions and effects determinations for DS and TG 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 determinations are provided in **Table 1-3**.

Table 1-1. Effects Determination Summary for Effects of Diazinon on the Delta Smelt and Tidewater Goby

Species	Effects Determination	Basis for Determination
Delta smelt (*Hypomesus transpacificus*) and Tidewater Goby (*Eucyclogobius newberryi*)	May Affect, Likely to Adversely Affect (LAA)	**Potential for Direct Effects** Using fish toxicity data for rainbow trout (*Oncorhynchus mykiss*), brook trout (*Salvelinus fontinalis*), sheepshead minnow (*Cyprinodon variegates*), and striped mullet (*Mugil cephalus*) and modeled [estimated] environmental concentrations (EECs), risk could not be precluded for any of the assessed uses due to the potential for chronic effects. Additionally, likelihood of acute effects (mortality) could not be precluded for uses on almonds, tree fruit, beans, row crops, dormant use on berries, cole crops, leafy vegetables, lettuce, garlic and leek, melons with 26 applications, onions, strawberry, and tomato. **Potential for Indirect Effects** ***Aquatic prey items, aquatic habitat, cover and/or primary productivity*** Using toxicity data representing freshwater (*Ceriodaphnia dubia*) and estuarine invertebrates (mysid shrimp; *Americamysis bahia*) and modeled exposures, risks could not be precluded based on acute and chronic effects to prey items for all use patterns. This includes risk to benthic invertebrates. Available data on one species of non-vascular aquatic plants (green algae; *Pseudokirchneriella subcapitata*) suggests that risk to dietary items for young DS and TG and to non-vascular plants important for maintaining aquatic habitat is not likely because risk quotients did not exceed LOCs. Based on the mode of action of diazinon not being particularly toxic to plants, results from mesocosm studies, and the lack of incidents reported for aquatic plants; the likelihood of adverse effects on aquatic plants is considered low. ***Terrestrial prey items, riparian habitat*** RQs for terrestrial plants for transplant applications to cole crops exceeded the LOC for dicots and could exceed the LOC for monocots whose available endpoint is a greater than value, indicating there is a potential for risk to terrestrial plants for the transplant per plant rate for cole crops. RQs for all other uses were less than 1.0 and risk to terrestrial plants is not expected for any other use.[1]

[1] The risk to terrestrial plants was identified for a transplant use on cole crops. The application rate on the label is on a per plant basis and application rate on a lbs a.i./A was estimated based on the maximum number of plants that may be planted in an acre resulting in a very high application rate of 116 lbs a.i./A. This high application rate may not commonly occur. The application rate would need to be reduced to an equivalent of 26 lbs a.i./A to reduce RQs to below LOCs for terrestrial plants.

Table 1-2. Effects Determination Summary for the Critical Habitat Impact Analysis for the Delta Smelt and Tidewater Goby

Designated Critical Habitat for:	Effects Determination	Basis for Determination
Delta smelt (*Hypomesus transpacificus*) and Tidewater Goby (*Eucyclogobius newberryi*)	Habitat Modification	***Aquatic prey items, aquatic habitat, cover and/or primary productivity*** Using toxicity data representing freshwater (*C. dubia*) and estuarine invertebrates (*A. bahia*) and modeled exposures, risks could not be precluded based on acute and chronic effects to prey items for all use patterns. This includes risk to benthic invertebrates. Available data on one species of non-vascular aquatic plants (*P. subcapitata*) suggests that risk to dietary items for young DS and TG and to non-vascular

Designated Critical Habitat for:	Effects Determination	Basis for Determination
		plants important for maintaining aquatic habitat is not likely because risk quotients did not exceed LOCs. Based on the mode of action of diazinon not being particularly toxic to plants, results from mesocosm studies, and the lack of incidents reported for aquatic plants; the likelihood of risk to aquatic plants is assumed to be low.
		Terrestrial prey items, riparian habitat RQs for terrestrial plants for transplant applications to cole crops exceeded the LOC for dicots and could exceed the LOC for monocots whose available endpoint is a greater than value, indicating there is a potential for risk to terrestrial plants for the transplant per plant rate for cole crops. RQs for all other uses were less than 1.0 and risk to terrestrial plants is not expected for any other use.[1]

[1] The risk to terrestrial plants was identified for a transplant use on cole crops. The application rate on the label is on a per plant basis and application rate on a lbs a.i./A was estimated based on the maximum number of plants that may be planted in an acre resulting in a very high application rate of 116 lbs a.i./A. This high application rate may not commonly occur. The application rate would need to be reduced to an equivalent of 26 lbs a.i./A to reduce RQs to below LOCs for terrestrial plants.

Table 1-3. Use Specific Summary of The Potential for Adverse Effects to Delta Smelt and Tidewater Goby

Uses	Potential for Effects to Identified Taxa Found in the Aquatic Environment:									
	Delta smelt, Tidewater Goby and Estuarine/Marine Vertebrates[1]		Delta smelt, Tidewater Goby and Freshwater Vertebrates[2]		Freshwater Invertebrates[3]		Estuarine/Marine Invertebrates[4]		Aquatic Vascular Plants[5]	Aquatic Non-vascular Plant[6]
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic		
Almonds	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Tree Fruit	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Fig	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No
Beans	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Row Crop	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Berries except blueberry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Blueberry	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No
Cole Crops	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Leafy Vegetables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Lettuce	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Garlic and Leek	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Melons	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Onion	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Rutabega	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Outdoor ornamentals	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Strawberry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Tomato	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Cattle Ear Tags	No	No	No	No	No	No	No	No	No	No

1 A yes in this column indicates a potential for direct effects to DS and TG.
2 A yes in this column indicates a potential for direct effects to DS and TG.
3 A yes in this column indicates a potential for indirect effects to DS and TG.
4 A yes in this column indicates a potential for indirect effects to DS and TG.
5 Available data on one species of nonvascular plants suggests that risk to dietary items for young and nonvascular plants important for maintaining aquatic habitat is not likely because risk quotients did not exceed LOCs. Based on the mode of action of diazinon not being particularly toxic to plants, results from mesocosm studies, and the lack of incidents reported for aquatic plants; the likelihood of risk to aquatic plants is assumed to be low.
6 Data are only available on one nonvascular plant species. Available data indicate risk to that species is unlikely; however, data are typically available on four species and it is possible that the species tested does not reflect the toxicity to the most sensitive species of the standard species tested.

Based on the conclusions of this assessment, a formal consultation with the USFWS 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.

- Enhanced information on the density and distribution of DS and TG 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 United States Environmental Protection

Agency's (USEPA) *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, 2004c) and reviewed by the United States Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) (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 threatened DS and the endangered TG arising from FIFRA regulatory actions regarding use of diazinon on fruit, nuts and vegetables and non-agricultural uses on outdoor ornamental crops.

In this assessment, direct and indirect effects to the DS and the TG and potential modification to designated critical habitats for the DS and TG were evaluated in accordance with the USFWS and NMFS *Endangered Species Consultation Handbook* (USFWS/NMFS, 1998), procedures outlined in the Agency's Overview Document (USEPA, 2004c), and consistent with a stipulated injunction ordered by the Federal District Court for the Northern District of California in the case *Center for Biological Diversity (CBD) vs. EPA* et al. (Case No. 07-2794-JCS).

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 DS move into freshwater.

The TG was listed as endangered on March 7, 1994 (59 FR 5494) by the USFWS. TG are found primarily in waters of coastal lagoons, estuaries, and marshes. The animals are benthic in nature and all life stages are found in lagoons, estuaries and marshes in areas of low to moderate salinity[4]. TG also occur in freshwater streams up gradient and tributary to brackish habitats (68920 FR Vol 71, No 228).

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 diazinon 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 diazinon 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 DS and TG and their designated critical habitat within the state of California. As part of the "effects determination," one of the following three conclusions will be reached for the DS and TG regarding the potential use of diazinon in accordance with current labels:

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

- "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.

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 diazinon in accordance with the approved product labels for California is "the action" relevant to this ecological risk assessment.

Diazinon is an organophophate insecticide registered for control of a wide range of insect and other arthropod pests. Based on previous assessments and risk management decisions described in Section 2.3 of this document, diazinon's use profile has been considerably diminished as compared to usage prior to 2004 as many uses were cancelled at this time.[5] Currently, applications to fruit, nut, vegetable and outdoor ornamental crops are allowed. Additionally, there are uses as cattle ear tags. Use of diazinon in cattle ear tags was assumed to result in mimimal exposure to the assessed species.

Although current registrations of diazinon allow for use nationwide, this ecological risk assessment and effects determination addresses currently registered uses of diazinon in portions of the action area that are reasonably assumed to be biologically relevant to the DS and TG and their designated critical habitats. Further discussion of the action areas for the DS and TG and their critical habitats is provided in Section 2.8.

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[5] The chemical was once one of the most widely used insecticides in the United States for household as well as agricultural pest control. However, a December 2000 agreement with the technical registrants phased out and cancelled all indoor and outdoor residential uses of diazinon by 2005. Additionally, all registrations for granular products, except use on lettuce in California and Arizona and two current Section 24c registrations for control of cranberry girdler in the Pacific Northwest were cancelled by 2005. Many mitigation measures that were identified in the 2002 IRED have been implemented, including deletion of aerial applications for all uses except on lettuce, cancellation of all seed treatment uses, and cancellation of foliar applications to all vegetable crops except honeydew melons in California to control leafhoppers. For most uses, only one application per growing season is allowed. Crops with dormant-season and in-season uses, *e.g.* stone fruits, are limited to a single application per season, for a total of two applications per year. Section 3 registrations on succulent beans, succulent peas, peppers, potatoes, and squash were cancelled by August 2004; watercress was phased out in all states but Hawaii by 2006.

2.2.1. Evaluation of Degradates and Other Stressors of Concern

This assessment quantitatively considers effects of exposures of diazinon only. Diazinon degrades into two notable degradates: oxypyrimidine and diazoxon. Oxypyrimidine is the primary degradate of diazinon and is seen in both the laboratory studies and field studies. Diazoxon, which degrades further to oxypyrimidine, was detected in field dissipation studies, but was not reported to be a major degradate in laboratory studies. In monitoring studies in California, diazoxon has been detected in air and precipitation samples (Section 3.4). Comparison of available toxicity information for the degradates of diazinon indicates that oxypyrimidine is practically nontoxic to aquatic (fish and invertebrates) and terrestrial animals (birds) on an acute exposure basis and it is practically nontoxic to terrestrial animals (birds) on a subacute dietary exposure basis (Section 4.4). Diazoxon has greater toxicity compared to that of the parent based on avian data. Diazoxon is very highly toxic to birds on an acute oral exposure basis and is highly toxic to birds on a subacute dietary exposure basis. Available data indicate that diazoxon is an order of magnitude more toxic to aquatic amphibians than the parent compound (Sparling and Fellers, 2007, E 92498). A detailed summary of the available ecotoxicity information for the diazinon degradates is presented in **Appendix I**.

Diazoxon was not considered in the calculation of risk quotients for aquatic organisms because data are not available to include its analysis in the calculations. Diazoxon was not detected in laboratory fate studies, so it is not possible to estimate the amount of diazoxon that would be observed in the aquatic environment using EFED's standard methods. Additionally, only limited toxicity data are available on diazoxon for aquatic organisms. Potential diazoxon risk is discussed in the uncertainties section.

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, 2004b ; USFWS/NMFS/NOAA, 2004).

Diazinon has registered products (cattle ear tags) that contain multiple active ingredients. Often acute oral toxicity studies on rats or mice are available for formulations so that appropriate label hazard statements are included on a label. These data may also be used to better understand differences in the toxicity of different formulations. Data have been submitted for one product (MRID 46076802) using a premix to the ear tag; however, the study has not been reviewed. Additionally, acute oral studies for both of the products were waived. Both of the products contain another organophosphate (coumaphos or chlorpyrifos) which are likely to influence the toxicity of the products as they share a common mode of action with diazinon; however, as they are ear tags exposure to aquatic organisms and plants is expected to be minimal.

According to the available data, other pesticides may combine with diazinon to produce synergistic, additive, and/or antagonistic toxic effects. Synergistic effects with diazinon have been demonstrated for atrazine (Anderson and Lydy, 2002). If chemicals that show synergistic effects with diazinon are present in the environment in combination with diazinon, the toxicity of diazinon may be increased.[6] Other mixtures containing diazinon showed less than additive toxicity (Banks *et al.*, 2005; Van der Geest *et al.*, 2000).[7] The toxicity of chemical mixtures in general can be a function of (1) the exposed species, (2) the co-contaminants in the mixture, (3) the ratio of diazinon and co-contaminant concentrations, (4) differences in the pattern and duration of exposure among contaminants, and (5) the differential effects of other physical/chemical characteristics of receiving waters (*e.g* organic matter present in sediment and suspended water). Quantitatively predicting the combined effects of all these variables on mixture toxicity to any given taxa with confidence is beyond the current abilities of ecotoxicology. Consequently, the risk quotients were calculated for diazinon alone as toxicity data are not available to evaluate the toxicity of the mixtures. However, a discussion of implications of the available pesticide mixture effects data involving diazinon on the confidence of risk assessment conclusions is addressed as part of the uncertainty analysis for this effects determination.

2.3. Previous Assessments

2.3.1. Diazinon Interim Reregistration Eligibility Decision

The Agency completed a screening-level ecological risk assessment for diazinon use in February 2000 (USEPA, 2002, D183157). This assessment was based on laboratory ecotoxicological data submitted by the registrant in support of reregistration and from data in publicly available literature, a substantial amount of monitoring data for freshwater streams, lakes, reservoirs and estuarine areas, and incident reports of adverse effects on aquatic and terrestrial organisms associated with the use of diazinon. The results of the Agency's ecological assessments for diazinon are fully discussed in the July 31, 2006, final Interim Reregistration Eligibility Decision (IRED) (http://www.epa.gov/pesticides/reregistration/REDs/diazinon_ired.pdf)(USEPA, 2004a).

2.3.2. Diazinon Endangered Species Assessments

2.3.2.a. Pacific Anadromous Salmonids

The Agency completed an ecological risk assessment evaluating the potential effects of diazinon on the endangered Pacific Anadromous Salmonids (*Oncorhynchus spp.*) in November 2002 (http://www.epa.gov/espp/litstatus/effects/diazinon-analysis-final.pdf) ((USEPA, 2002). The assessment was a component of the settlement of the court case[8] where the Washington Toxics Coalition for Alternatives to Pesticides, Pacific Coast Federation of Fisherman's Associations and Institute for Fisheries Resources alleged that the EPA violated Section 7(a)(2) of the ESA by

[6] Banks *et al*. (2005) examined the toxicity of atrazine and diazinon to *Ceriodaphnia dubia* and found that there was a potential for increased toxicity from mixtures of these compounds at environmentally realistic concentrations.
[7] Van der Geest *et al.* (2000) examined the toxicity of copper and diazinon to larvae of the mayfly (*Ephoron virgo*) demonstrated that the two compounds may act in a less than concentration additive manner.
[8] Filed in the U.S. District Court for the Western District of Washington, Civ. No.l 01-132.

failing to consult on 54 pesticides due to their potential effects on Pacific salmon. The Office of Pesticide Programs (OPP) determined that the use of diazinon may affect 22 Evolutionarily Significant Units (ESUs) of federally listed Pacific salmon and steelhead and that use of diazinon may affect, but is not likely to adversely affect, 4 ESUs. The NMFS issued a Final Biological Opinion in response to OPPs determination in 2008 (NMFS, 2008). NMFS determined that the continued registration of diazinon is likely to jeopardize the continued existence of 27 listed Pacific salmonids. EPA responded to the Biological Opinion in 2009 (USEPA, 2009b) stating, "Consistent with the goals of the BiOp, EPA intends to comply with the Endangered Species Act (ESA) by requiring changes to the registration of the pesticides included in the BiOp to assure that the registered use of these pesticides will not result in likely jeopardy to the continued existence of federally listed threatened or endangered species or destroy or adversely modify their designated critical habitat."

2.3.2.b. Barton Springs Salamander

The Agency completed an ecological risk assessment evaluating the potential effects of diazinon on the endangered Barton Springs salamander (*Eurycea sosorum*) in May 2007 (http://www.epa.gov/espp/litstatus/effects/bss-diazinon-assessment.pdf (USEPA, 2002) . Conclusions regarding diazinon use in the Barton Springs salamander action area were: diazinon would have no direct acute effect on the salamander; diazinon use would not likely adversely affect the salamander through direct chronic effects; diazinon was not likely to adversely affect the salamander through effects on it prey; and diazinon use would have no effect on the salamander's habitat.

2.3.2.c. California Red Legged Frog

In July 2007, the Agency completed an ecological risk assessment evaluating the potential effects of diazinon on the endangered California red-legged frog (CRLF; *Rana aurora draytonii*). The assessment was a component of the settlement of the court case "*Center for Biological Diversity (CBD) vs. EPA et al.* No. 02-1580-JSW(JL) (http://www.epa.gov/espp/litstatus/effects/redleg-frog/diazinon/analysis.pdf) (USEPA, 2007b). The effects determination was a Likely to Adversely Affect (LAA) due to the potential for acute and chronic direct effects to the CRLF and acute and chronic indirect effects to the CRLF through effects on prey.

2.3.3. Final Biological Opinion on Diazinon in Response for Consultation

EPA reinitiated a formal consultation with the USFWS in 1989 regarding diazinon impacts on endangered species. This consultation was on selected portions of five previous "cluster" biological opinions evaluating pesticides for certain crops (corn, cotton, soybeans, sorghum, wheat, barley, oats and rye), forestry uses pesticides, mosquito larvicides, and rangeland and pastureland pesticides. As a result, the USFWS issued a formal Biological Opinion (USEPA, 2002) which identified reasonable and prudent measures and alternatives to mitigate potential effects of diazinon use on endangered species. The opinion identified 6 amphibians, 77 fishes, 32 freshwater mussels, 10 arthropods, 5 birds and 2 snakes potentially affected by the use of diazinon. Of the 132 species identified, 84 were classified as in jeopardy.

2.4. Aquatic Life Criteria

The Clean Water Act requires the EPA to publish water quality criteria that accurately reflect the latest scientific knowledge on the kind and extent of all identifiable effects on health and welfare which might be expected from the presence of pollutants in any body of water. An Aquatic Life Ambient Water Quality Criteria document was published for diazinon in 2005 (USEPA, 2005). The criteria concentrations reflect the level of a pollutant or other measurable parameter that allows for protection of aquatic life in our nation's water as developed under Section 304(a) of the Clean Water Act of 1972. The recommendation of the document in regards to freshwater aquatic life includes the following: "Freshwater aquatic life should not be affected if the one-hour average concentration of diazinon does not exceed 0.17 micrograms per liter more than once every three years on the average (acute criterion) and if the four-day average concentration of diazinon does not exceed 0.17 micrograms per liter more than once every three years on the average (chronic criterion)." The saltwater aquatic life criteria state the following: "Saltwater aquatic life should not be affected if the one-hour average concentration of diazinon does not exceed 0.82 micrograms per liter more than once every three years on the average (acute criterion) and if the four-day average concentration of diazinon does not exceed 0.82 micrograms per liter more than once every three years on the average (chronic criterion)" (http://water.epa.gov/scitech/swguidance/standards/criteria/aqlife/pollutants/diazinon/diazinon-fs.cfm). While these recommended criteria do not, in themselves, impose any requirements, states and authorized tribes can use them to develop water quality standards.

2.5. Environmental Fate Properties

Physical-Chemical Properties

Table 2-1 lists the physical-chemical properties of diazinon. Environmental fate and transport data are summarized in **Table 2-2**. Diazinon will enter the environment via spray directly onto soil or foliage. It may move off-site via spray drift, leaching, runoff, and volatilization. Diazinon has an acid dissociation constant (pK_a) of 2.6, indicating that its form will not change significantly at environmentally relevant pH. The vapor pressure, air-water partition coefficient (K_{AW}), and $C_{water+soil}/C_{air}$ indicate that diazinon should be considered semi-volatile from dry nonadsorbing surfaces, slightly volatile from water, and slightly volatile to non-volatile from moist soil (using uncertain sorption coefficients and OPPTS[9] Guideline 835.6100 classifications). The log octanol-water partition coefficient (log K_{ow}) is 3.8 at 25°C and the log octanol-air partition coefficient (log K_{OA}) is 8.4 suggesting that diazinon is likely to bioconcentrate in terrestrial organisms, if it does not degrade and is not metabolized (Armitage and Gobas, 2007; Gobas *et al.*, 2003; USEPA, 2009f). Note that risk to terrestrial animals is not addressed in this risk assessment as they are not relevant dietary items or important for habitat for DS and TG. Because diazinon's log K_{OW} is less than four, risk to terrestrial organisms due to consumption of residues in aquatic organisms due to bioconcentration is assumed to be

[9] Office of Prevention, Pesticides, and Toxic Substances (OPPTS) is now the Office of Chemical Safety and Pollution Prevention (OCSPP); however, the guidelines still reference OPPTS and so the guidelines are referenced with OPPTS in this document.

minimal.[10] Typically, risk to sediment is evaluated when the log K_{OW} is greater than three as compounds with a high K_{OW} are more likely found in sediment (40 CFR Part 158.630 Terrestrial and Aquatic Nontarget Organism Data Requirements); consequently, a risk assessment on sediment-dwelling organisms is relevant to diazinon.

Table 2-1. Physical-chemical Properties of Diazinon

Parameter	Value and Units	Source	Comments
PC Code	057801	--	--
CAS Number	333-41-5	(USNLM, 2009)	--
Chemical Name	*O*,*O*-diethyl *O*-2-isopropyl-6-methylpyrimidin-4-yl phosphorothioate	(AERU, 2009)	--
Molecular Weight	304.35 g/mole	(AERU, 2009)	--
Water Solubility	40 mg/L at 25°C pH NR	(USNLM, 2009)	--
	65.5 mg/L at 25°C pH NR	MRID 42970808	Originally reported as 6.55×10^{-3} g/100 mL
	59.5±3.3 mg/L at 25°C and pH 6.07	MRID 40226101	Solubility not pH dependent at pH 5, 7, and 9
Vapor Pressure	9.01×10^{-5} Torr at 25°C	(USNLM, 2009)	Semivolatile from dry nonadsorbing surfaces.
	7.22×10^{-5} Torr at 25°C	MRID 42970809	
	$6.6\pm0.27\times10^{-5}$ Torr at 25°C	MRID 40226101	
Henry's Law constant	1.13×10^{-7} atm-m^3/mol at 23°C	(Fendinger and Glotfelty, 1988)	Calculated from measured value reported as a unitless value of 4.6×10^{-6}
	4.4×10^{-7} atm-m^3/mol at 25°C (estimated)	Calculated[1]	Calculated with 6.6×10^{-5} torr vapor pressure and 59.5 mg/L water solubility.
Acid Dissociation Constant (pKa)	2.6 (temperature not reported)	MRID 46523401	--
n-octanol-Water Partition Coefficient (K_{OW})	6456 (log K_{OW}=3.81) at NR°C	(USNLM, 2009)	Not likely to bioconcentrate (USEPA, 2010a), Sediment data may be needed
	4898 (log K_{OW}=3.69) at 24°C	MRID 42970810	
	6393 (log K_{OW}=3.8) at 25°C	MRID 40226101	
Air-water	1.80×10^{-5} (log K_{AW} = -4.74)	Calculated[1]	Slightly volatile from a water surface

[10] The Kow (based) Aquatic BioAccumulation Model (KABAM) is the model used in EFED to assess potential risk to terrestrial organisms due to consumption or residues of pesticides in aquatic organisms. The user guide recommends that KABAM be used in the assessment when the log K_{OW}value is between four and eight (USEPA, 2009g). A model is not currently available to assess risk to aquatic organisms due to bioconcentration and toxicity data based on tissue residue analysis is not available for aquatic organisms; however, bioconcentration factor data are typically requested for chemicals with a log K_{OW} of at least three.

Partition Coefficient (K_{AW})	4.6×10^{-6} at 23°C (log K_{AW} = -5.3)	(Fendinger and Glotfelty, 1988)	(USEPA, 2010a)
Octanol-air Partition Coefficient (K_{OA})	2.7×10^{8} (log K_{OA} = 8.4)	Calculated[1]	May biomagnify in terrestrial food chains if degradation is low [2] (Gobas *et al.*, 2003; USEPA, 2009f)
$C_{water+soil}/C_{air}$	2.57×10^{5} to 6.3×10^{6}	Calculated using Kd of 113.5 and 4.5 L/kg	Slightly volatile to non-volatile from moist soil (USEPA, 2010a)

NR=not reported

[1]All estimated values were calculated according to "*Guidance for Reporting on the Environmental Fate and Transport of the Stressors of Concern in Problem Formulations for Registration Review, Registration Review Risk Assessments, Listed Species Litigation Assessments, New Chemical Risk Assessments, and Other Relevant Risk Assessments*" (USEPA, 2010a).

[2] A recent FIFRA Scientific Advisory Panel (SAP) reported, "Gobas *et al* (2003) concluded that chemicals with a log K_{OA} >5 can biomagnify in terrestrial food chains if log K_{OW} >2 and the rate of chemical transformation is low. However, further proof is needed before accepting these limits without reservations" (USEPA, 2009f). This was also supported by Armitage and Gobas's work completed in 2007 (Armitage and Gobas, 2007).

Table 2-2. Summary of Diazinon Environmental Fate Properties

Study and Units	Value or information gained from study	Source / Study Classification	Comments
Abiotic Hydrolysis Half-life (days)	Half-life, nonlinear regression[1] at 23-25°C: Parent only, 13 (pH 5) 139 (pH 7) 77 (pH 9) Parent+unidentified residue: 13 (pH 5) 317 (pH 7) 114 (pH 9)	MRID 40931101/ Acceptable DER 02/8/2008 DER amendment 02/29/2012	There was an unidentified peak (in HPLC analysis) that was increasing at the end of the study. Half-lives were calculated assuming that the peak was a residue of concern, as well as for the parent only.
	Half-life, linear regression[1] at 20°C: Diazinon: 0.49 days, pH 3.1 31 days, pH 5 185 days, pH 7.4 136 days, pH 9.0 Diazoxon: 0.016, pH 3.1 1.3, pH 5.0 29, pH 7.4 18, pH 9 0.42, pH 10.4	MRID 132726/ Supplemental-not for use in modeling DER 03/12/2008	No mass balance. Only one replicate, no signed good laboratory practices (GLP) statement, no sterility check. This study included analysis of diazoxon. Maintained under light. Diazoxon values could be used qualitatively to better understand its hydrolysis as it compares to diazinon.
Atmospheric Half-life (days)	Half-life: 0.111(estimated)	(USEPA, 2009c)/ NA	Estimated Using EPIWeb Version 4.1

Study and Units	Value or information gained from study	Source / Study Classification	Comments
Direct Aqueous Photolysis Half-life (days)	No data available[3]	--	--
Soil Photolysis	Does undergo photolysis in soil.	MRID 153229/ Supplemental-not for use in modeling DER 03/28/1988 amended 02/15/2008	Temperature range 16-31°C for natural sunlight, and 25°C for dark controls. Up to 30% bound residues. Half-life in natural sunlight was 17.3 hours (not corrected for dark control). Half-life in the dark control was 14.7 days.
	Does undergo photolysis in soil.	MRID 153230/ Supplemental-not for use in modeling DER 03/28/1988 amended 03/03/2008 Amended 02/29/2012	Temperatures not reported for natural sunlight. Intensity of sunlight not reported.
Aerobic Soil Metabolism Half-life (days)[4]	Half-life, nonlinear regression[1] at 20°C: 5.5, Les Evouettes silt loam	MRID 46867004/ Supplemental DER 05/5/2011	Swiss soil, could not determine whether the soil was comparable to U.S. Soil. One replicate.
	Half-life, linear regression[1] at 20°C: 39, sandy loam	MRID 44746001/ Supplemental DER no date	Unexplained loss of approximately 25% of applied radioactivity at all sampling intervals after 181 days. There were no sampling intervals between 30 and 90 days.
	Half-life, method not specified at 25°C: 11, sandy loam, Switzerland	MRID 118031/ Supplemental- not for quantitative use in risk assessment DER 03/28/1988	Raw data were missing. One replicate. Purity not specified. Switzerland soil. Dropped from 100 to 12% between the first and second data point. Recovery of radioactivity was low at some points. Maximum unextracted residue was 15.1% and is unlikely to be parent.
Anaerobic Soil Metabolism Half-life (days)	No data available.		
Aerobic Aquatic Metabolism (days)	Half-life, nonlinear regression[1] at 20°C: 9.9, pond water-clay loam sediment 11.6, Lake water, sandy	MRID 46386604/ Acceptable DER 05/5/2011	Water and sediment collected from sites in UK. Up to 49% unextracted residues in pond-clay loam sediment system and 23% in lake-sandy loam system. The unextracted residues did not begin to increase substantially until most

Study and Units	Value or information gained from study	Source / Study Classification	Comments
	loam sediment		diazinon degraded. Unextracted residues are unlikely to be the parent. Total system half-life is reported.
Anaerobic Aquatic Metabolism (days)	Half-life, nonlinear regression[1] at 20°C: Parent Only: 24.5, sandy loam soil, UK	MRID 46386602/ Acceptable DER 05/5/2011	Conducted on soil instead of sediment. Aerobic aquatic studies should be conducted using a sediment to simulate microbes and aquatic systems. Single samples. Total system half-life is reported.
Organic-carbon normalized distribution coefficient (K_{OC}) in L/kg-organic carbon[5]	2184 (estimated)	Not applicable	Estimated Using EPIWeb Version 4.1 and a log K_{OW} of 3.81
Soil Column Leaching	Maximum Percent leached: Parent: 2.84, MD sand, pH 6.8, OC 0.9% 0.71, CA sandy loam, pH 6.5, OC 0.5% 0.19, MS silt loam, pH 5.9, OC 4.8% 0.50, MD clay, pH 7.5, OC 1.0% Oxypyrimidine: 71.82, MD sand, pH 6.8, OC 0.9% 15.54, CA sandy loam, pH 6.5, OC 0.5% 5.47, MS silt loam, pH 5.9, OC 4.8% 14.68, MD clay, pH 7.5, OC 1.0%	MRID 40512601/ Acceptable DER no date	Residues of diazinon observed in leachate of a 30 cm column, 50.7 cm of water.
	Greater than 75% of ^{14}C material was found in leachate with most present as oxypyrimidine.	MRID 132734/ 132735 Supplemental DER 03/28/1988	132734 and 132735 are identical submissions. Foreign soils. Only 20.3 cm of water rather than required 50 cm was used in study. It is likely to underestimate leaching amounts.
Terrestrial Field Dissipation[2]	DT50 range from 5-17 days	**Table 2-6**	--

Study and Units	Value or information gained from study	Source / Study Classification	Comments
Aquatic Field Dissipation[2]	Maximum residue in pond was 113.0 µg/L. No quantifiable residues observed in sediment.	MRID 41490401/ Supplemental DER 10/10/1991	Applied diazinon at rate of 3 lbs a.i./A on an orchard six times and measured residues in adjacent pond.
	Maximum residues measured in pond were 82.1µg/L.	MRID 41490402/ Supplemental DER 10/10/1991	Applied diazinon at rate of 3 lbs a.i./A on an orchard six times and measured residues in adjacent pond.
	Maximum residues in pond adjacent to site treated with diazinon was 12.8 µg/L.	MRID 41490403/ Supplemental DER 10/10/1991	Applied diazinon at rate of 3 lbs a.i./A on an orchard six times and measured residues in adjacent pond.
Bioconcentration Factor (BCF)- Bluegill (*Lepomis macrochirus*) [6]	Diazinon, oxypyrimidine, and GS-31144 are residues likely to be observed in fish tissue in fish exposed to diazinon and/or its metabolites in water.	MRID 40660808/ 41194401 Supplemental DER amendment 03/06/2012	Identities of residues were not characterized in water and only at the final sampling interval (29 days) in fish. Residues measured in fish after 29 days were identified in 41194401. BCFs cannot be calculated without knowledge of the identity of residues over the duration of the study in fish and water.

[1]Half-lives were calculated using the single-first order (SFO) equation and nonlinear regression or data were transformed using the natural log to allow use of linear regression with the SFO equation.
[2]The value may reflect both dissipation and degradation processes.
[3] Results from an aqueous photolysis study (MRID 40863401) were reported in a previous risk assessment. MRID 40863401 was classified as invalid in 2008 due to a low recoveries in the material balance, time in dark conditions was not clearly reported, and diazoxon was not monitored (DER 03/03/2008).
[4] An aerobic soil study (MRID 40028701) was reported in a previous risk assessment. MRID 40028701 was classified as not acceptable in 2008 due to a low material balance, variability in results, not identifying all major transformation products (DER 02/20/2008).
[5] Sorption coefficients (MRID 11 8032) were reported in previous assessments. MRID 11 8032 was reclassified in (DER amendment 02/29/2012) 2012 as invalid due to numerous deficiencies including the identity of residues associated with measured radioactivity was not identified.
[6] Bioconcentration factor (MRID 40660808 and 41194401) were reported in previous risk assessments. The study was reclassified as supplemental because the identity of radioactivity was not determined in water and only in fish for the last samples collected (DER amendment 03/06/2012).

Degradation

Chemicals with half-lives greater than 60 days in soil, water, and sediment are considered persistent (USEPA, 2008). Limited data on aerobic aquatic and aerobic soil metabolism half-lives indicate that diazinon is not persistent. Aerobic soil metabolism half-lives in three soils ranged from 6 to 39 days (MRID 46867004, 44746001, 118031). Aerobic aquatic metabolism half-lives in two systems ranged from 10 to 12 days (MRID 46386 604). Anaerobic aquatic metabolism was measured in one water-soil system[11] and a half-life of 25 days was observed (MRID 46386602). It is uncertain whether this value would apply to a water-sediment system as the microbes present and sorption behavior could be different in soils as compared to sediment. Degradation due to hydrolysis varies with pH, with half-life values (for parent only) of 13, 139

[11] The soil was a sandy loam soil.

and 77 days at pH 5, 7 and 9 (measured at 25°C), respectively (MRID 40931101). No acceptable aqueous photolysis data are available. Only supplemental soil photolysis data are available (MRID 153229, 153230). These studies were considered supplemental because temperatures of the studies were not constant and light intensity was not measured; however, their results suggest that diazinon can undergo photolysis in the soil and water (MRID 153229, 153230). The dominant degradation process is expected to depend on environmental conditions. It appears photolysis rates may be the fastest degradation rates and photolysis will only occur in some environments.

Transformation Products

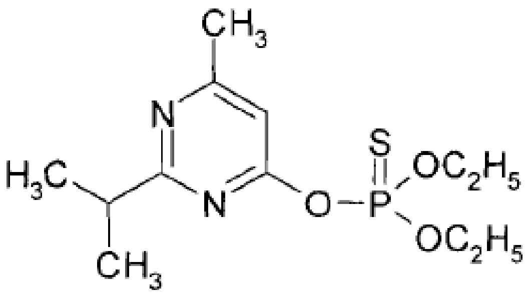
Transformation products resulting from environmental degradation of diazinon include:

- oxypyrimidine (2-isopropyl-4-methyl-6-hydroxypyrimidine)
- diazoxon (diethyl 2-isopropyl-6-methyl-4-pyrimidinyl phosphate)
- GS-31144 (2-(2-Hydroxy-2-propanyl)-6-methyl-4(1H)-pyrimidinone)
- demethyl oxypyrimidine.

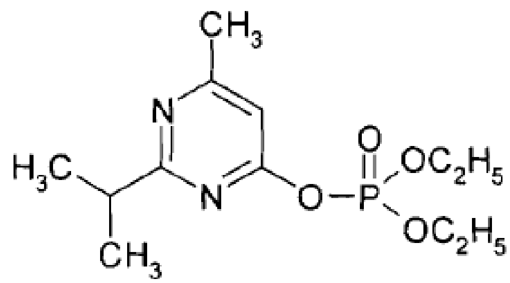
Structures of the parent and degradates are shown in **Figure 2-1**. Diazinon and diazoxon are both organophosphates, with the sulfur atom replaced by oxygen in the case of the oxon. Oxypyrimidine, GS-31144, and demethyl oxypyrimidine are not organophosphates and all have a similar structure. The maximum amounts of degradates observed in fate studies are summarized in **Table 2-3** with detailed information available in **Appendix B**. Oxypyrimidine and GS-31144 were each found to be major degradates (*i.e.*, present at greater than or equal to 10% applied radioactivity) in at least one environmental fate study. All other degradates were minor.

Oxypyrimidine was observed in every fate study conducted, and the maximum radioactivity observed associated with oxypyrimidine was frequently greater than 50% (maximum 82%). In the hydrolysis and photolysis studies, the maximum amount detected was observed at the final sampling interval indicating that oxypyrimidine's abiotic degradation rates are slower than its rate of formation, and the maximum amount that may be formed was probably not observed. While residues declined with time in some of the aerobic metabolism studies, they often remained at very high percentages for significant periods of time. For example, in an aerobic aquatic metabolism study, 70% of applied radioactivity was associated with oxypyrimidine at 30 days, and 66% was still associated with oxypyrimidine at 100 days (MRID 46386604). The same trend was observed in the anaerobic aquatic study. This indicates that oxypyrimidine is relatively stable in both aerobic and anaerobic environments. GS-31144 was observed at a maximum of 13% of applied radioactivity at 195 days in one aerobic soil metabolism study, but was a minor degradate in all other studies. Demethyl oxypyrimidine was not monitored in laboratory studies but was observed at low concentrations (ranging from not detected to 0.17 mg/kg soil) near the level of detection in terrestrial field dissipation studies.

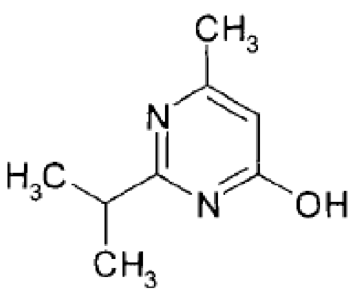
Diazoxon is considered a residue of concern as it retains the organophosphorus functional group and has been shown to be more toxic to some organisms than the parent (Section 4.4). Diazoxon was not monitored in many environmental fate studies, and was not detected in others in which it was monitored. Limits of quantitation for diazoxon were high (0.01 to 0.02 mg/kg-soil) in the studies where it was examined. Although formation and degradation of diazoxon cannot be quantified from available laboratory fate studies involving diazinon, diazoxon has been detected in air, rain, fog (Majewski and Capel, 1995) and surface waters in the United States (USGS, 2011). Circumstances involving formation of diazoxon in the environment as well as its persistence are unknown. This represents a major uncertainty in the Agency's understanding of the fate and persistence of diazinon and its residues of concern.



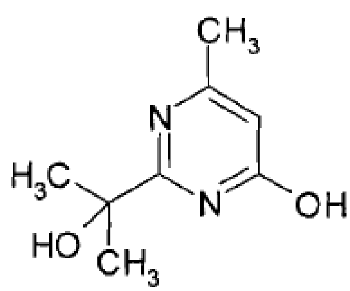
Diazinon



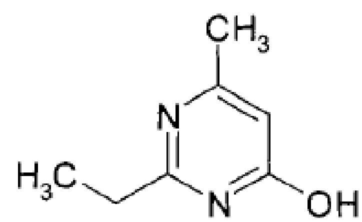
Diazoxon



Oxypyrimidine



GS3114



Demethyl oxypyrimidine

Figure 2-1. Chemical Structures of Diazinon and its Identified Degradates

Table 2-3. Summary of Maximum Amounts of Transformation Products Observed in Laboratory Fate Studies

Transformation Product	Maximum radioactivity associated with compound as %of total applied (day) Radioactivity associated with compound at study termination as % of total applied(day)						
	Hydrolysis	Aqueous Photolysis	Soil Photolysis	Aerobic Soil	Aerobic Aquatic	Anaerobic Soil	Anaerobic Aquatic
Oxypyrimidine	68 (21d) 68 (21d)	39 (15d) 39 (15d)	24 (1.4d) 24 (1.4d)	82 (21d) 1 (119d)	70 (30d) 56 (100d)	72 (14d) 72 (14d)	66 (87d) 56 (366d)
GS-31144	NR	NR	4 (1.4d) 4(1.4d)	13 (195d) 6 (371d)	ND	0.1 (31d) 0.1 (31d)	2 (59d) 2 (59d)
Diazoxon	NR	NR	NR	NR	ND	NR	ND
Demethyl oxypyrimidine	NR	NR	NR	NR	NR	NR	NR

NR=not reported; ND=not detected

Sorption and Mobility

No acceptable batch equilibrium data are available for diazinon. Open literature studies suggest that organic-carbon water normalized distribution coefficient (K_{oc}) values range from 208 to 4204 L/kg-organic carbon measured in 27 soils (Arienzo *et al.*, 1994; IglesiasJimenez *et al.*, 1996; Nemeth-Konda *et al.*, 2002). These values are uncertain as the studies either did not identify radiolabeled compounds or did not include a material balance. EPIWEB version 4.1 (USEPA, 2009c) predicts a K_{oc} of 2,184 L/kg-organic carbon, which is within the range of the values reported in the open literature. Each of the open literatures studies is discussed briefly below and the measured sorption coefficients are provided in **Table 2-4**. All studies reported that diazinon sorption coefficients correlated with the amount of organic carbon present in the soil.

Table 2-4. Summary of Supplemental Sorption Coefficients Reported in Open Literature Studies

Soil Texture	pH	%OC	K_F L/kg-soil	K_{FOC} L/kg-organic carbon	Freundlich Exponent	Source
Silty clay	7.7	0.48	20.04	4204	1.05	(Arienzo *et al.*, 1994)
clayed	7.8	0.64	4.83	755	1.02	
clayed	7.6	0.90	7.15	793	1.13	
clayed	7.7	0.33	5.35	1614	1.06	
sandy clay loam	7.8	1.26	6.25	498	1.13	
sandy clay loam	7.9	0.32	1.58	494	0.97	
sandy clay loam	7.9	0.27	0.7	256	0.92	
sandy clay loam	7.7	0.54	2.74	507	1.03	
sandy clay	7.4	0.33	1.46	441	0.92	
sandy clay loam	4.6	0.09	1.58	1812	0.8	
sandy loam	5.8	0.76	4.14	548	1.1	
sandy loam	4.6	0.13	2.58	2017	0.91	
sandy loam	7.9	0.42	1.79	428	1.07	
clayed	7.4	1.17	4.2	359	1.08	

Soil Texture	pH	%OC	K_F L/kg-soil	K_{FOC} L/kg-organic carbon	Freundlich Exponent	Source
clayed	7.4	1.51	5.11	338	1.06	
sandy clay loam	7.9	1.10	6.57	598	1.26	
sandy clay loam	7.2	0.88	5.15	583	1.11	
sandy clay loam	7.9	0.30	2.45	810	0.99	
sandy	5.2	0.40	1.75	436	0.94	
sandy loam	7.5	0.45	0.93	208	0.85	
sandy loam	4.7	5.93	22.73	383	1.07	
sandy loam	5	5.17	25.73	497	1.18	
loamy sand	5.3	3.46	19.76	571	1.27	
loamy sand	5.1	2.71	9.42	348	1.17	
sandy loam	5.6	2.00	9.83	492	1.05	
sandy loam	7.5	0.01	9.95	1292	0.91	(IglesiasJimenez *et al.*, 1996)
clayed	6.1	0.68	10.19	1499	0.98	(Nemeth-Konda *et al.*, 2002)
Average			7.2	844		
Standard Deviation			14.0	1660		

Nemeth-Konda *et al.* (2002) conducted batch equilibrium experiments where the sorption coefficient was based on the difference between the total applied and the total measured in solution after shaking for 24 hours at 20 °C. The soil was a brown forest soil with clay alluviation which contained 0.68% organic carbon and pH of 6.1. The soil was sieved (<2mm) and the solution was a 0.01 M calcium chloride solution. A control polypropylene tube showed loss of diazinon to walls and the diazinon experiment was conducted in glass tubes with Teflon lined lids. The measured organic carbon normalized Freundlich sorption coefficient was 1499 L/kg-organic carbon and the corresponding Freundlich exponent was 0.98. The main deficiency in this experiment is that there was no mass balance for the total system and loss of diazinon was observed in the polypropylene tubes. It was not clear from the study description whether there was a control tube for the experiment conducted with glass tubes. Additionally, the location that the soil was collected from was not described and it was not determined whether the collected soil already contained some background diazinon.

Iglesias-Jimenez *et al.* (1996) measured sorption coefficients of diazinon with and without the presence of surfactants on a soil collected in Salamanca, Spain. Batch equilibrium experiments were conducted with radiolabeled diazinon and the amount of radioactivity in the solution was measured. Sorption coefficients were calculated based on the difference between the total radioactivity added to the system and the amount measured in a 1mL aliquot of solution. The batch equilibrium systems were shaken for 16 hours at 20°C and soils were sieved (<2mm). The experiments were conducted in duplicate. Typically, batch equilibrium experiments require that the identity of the radioactivity be confirmed to determine whether degradation occurred. Additionally, if a sorption coefficient is going to be determined based on the difference in the amount added and the amount added to solution, usually a control is completed to determine whether loss of the chemical occurred through either degradation or sorption to the vessel walls.

Sorption of diazinon to vessel walls was observed by Nemeth-Konda *et al.* (2002) with polypropylene tubes and Iglesias-Jimenez et al. (1996) did not report the type of centrifuge tube used. The control sample serves to determine the total amount in the system. These two deficiencies indicate that these measured sorption coefficients may not be accurate. The measured Freundlich distribution coefficient in a Eutric Cambisol collected in Spain was 9.95 L/kg and the Freundlich coefficient was 0.91. The soil contained 0.01% organic carbon and the pH was 7.5. A K_{OC} value was not reported but was estimated to be 1292 L/kg-organic carbon. This study did not determine whether diazinon was present in the soil before it was used in the sorption experiment.

Arienzo *et al.* (1994) measured sorption of diazinon in 25 soils. Twenty soils were from Marismas del Guadalquivir and five soils were from the province of Salamanca. Soils were air dried and sieved (<2-mm). Batch equilibrium experiments were conducted with radiolabeled diazinon with initial concentrations ranging from 5 -25 mg/L. The samples were shaken intermittently for 24 hours at 20°C. After 24-hours the samples were centrifuged and a 1-mL aliquot was removed and the radioactivity measured in the aliquot. Sorption coefficients were calculated based on the difference between the diazinon added and the amount measured in the aliquot. The type of container that the samples were shaken in was not specified. It is possible that some sorption of diazinon to vessel walls occurred or degradation of diazinon occurred. Organic-carbon Normalized Freundlich Sorption coefficients for the 25 soils ranged from 208 to 4204 L/kg-organic carbon (L/kg_{oc}).

Using these preliminary sorption coefficient estimates, diazinon is classified as moderately mobile to slightly mobile using the FAO classification system, which means diazinon may be transported into surface and groundwater (FAO, 2000). Results of several column leaching studies also demonstrate mobility of diazinon and oxypyrimidine, with both compounds found in column leachate (MRID 40512601, 132734, 118034). The majority of the radioactivity that leached through columns in these studies was associated with oxypyrimidine, however a small percentage (approximately 0-3%) was also associated with diazinon.

Field Dissipation

The terrestrial field dissipation of diazinon was studied at sixteen United States sites on various crops, and on bare ground plots and with granular, wettable powder, and emulsifiable concentrate formulations. These studies are summarized in **Table 2-6**. Application rates in the studies ranged from 2.2 lbs a.i./A to 10 lbs a.i./A with single and multiple applications depending on the site. These application rates are on the high end of current labeled uses of diazinon. The dissipation half-lives for diazinon ranged from five to 20 days and did not show a trend with cropped versus bare plots or formulations. Diazinon accumulated in soils with repeated application at some sites, but not at others. The highest measured concentration of diazinon in soil was 6.36 mg/kg-soil, and the maximum depth to which the compound leached was 48 inches. In one study in which diazinon was detected at 48 inches, that was the deepest depth sampled. In another, there were deeper sampling depths. Oxypyrimidine was detected at the maximum depth sampled (48 inches) at one site, and was detected at a maximum concentration of 3.26 mg/kg-soil at another site. GS-31144 was detected at a maximum depth of 18 inches and a maximum concentration of 0.178 mg/kg-soil at the same site. Diazoxon was detected near the level of quantitation (0.014 to 0.02 mg/kg-soil), and at a maximum depth of 12 inches. It is likely that these concentrations underestimate the true concentration of diazoxon, as this degradate was shown to be unstable when storing samples for 30 days, and samples were stored for lengths of time that were unspecified in some cases, and greater than 190 days in others. Given that diazoxon is a residue of concern, this produces significant uncertainty in the understanding of the environmental fate of diazinon and its degradates. It is possible that diazoxon could move into surface water through runoff.

Three field dissipation studies (MRID 41490401, 41490402, and 41490403) were conducted where diazinon was applied to apple orchards at six times at 3 lbs a.i./A and concentrations of diazinon were measured in an adjacent pond. Maximum and the range of concentrations are summarized in **Table 2-5**. Residues were detected close to the applications and rainfall events with concentrations decreasing through October, when the final samples were collected. The final mean measured concentrations ranged from 0.2 to 0.5 µg/L. The final applications were in July.

Table 2-5. Summary of Diazinon Concentrations Observed in Ponds near Apple Orchards where Concentrations were Monitored in Field Studies after Applications of Diazinon at 3 lbs a.i./A with Six Applications.*

Site/MRID	Maximum Concentration (µg/L)	Range of Average Concentration (µg/L)	Comments
Jack Ely/MRID 41490402	82.1	0.5 to 11.3	Detectable residues in sediment
R.R.Showers/ MRID 41490403	12.8	0.5 to 3.2	
Ronald Rice/MRID 41490401	113.0	0.2 to 20.2	Stream adjacent to pond. Residues

*These studies were classified as supplemental.

Table 2-6. Summary of Supplemental Terrestrial Field Dissipation Studies Submitted for Diazinon[g]

MRID	Form	Study Location, Crop	Half-life (days)b	Max depth of leaching (inches unless otherwise listed)/Max Concentration mg/kg-soil unless otherwise listed[c]					Application Rate, number of apps, application interval
				Diazinon	Oxypyrimidine	GS-31144	Diazoxon[e]	demethyl G27550	
46867006	EC	CA, turf	d	44.74 mg/kg dislodgeable residues[f] 138.34 mg/kg wet weight thatch[f]	NR	NR	0.24 mg/kg wet weight dislodgeable residues[f] 0.64 mg/kg wet weight thatch[f]	NR	5.0 lbs a.i./A, 3 apps, 14 day
46867006	EC	CA, bare	d	0-1 cm[a]/29.23[f]	NR	NR	ND/ <0.01[f]	NR	5.0 lbs a.i./A, 3 apps, 14 day
41320101	G	CA, corn	9	6/3.4	12/0.72	6/0.04	ND	ND	2.2 lbs a.i./A, 4 apps, 7 day
41320102	G	CA, bare	7	6/5.6	24/0.28	6/0.027	ND	ND	8 lbs a.i./A, 1 app
41320103	WP	FL, citrus	5.51	24/1.022	48a/0.502	6/0.048	**12/0.015**	6/0.01	3.3-5.5 lbs a.i./A, 5 apps, 7 day
41320104	EC	CA, bare	20	48a/3.89	36/1.47	ND	ND	ND	8 lbs a.i./A, 1 app
41320105	EC	CA, orange	7	36/2.82	48/1.45	12/0.04	ND	6/0.04	3.3-5.5 lbs a.i./A, 5 apps, 7 day
41432701	G	IL, corn	5	12/2.2	72/0.32	6/0.021	ND	ND	2.2 lbs a.i./A, 7 apps, 7 day
41432702	G	IL, bare	6	12/2.6	72/0.26	<0.012	ND	6/0.012	8 lbs a.i./A, 1 app
41432703	WP	CA, apples	10	18/1.538	48/1.267	**18/0.178**	6/0.02	6/0.011	3.3 lbs a.i./A, 7 apps, 14 day
41432704	WP	CA, bare	6	**48**/2.313	48/2.029	6/0.128	6/0.012	ND	10 lbs a.i./A, 1 app
41432705	WP	FL, bare	8.23	18/1.334	**48a**/0.210	ND	12/0.014	6/0.015	10 lbs a.i./A, 1 app
41432706	EC	NY, bare	5.3	12/**6.36**	24/**3.26**	12/0.13	ND	**6/0.17**	10 lbs a.i./A, 1 app

MRID	Form	Study Location, Crop	Half-life (days)b	Max depth of leaching (inches unless otherwise listed)/Max Concentration mg/kg-soil unless otherwise listed[c]					Application Rate, number of apps, application interval
				Diazinon	**Oxypyrimidine**	**GS-31144**	**Diazoxon[e]**	**demethyl G27550**	
41432707	EC	NY, apples	17	12/1.93	12/ 0.79	12/ 0.09	ND	ND	3.3 lbs a.i./A, 7 app, 14-21 day
118024	EC	CA, turf	<7	15/4.7	NR	NR	NR	NR	6 lbs a.i./A, 1 app.
118024	EC	WA, turf	<7	15/3.4	NR	NR	NR	NR	5.5 lbs a.i./A, 1 app.
118024	EC	PA, turf	<7	15/0.75	NR	NR	NR	NR	6 lbs a.i./A, 1 app.
118024	EC	TX, turf	<7	15/0.30	NR	NR	NR	NR	4 lbs a.i./A, 1 app.

Form=formulation; G=granular; WP=wettable powder; EC=emulsifiable concentration; NR=not reported; app=application

a Detected at the highest depth sampled.

b Half-life calculated using ln/linear regression and the single first order equation. The value reflects residues in the top six inches of soil only.

c. Bold values indicate that highest depth sampled or concentration detected in soil.

d Values could not be calculated due to insufficient analytical methods.

e Storage stability studies indicate that diazoxon was not stable in samples and these concentrations likely lower than actual concentrations that occurred in the field.

f Residues may be lower than actual values due to little information on analytical method.

g All studies were classified as supplemental due to insufficient storage stability and analytical method data discussed in previous footnotes.

2.5.1. Environmental Transport Mechanisms

Potential transport mechanisms include pesticide runoff, spray drift, and secondary drift of volatilized or soil-bound residues leading to deposition onto nearby or more distant ecosystems. Runoff and spray drift are expected to be the major routes of exposure to DS and TG for diazinon.

Atmospheric Transport and Drift

A number of studies have documented atmospheric transport and re-deposition of pesticides from the Central Valley to the Sierra Nevada Mountains (Fellers *et al.*, 2004; LeNoir *et al.*, 1999; McConnell *et al.*, 1998; Sparling *et al.*, 2001). Diazinon was observed in these studies and residues have been observed in deposition, air, and water samples (Section 3.4). Prevailing winds blow across the Central Valley eastward to the Sierra Nevada Mountains, transporting airborne industrial and agricultural pollutants into the Sierra Nevada ecosystems (Fellers *et al.*, 2004; LeNoir *et al.*, 1999; McConnell *et al.*, 1998). Neither the DS nor the TG have critical habitat east of the Central Valley; however, residues of diazinon and diazoxon may be transported into the critical habitat of both the DS and TG via air or through movement of surface water.

The magnitude of transport via secondary drift of volatilized or soil-bound residues depends on diazinon's propensity to be mobilized into air and its eventual removal through wet and dry deposition of gases/particles and photochemical reactions in the atmosphere. Therefore in evaluating the potential for atmospheric transport of diazinon to locations where it could impact DS or TG, physicochemical properties of diazinon that describe its potential to enter the air from water or soil (*e.g.,* Henry's Law constant and vapor pressure), pesticide use data, modeled estimated concentrations in water and air, and available air monitoring data from the Central Valley and the Sierra Nevadas are considered. Residues of diazinon have been measured volatilizing off of treated fields (Glotfelty *et al.*, 1990; Majewski *et al.*, 1990). Diazinon has also been detected in air, rain, and fog, as reported by USGS and various researchers (see Section 3.4.2 for details).

At this time, EFED does not have an approved model for estimating long-range atmospheric transport of pesticides, and resulting exposure to aquatic organisms in areas receiving pesticide deposition from the atmosphere. Potential mechanisms of entrainment of diazinon into the atmosphere for long range transport, such as volatilization, wind erosion of soil, and spray drift, were not considered in the calculation of risk quotients; however, atmospheric transport was discussed in characterization of risk and uncertainties. The extent to which diazinon may be deposited from the air to the action area is unknown. The possible concentrations resulting from wet deposition are estimated in the uncertainties section.

Water Transport

The environmental fate characteristics of diazinon are consistent with those of compounds expected to have the potential to impact water resources. There are considerable data showing diazinon in both ground and surface water as a result of nonagricultural and agricultural uses.

2.5.2. Mechanism of Action

Diazinon, O,O-Diethyl O -(2-isopropyl-4-methyl-6-pyrimidinyl)phosphorothioate is an insecticide/acaricide belonging to the organophosphate class of pesticides and is used to kill a broad range of insects and mites. Organophosphate toxicity is based on the inhibition of the enzyme acetylcholinesterase which cleaves the neurotransmitter acetylcholine. Inhibition of acetylcholinesterase by organophosphate insecticides, such as diazinon, interferes with proper neurotransmission in cholinergic synapses and neuromuscular junctions (USEPA, 2000, D154949, D159643, D183157).

2.5.3. Use Characterization

In 2004, all residential uses of diazinon were phased out (USEPA, 2012b) and thus use of diazinon has substantially declined from this time. The pesticide is used to control foliage and soil insects and pests of many fruit, nut, vegetable, and ornamental crops as well as insect pests of cattle. The IRED reported that approximately four million pounds of diazinon were used annually on agricultural sites with primary usage on stone fruits and almonds (USEPA, 2004a). **Figure 2-4** presents the national distribution of annual diazinon agricultural use (USEPA, 2012a). The map shows that California has some of the highest usage of diazinon as compared to other areas in the United States and there is usage in areas relevant to DS and TG.

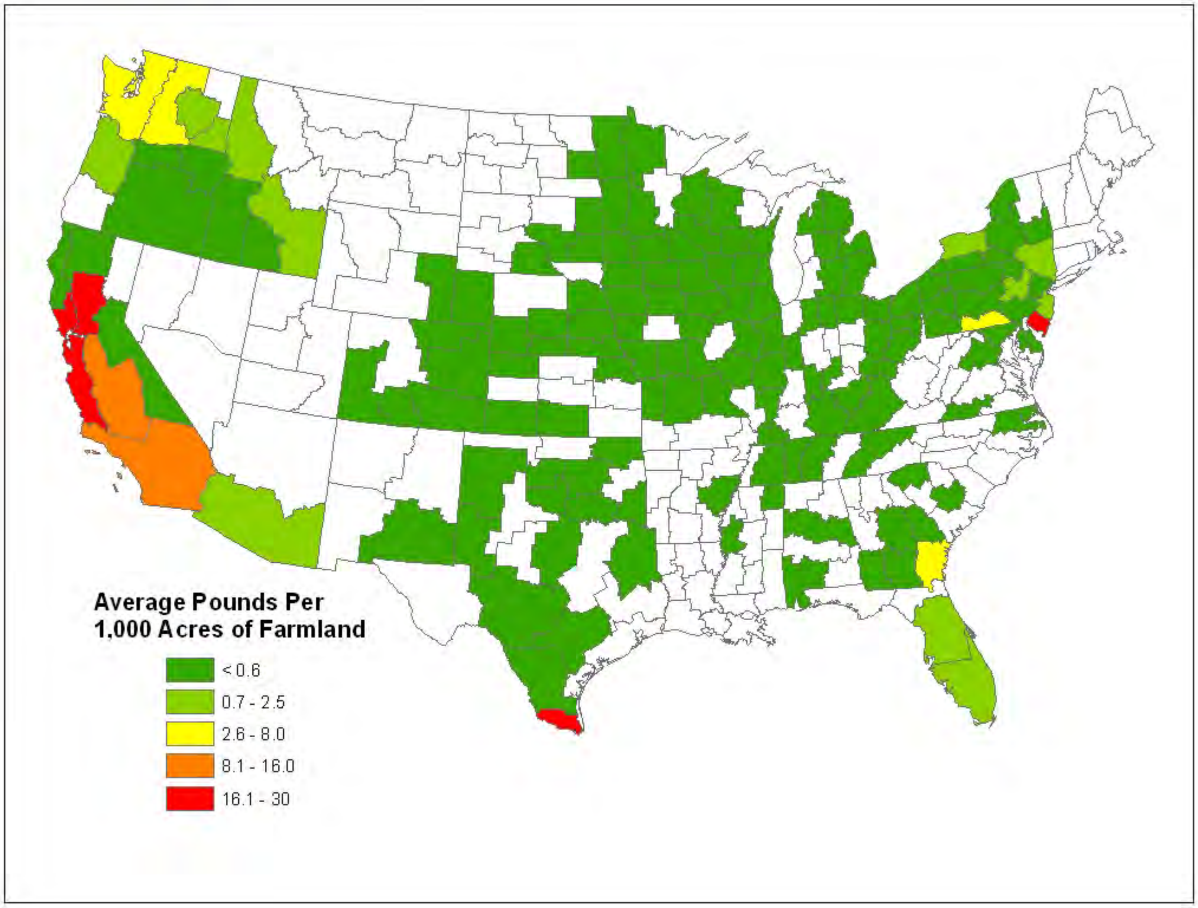


Figure 2-2. Average Pounds Diazinon Used by Crop Reporting District (2006-2010).[12]

Analysis of labeled use information is the critical first step in evaluating the federal action. The current labels for diazinon represent the FIFRA regulatory action; therefore, labeled 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.

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[12] This is a map of agricultural pesticide usage at the Crop Reporting District (CRD) level. CRDs are boundaries created by USDA NASS which are aggregates of counties (USDA, 2010). Pesticide usage is displayed as average pounds (for the years 2006-2010) per 1,000 acres of farmland in a CRD to normalize for the variation in farmland between CRDs. Farmland acreage was obtained from USDA (2007).

Usage is based on private market surveys of pesticide use in agriculture (Proprietary Data, 2006-2010). The survey data are limited to the states that represent the top 80-90% of acreage for the individual crops, therefore, use may be occurring in regions outside the scope of the survey. CRDs showing no usage of pesticides may be due to either the lack of pesticide use in the region or non-participation in the agricultural surveys. In addition, across the years, there may be variations in the specific crops included in the CRD survey. This may result in a lower annual average for the CRD.

Diazinon labels may be categorized into two types: labels for manufacturing uses (including technical grade diazinon and its formulated products) and end-use products. While technical products, which contain diazinon of high purity, are not used directly in the environment, they are used to make formulated products, which can be applied in specific areas to control annual grasses and broadleaf weeds. The formulated product labels legally limit diazinon's potential use to only those sites that are specified on the labels.

Currently, labeled uses of diazinon include several fruit, nut, vegetable crops, ornamental nursery stock, use on a per plant basis for transplant uses on cole crops, ant mounds in blueberry orchards, and use as cattle ear tags. Formulations include wettable powder, emulsifiable concentrate, and ear tags. All agricultural products are applied in liquid form. There are 15 active Section 3 labels of products containing diazinon. In addition, there are two special local needs (Section 24c) labels for California. A comprehensive list of these uses, along with the methods and rates associated with applications of diazinon is included in **Table 2-7**. In this assessment, crops are grouped based on similar forms and application practices. These groups and the specific crops associated with these groups are defined in **Table 2-8.**

Table 2-7. Summary of Section 3 and Section 24C California Registrations for Diazinon

Registration #	Percent Diazinon	Formulation	Product Name
11678-61	92	Technical	Diazol® Diazinon Technical Stabilized Ag
11678-63	87	Technical	Diazol® (Diazinon) Stabilized Oil Concentrate Ag
19713-523	87	Technical	Drexel® Diazinon Technical Ag
11556-123	20	Insecticide Cattle Ear Tag	Co-ral® Plus Insecticide Cattle Ear Tag
11556-148	35	Insecticide Cattle Ear Tag	Corathon®
19713-91	48.2	Emulsifiable Concentrate	Drexel® Diazinon Insecticide
39039-3	21	Insecticide Cattle Ear Tag	Optimizer® Insecticide Ear Tag
39039-6	30	Insecticide Cattle Ear Tag	Warrior® Insecticide Cattle Ear Tag
61483-78	20	Insecticide Cattle Ear Tag	Terminator® Insecticide Cattle Ear Tag
61483-80	40	Insecticide Cattle Ear Tag	Patriot® Insecticide Cattle Ear Tag
19713-492	50	Wettable Powder	Diazinon® 50WP Insecticide
5905-248	48	Emulsifiable Concentrate	Diazinon® AG500 Insecticide
66222-9	48	Emulsifiable Concentrate	Diazinon® AG500
66222-10	50	Wettable Powder	Diazinon 50W
66222-103	56	Emulsifiable Concentrate	Diazinon® AG600
CA030014	48	Emulsifiable Concentrate	Diazinon® AG 500
CA050002	48	Emulsifiable Concentrate	Diazinon® AG 500

Table 2-8. Diazinon Uses Assessed for California (no minimum retreatment intervals were specified)[c]

Uses	Application type**	Application Timing	Maximum application rate / application (lbs a.i./A)	Number of applications/ year	Maximum application rate/year (lbs a.i./A/yr)	Crop cycles per year[e]
Almonds	Chemigation Ground	Dormant	3.024	1	3.024a	1(USDA, 1999a)
			3	1	3	
			2.81	1	2.81	
			0.77	NS (4 assumed)	3.07	
Tree Fruit: Apple, Cherry, Pear	Chemigation Ground Low Volume Ground	Dormant Foliar	1.87 - 2.0	2	3.74 - 4.0a	1
			0.51	1 foliar 1 dormant	2.04	
			0.5 -0.625	2	1.0a – 1.25a	
			0.09	2	0.18a	
Apricot, Nectarine, Plum, Prune	Chemigation Ground Low Volume Ground Spray Soil Drench	Dormant Foliar	1.87 - 2.016	2	3.74 - 4.032a 1.87 – 2.016/cc	1
			0.51	1 foliar 1 dormant	2.0485/cc	
			0.504	2	2.016	
			0.5	2	2	
Peach	Chemigation Ground Low Volume Ground	Dormant Foliar Post-harvest	1.0 - 2.016	2	2.01 - 2.016	1
	Chemigation Ground Spray Low Volume Ground	Dormant Foliar Post-harvest	1.87	2	3.74a	
	Chemigation Ground Low Volume Ground Soil Drench	Foliar Petal Fall Dormant	0.50 - 0.51	4[b]	2.02 - 2.05	
	Chemigation	Dormant Foliar Petal Fall	0.504	4[b]	2.016	
Beans, succulent (Lima, snap)	Soil Incorporated (max depth of 8 inches)	Preplant	3.984	NS	NS	2 for snap 1 for succulent
	Chemigation Ground Soil Drench		4.0 - 4.032	1	4.0 - 4.032a	
Beets	Chemigation Soil Incorporation (maximum depth not specified) Ground	Preplant	4.0 - 4.097	1	4.0 - 4.097a	2 rotates with lettuce

Uses	Application type**	Application Timing	Maximum application rate / application (lbs a.i./A)	Number of applications/ year	Maximum application rate/year (lbs a.i./A/yr)	Crop cycles per year[e]
Blackberry, Caneberry, Boysenberry, Dewberry, Loganberry, Raspberry	Chemigation Drencher Ground Low Volume Ground	Dormant Foliar Before or Near bud Break	1.87 - 2.0485	1	1.87 - 2.0485a	1
	Chemigation Low Volume Ground Ground	At Bud Break	1.0 - 1.02	1	1.0- 1.02a	
Blueberry	Chemigation Ground Low Volume Ground	Foliar	1.008	2	2.016	1
			0.47-0.51	1-2	0.94-1.008	
	Mound treatment	NA	0.128 – 14.4[f]	1-2	NS	
Cole Crops: Broccoli, Brussel Sprouts, Cabbage, Cauliflower, Collard, Kale, Mustard[d]	Chemigation Soil Incorporated (8 inch max soil depth) Soil Drench Ground	Preplant	3.74- 4.1	1	3.74-4.10[a]	1-2 broccoli 1 sprouts 3 cabbage 1-2 cauliflower 2-3 collard 3-4 kale and mustard
	Ground Water Treatment	Transplant	1.0	1	1.0a	
			0.24-0.25	1	0.24-0.25[a]	
	Water treatment		116[g]	1	116[h]	
Row crop: Carrot, peas	Chemigation Ground	Preplant	3.74 – 4.10	1	3.74 – 4.10[a]	1
	Soil in Furrow Drench Treatment (incorporate to max depth of 8 inches)	At plant	2.0	1	2.0[a]	
Pepper	Ground Low Volume Ground	Preplant	4.032	1/cc	4.032	1
Fig	Chemigation Ground Low Volume Ground Soil Drench	Foliar	0.5	1	0.5[a]	1(USDA, 1999b)
Leafy vegetables: endive, Spinach	Chemigation Ground	Preplant	3.74 – 4.10	1	3.74 – 4.10[a]	1-3
Lettuce	Chemigation Soil Incorporation (max depth 8 inches) Ground Aircraft	Preplant	1.87 – 2.05	NS	NS and 2.05	1-2
	Chemigation	Foliar	0.51	4[b]	2.04	

Uses	Application type**	Application Timing	Maximum application rate / application (lbs a.i./A)	Number of applications/ year	Maximum application rate/year (lbs a.i./A/yr)	Crop cycles per year[e]
	Aircraft Low Volume Spray					
	Chemigation Aircraft Low Volume Spray Soil Drench	Foliar	0.46 – 0.50	NS	NS	
Garlic and Leek	Chemigation Ground	Preplant	4.00 – 4.03	1	4.00 – 4.03[a]	1
Melons: Musk, water, winter, honeydew, cantaloupe,	Chemigation Soil Incorporated (max depth 8 inches) Ground Soil Drench	Preplant Foliar	3.75 – 4.10	1	3.75 – 4.10[a]	1
			3.75 – 4.10	NS	NS	
	Chemigation Ground Low Volume Ground	Foliar	0.70 – 0.77	1	0.70 – 0.77[a]	
			0.70 – 0.77	NS	NS	
Onion, Green onion, Scallions, Spring onion, Radish, Shallot	Chemigation Soil incorporation (max depth 8 inches) Ground	Preplant	3.75 – 4.10	1	3.75 – 4.10[a]	3 green onion 1 bulb onion
Ornamentals: herbaceous plants, nonflowering plants, woody shrubs and vines, trees, shade trees and other miscellaneous nursery stock	Misc Nursery Stock[i]	Nursery Stock	3.98	4	11.52	NA
	Chemigation Ground		1.02	1	1.02[a]	
	Chemigation Soil Drench Ground Low Volume Ground		1.00	1[a]/cc	1.0/cc	
	Chemigation Ground Spray		1.0	NS	NS	
Rutabega	Chemigation Ground	Preplant	3.74 – 4.03	1	3.74-4.03[a]	
Strawberry	Ground Soil Incorporation (max 2 inch depth)	Foliar Pretransplant	0.94 - 1.02	NS	NS	1
	Ground Low volume ground	Foliar Pretransplant	1.00	NS	1.00/cc	
	Chemigation Ground Low volume spray Soil Drench	Foliar Bloom	1.0	1/cc	1.0[a]	
			0.51	NS	NS	
			0.5	2[b]	1	
Tomato	Chemigation	Preplant	3.74 – 4.0	1	3.74 – 4.0	1

Uses	Application type**	Application Timing	Maximum application rate / application (lbs a.i./A)	Number of applications/ year	Maximum application rate/year (lbs a.i./A/yr)	Crop cycles per year[e]
	Soil Incorporated (max of 8 inch depth) Soil Drench Ground					
	Chemigation Low Volume Ground	Foliar	0.77	5/cc	3.85[a]/cc	

NS=not specified; NA=not applicable; cc=crop cycle; yr=year

a Calculated from maximum rate per application and maximum number of applications per year.

b Calculated from maximum number of applications and maximum single application rate.

c Ginseng, cranberries and pineapple are a listed crop for diazinon; however, they are not grown in California and were not assessed in this assessment. Watercress is a use allowed in Hawaii and was not examined. Filbert is allowed for use in Washington and Oregon.

d Does not have any transplant uses.

e Crop cycles per year are based on a memo from Mohammed Ruhman completed in 2009 (USEPA, 2009e) or a memo from BEAD produced for a methomyl assessment (USEPA, 2007a), unless another reference is provided.

f Estimated from a reported application rate of 0.0008 lbs a.i./inch diameter of ant mound. Reported diameter ranges of ant mounds ranged from 8 to 18 inches (Pest Control Solutions, 2012) in diameter with 20 to 1000 plus mounds per acre (Texas Imported Fire Ant Research and Management Project, 2012). Assuming an 18 inch diameter and 1000 mounds per acre estimates a maximum application rate of 14.4 lbs a.i./A. Assuming an 8 inch diameter and 1000 mounds per acre estimates a maximum application rate of 2.8 lbs a.i./A. The low end of an application rate would assume an average 8 inch diameter and 20 mounds per acre resulting in an application rate of 0.128 lbs a.i./A.

g Estimated from a reported application rate for transplants of 0.003 lbs a.i./plant x 38,720 plants/acre = 116 lbs a.i./A (Kahn *et al.*).

i The special local needs (SLN) label CA-50002 is registered to the California Department of Food and Agriculture, to be used for fruit fly pests subject to State quarantine action on ornamental tree fruit nursery stock (all fruit must be removed from plants) and ornamental nursery stock. Uses are for an SLN Uses include almonds, apple, apricot, beans, bushberry, cherry, corn, fig, filbert, Grapes, melons, nectarine, olive, ornamentals, peach pear, peas, pecan, pepper, plum, prune, tomato, walnut, squash, and strawberry. This use is assessed; however, use is expected to be only under the close supervision of state and county authorized individuals and risk to endangered species may be limited.

Most diazinon labels provide a maximum application rate per year. Maximum application rates on a crop cycle basis were provided for crops with one crop cycle. Therefore, even though some of the crops have multiple crop cycles, the labeled rates apply to the entire year. Uses that do not have a maximum application rate per year that were applied at preplant were assumed to be allowed for one application per year, unless the crop had multiple crop cycles. If the crop had multiple crop cycles per year, the number of crop cycles was assumed to be the maximum number of applications when the maximum number was not specified on the label.

There are a few uses where a maximum number of applications and a maximum yearly application rate were not available (melons, strawberries, lettuce, and nursery stock). Finally, the use rates on ant mounds (0.0007 to 0.0008 lbs a.i./inch diameter of ant mound in blueberries) and cole crop transplant rates (0.003 lbs a.i./plant) are not available in typically used units. Reported diameter ranges of ant mounds ranged from 8 to 18 inches (Pest Control Solutions, 2012) in diameter with 20 to 1000 plus mounds per acre (Texas Imported Fire Ant Research and Management Project, 2012). Assuming an average 18 inch diameter for ant mounds and 1000 mounds per acre results in an estimated maximum application rate of 14.4 lbs a.i./A. Assuming an average 8 inch diameter ant mound and 1000 mounds per acre results in an estimated maximum application rate of 2.8 lbs a.i./A. The low end of an application rate was calculated assuming an average 8 inch diameter ant mound and 20 mounds per acre resulting in an application rate of 0.128 lbs a.i./A. In this assessment, high and low application rates of 14.4 lbs a.i./A and 2.8 lbs a.i./A were assumed for use on ant mounds. For the transplant use on cole crops on a per plant basis, the application rate was estimated from a reported application rate for transplants of 0.003 lbs a.i./plant multiplied by 38,720 plants/acre, resulting in an application rate of 116 lbs a.i./A (Kahn *et al.*).

The special local needs (SLN) label CA-50002 is registered to the California Department of Food and Agriculture, to be used for fruit fly pests subject to State quarantine action on ornamental tree fruit nursery stock (all fruit must be removed from plants) and ornamental nursery stock. This SLN is for soil drench under host plants. Treatments are for quarantine and eradication purposes and are limited to applications under direct supervision by federal, state or county authorized persons. This SLN is generally used at large nurseries in southern California to treat fruit fly infestations. This treatment is not used every year, and is generally used as a last resort. The SLN is labeled for three applications at 14 day intervals at a maximum rate of 3.984 lbs a.i./A per application. Uses include almonds, apple, apricot, beans, bushberry, cherry, corn, fig, filbert, grapes, melons, nectarine, olive, ornamentals, peach pear, peas, pecan, pepper, plum, prune, tomato, walnut, squash, and strawberry.

Labels also permit applications of diazinon to ginseng, cranberry, and pineapple (which are not included in **Table 2-8**); however, based on analysis of National Agricultural Statistics Service (NASS) data, these crops are not grown in California and are therefore, not relevant to this assessment. Watercress is a use allowed in Hawaii and was not examined. Use of diazinon on filbert is allowed only in Washington and Oregon.

There is potential use of diazinon in cattle ear tags within California. Ear tags may contain up to six grams of diazinon each (EPA Reg. No. 61483-80). Diazinon is expected to mainly stay associated with the ear tag and exposure is expected to be minimal for aquatic species. Therefore, this exposure route was not quantitatively assessed for potential risk to the DS and TG.

The Agency's Biological and Economic Analysis Division (BEAD) provides an analysis of both national- and county-level usage information (USEPA, 2012a) using state-level usage data obtained from USDA-NASS[13], 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[14]. 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 diazinon 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 made on every use site at the section level (approximately one square mile) of the public land survey system.[15] BEAD summarized these data to the county level by site, pesticide, and unit treated. Calculating county-level usage

[13] 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.
[14] 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.
[15] 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).

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 twelve years. The units of area treated are also provided where available.

Across California, uses on lettuce and on animal premises had the highest average annual pounds applied. Use on lettuce and animal premises accounted for 30 and 16% of average annual pounds applied, respectively. Use on almond, prune, and peach all had use accounting for greater than 5% of average annual pounds applied. A summary of diazinon usage for all California use sites is provided below in **Table 2-9.**

Pesticide use data available from the CDPR includes county-level data for various diazinon uses. Past uses of diazinon include all of the uses identified in **Table 2-8**, as well as uses that are no longer permitted. Analysis of the mass of diazinon applied with consideration of the application area indicates that applications have been made at or above the maximum application rates identified in **Table 2-8**.

Table 2-9. Summary of California Department of Pesticide Registration (CDPR) Pesticide Use Reporting (PUR) Data from 1999 to 2010 for Currently Registered Diazinon Uses[1]

Site Name	Average Annual Pounds Applied	Percentage of Average Annual Pounds Applied	Average Application Rate (lbs a.i./A)	Maximum Application Rate (lbs a.i./A)
LETTUCE, HEAD	63880	17.9%	0.6	21.4
ANIMAL PREMISE	58357	16.3%	0.1	0.2
LETTUCE, LEAF	43928	12.3%	0.7	17.9
ALMOND	24599	6.9%	1.9	31.9
PRUNE	22130	6.2%	1.7	20.6
PEACH	18872	5.3%	1.9	66.7
SPINACH	15353	4.3%	2.3	37.3
BROCCOLI	12232	3.4%	1.4	47.6
TOMATO, PROCESSING	10295	2.9%	1.3	7.5
ONION, DRY	10249	2.9%	1.2	16.6
SUGARBEET	8466	2.4%	0.5	6.1
LANDSCAPE MAINTENANCE	6880	1.9%	0.7	2.0
CHERRY	6071	1.7%	1.7	31.8
N-OUTDR TRANSPLANTS	5303	1.5%	0.7	12.6
PLUM	4913	1.4%	1.9	39.9
APPLE	4710	1.3%	1.5	49.1
CAULIFLOWER	4631	1.3%	1.5	12.4
CARROT	3218	0.9%	0.8	9.9
CANTALOUPE	2610	0.7%	0.5	5.6
PEAR	2563	0.7%	1.5	20.0
APRICOT	2529	0.7%	1.7	16.0
PEPPER, FRUITING	2316	0.6%	1.8	9.3

Site Name	Average Annual Pounds Applied	Percentage of Average Annual Pounds Applied	Average Application Rate (lbs a.i./A)	Maximum Application Rate (lbs a.i./A)
MELON	2206	0.6%	0.5	6.0
BEAN, SUCCULENT	2154	0.6%	2.7	15.0
WATERMELON	1810	0.5%	1.1	12.5
STRAWBERRY	1600	0.4%	0.9	23.5
CABBAGE	1571	0.4%	0.9	8.4
N-OUTDR PLANTS IN CONTAINERS	1424	0.4%	1.4	50.4
BEAN, UNSPECIFIED	1309	0.4%	2.0	8.0
BRUSSELS SPROUT	971	0.3%	0.6	4.0
ONION, GREEN	838	0.2%	1.4	6.0
MUSTARD	794	0.2%	2.1	6.7
N-GRNHS PLANTS IN CONTAINERS	784	0.2%	4.7	90.0
BEAN, DRIED	664	0.2%	3.6	15.9
TOMATO	650	0.2%	1.0	12.0
N-GRNHS FLOWER	586	0.2%	0.9	37.6
RAPPINI	579	0.2%	0.5	24.3
PEAS	570	0.2%	0.6	6.6
ENDIVE (ESCAROLE)	559	0.2%	0.6	5.0
KALE	523	0.1%	0.6	15.9
RASPBERRY	521	0.1%	1.2	62.5
CHINESE CABBAGE (NAPPA)	509	0.1%	0.5	7.5
BLACKBERRY	373	0.1%	1.5	5.2
BOK CHOY	358	0.1%	0.6	66.7
BLUEBERRY	341	0.1%	0.9	1.5
BEET	317	0.1%	2.2	62.4
RADISH	230	0.1%	2.4	7.5
N-OUTDR FLOWER	192	0.1%	0.9	100.0
RIGHTS OF WAY	165	0.0%	0.6	1.0
FIG	103	0.0%	1.5	7.9
N-GRNHS TRANSPLANTS	95	0.0%	0.5	10.8
TURNIP	75	0.0%	2.5	24.0
SWISS CHARD	68	0.0%	1.4	24.3
GAI LON	68	0.0%	1.0	5.0
GARLIC	45	0.0%	2.8	4.0
COLLARD	44	0.0%	0.6	4.5
CHINESE GREENS	34	0.0%	1.8	50.6
PARSLEY	32	0.0%	2.1	50.3
VEGETABLES, LEAFY	8	0.0%	1.7	4.0
LEEK	6	0.0%	0.8	5.6
CHRISTMAS TREE	5	0.0%	0.5	3.0

Site Name	Average Annual Pounds Applied	Percentage of Average Annual Pounds Applied	Average Application Rate (lbs a.i./A)	Maximum Application Rate (lbs a.i./A)
ARRUGULA	5	0.0%	2.0	2.2
STONE FRUIT	5	0.0%	1.1	4.0

N=Nursery
1- Based on data supplied by BEAD (USEPA, 2012a). Only registered uses were included in table.

2.6. Assessed Species

Table 2-10 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 III**. See for a map of the current range and designated critical habitat of the DS. Maps with details on TG current range and designated critical habitat are available in **Appendix N**.

The DS is a nearly translucent steely-blue fish found only in the brackish waters from Suisun Bay upstream through the Sacramento-San Joaquin River Delta in Contra Costa, Sacramento, San Joaquin, Solano and Yolo Counties. DS spawn in backwater sloughs and along channels with tidal influence. Most DS live one year and die after their first spawning. Young delta smelt then feed and grow in the mixing zone before starting their upstream spawning migration in late fall or early winter. Young feed entirely on zooplankton.

The TG is a small fish that inhabits brackish water along the coast of California. It is found in Marin, Sonoma and San Mateo Counties; it is extirpated from Contra Costa, Alameda and San Francisco Counties. TG are found in lagoons, estuaries and backwater marshes that are adjacent to the Pacific Ocean. TG feed on small invertebrates, usually mysids, amphipods, ostracods, snails, and aquatic insect larvae, particularly dipterans. Small TG (four to eight mm SL) probably feed on unicellular phytoplankton or zooplankton similar to many other early stage larval fishes.

Table 2-10. 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
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 Bay, CA	The species is adapted to living in fresh and brackish water. They typically occupy estuarine areas with salinities below 2 parts per thousand (although they have been found in areas	Yes	They spawn in fresh or slightly brackish water upstream of the mixing zone. Spawning season usually takes place from late March through mid-May, although it may occur from late winter (Dec.) to early	They primarily eat planktic copepods, cladocerans, amphipods, and insect larvae. Larvae feed on phytoplankton; juveniles feed on zooplankton.

Assessed Species	**Size**	**Current Range**	**Habitat Type**	**Designated Critical Habitat?**	**Reproductive Cycle**	**Diet**
			up to 18ppt). They live along the freshwater edge of the mixing zone (saltwater-freshwater interface).		summer (July-August). Eggs hatch in 9 – 14 days.	
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	Cahllow (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 late April to July	They feed mainly on macroinvertebrates such as mysid shrimp, gamarid amphipods, ostracods and aquatic insects such as chironomid larvae. Small TG (four to eight mm SL) probably feed on unicellular phytoplankton or zooplankton similar to many other early stage larval fishes.

[1] For more detailed information on the distribution, habitat requirements, and life history information of the assessed listed species, see Attachment III.

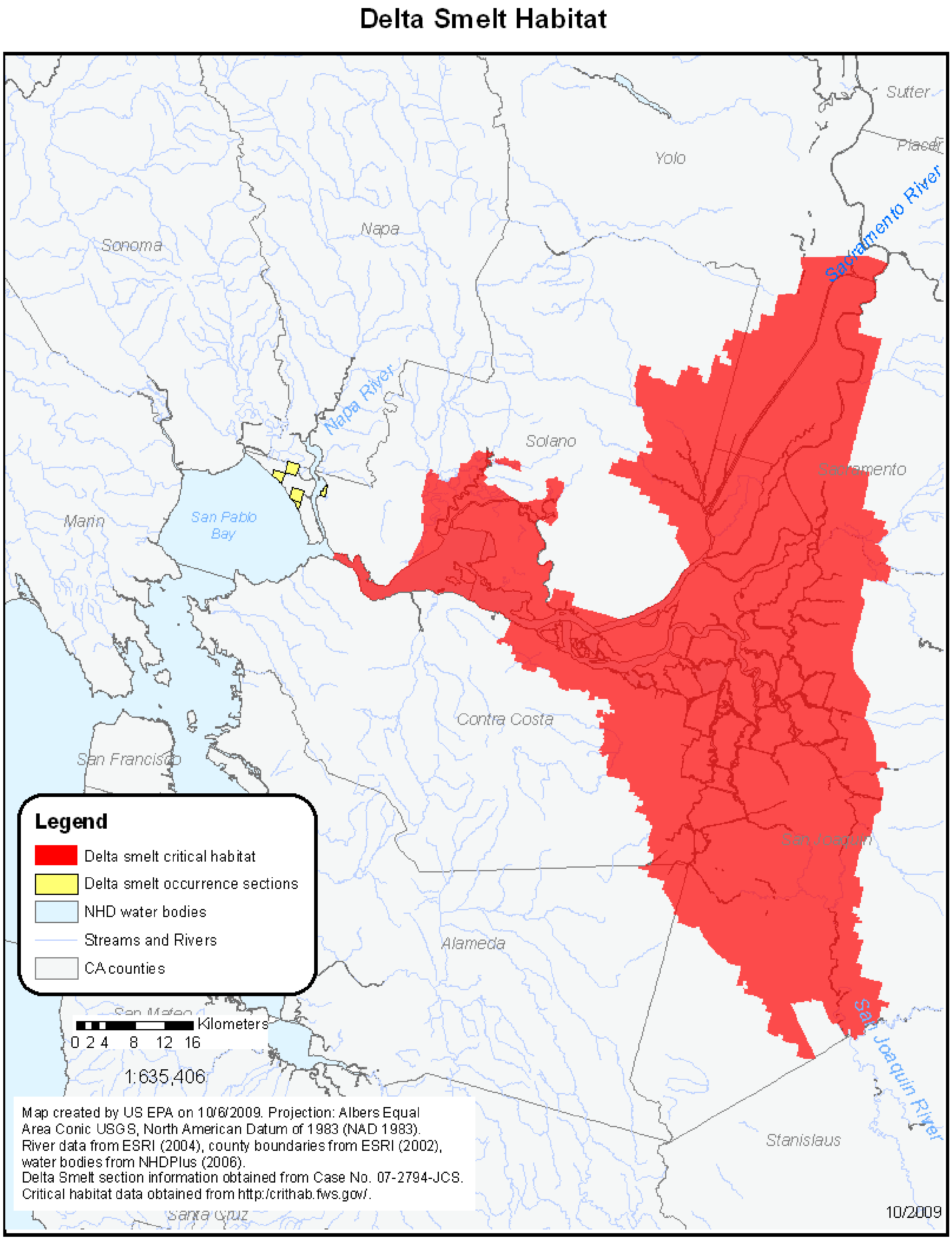

Figure 2-3. Delta Smelt Critical Habitat and Occurrence Sections outside of the critical habitat identified in Case No. 07-2794-JCS

2.7. Designated Critical Habitat

Critical habitat has been designated for the DS and TG. 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 2-11** describes the PCEs for the critical habitats designated for the DS and TG.

Table 2-11. Designated Critical Habitat PCEs for the Delta Smelt and Tidewater Goby[1].

Species	PCEs	Reference
Delta Smelt	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	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

Species	PCEs	Reference
	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.	

[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.

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 diazinon that may alter the PCEs of the designated critical habitat for the DS and the TG 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 diazinon is expected to directly impact living organisms within the action area, critical habitat analysis for diazinon 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.

2.8. Action Area and LAA Effects Determination Area

2.8.1. 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 diazinon is likely to encompass considerable portions of the United States based on the large array of 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 DS and TG and their designated critical habitat 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 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 DS and TG and designated critical habitat may be affected or modified via endpoints associated with reduced survival, growth, or reproduction.

2.8.2. 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 LAA effects 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 diazinon. An analysis of labeled uses and review of available product labels was completed. Several 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 food use crops and those that are non-food/non-agricultural uses. For those uses relevant to the assessed species, the analysis indicates that, for diazinon, the following uses are considered as part of the federal action evaluated in this assessment:

Agricultural Uses: almonds, apple, cherry, pear, apricot, nectarine, plum, prune, peach, succulent beans, lima beans, beans, snap beans, beets, blackberry, caneberry, boysenberry, dewberry, loganberry, raspberry, blueberry, broccoli, Brussel sprouts, cabbage, cauliflower, collard, kale, mustard, carrot, peas, pepper, fig, endive, spinach, lettuce, garlic, leek, musk melon, water melon, winter melon, honeydew melon, cantaloupe, onion, green onion, scallions, spring onion, radish, shallot, rutabaga, strawberry, tomato.

Nursery Stock: herbaceous ornamentals, nonflowering ornamentals, woody shrubs and vines, ornamental trees, and shade trees, and miscellaneous nursery stock to control fruit flies.[16]

[16] A special local needs label (CA-5002) is registered to the California Department of Food and Agriculture, to be used for fruit fly pests and is subject to State quarantine action on ornamental tree fruit nursery stock and ornamental nursery stock.

Following a determination of the assessed uses, an evaluation of the potential "footprint" of diazinon 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 represented by 1) agricultural landcovers, which are assumed to represent vegetable and non-orchard fruit crops as well as ornamental crops (NLCD 82 for cultivated cropland) and 2) orchard and vineyard landcovers which are assumed to be representative of tree fruit and almond crops. The nursery uses do not have an associated land cover; therefore, the potential area of effects is assumed to be all of California. A full discussion of the spatial analysis is available in **Appendix N**.

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 where exposure of one or more taxonomic groups to the pesticide will result in exceedances of the listed species LOCs. As diazinon is considered to have wide usage and could be used throughout California additional analysis was not completed to determine the distance from the edge of the field where LOCs would still be exceeded. It is already known that the use area overlaps with critical habitat for TG and DS.

In addition to the buffered area from the spray drift analysis, the Potential Area of LAA Effects area also considers the downstream extent of diazinon that exceeds the LOC based on downstream dilution analysis (discussed in Section 5.2.3).

Volatilization, atmospheric transport and deposition are characterized in the uncertainties section and are not considered in the calculation of RQs; therefore, it is possible that the final action area identified in the risk discussion is actually larger because of these transport pathways.

An evaluation of usage information was conducted to determine the area where use of diazinon 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 indicate that diazinon has historically been used on a wide variety of agricultural and non-agricultural uses throughout the watershed).

2.9. Assessment Endpoints and Measures of Ecological Effect

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

2.9.1. 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 2-12** identifies the taxon used to assess the potential for direct and indirect effects from the uses of diazinon 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 2-13**.

Table 2-12. Taxa Used in the Analyses of Direct and Indirect Effects for the Assessed Listed Species

Listed Species	Terrestrial Plants	FW Fish	FW Inverts.	Estuarine/ Marine Fish	Estuarine/ Marine Inverts.	Aquatic Plants
Delta smelt	Indirect (habitat)	Direct*	Indirect (prey)	Direct*	Indirect (prey)	Indirect (food/ habitat)
Tidewater goby	Indirect (habitat)	Direct*	Indirect (prey)	Direct*	Indirect (prey)	Indirect (food/ habitat)

Abbreviations: NA = Not applicable; Invert. = Invertebrate; FW = Freshwater
*The most sensitive fish species across freshwater and estuarine/marine environments is generally used to assess effects for these species because they may be found in freshwater or estuarine/marine environments. In this case both freshwater and saltwater acute test results were very similar.

Table 2-13. Taxa and Assessment Endpoints Used to Evaluate the Potential for Use of Diazinon 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 Aquatic-Phase Amphibians	Direct Effect – -Tidewater Goby* -Delta Smelt*	Survival, growth, and reproduction of individuals via direct effects	1a. Rainbow trout acute LC_{50} 1b. Brook trout chronic NOAEC
2. Freshwater Invertebrates	Indirect Effect (prey) -Tidewater Goby* -Delta Smelt*	Survival, growth, and reproduction of individuals or modification of critical habitat/habitat via indirect effects on aquatic prey food supply (*i.e.*, freshwater invertebrates)	2a. Waterflea acute EC_{50} 2b. Waterflea chronic NOAEC
3. Estuarine/Marine Fish	Direct Effect – -Tidewater Goby* - Delta Smelt*	Survival, growth, and reproduction of individuals via direct effects	3a. Striped mullet acute LC_{50} 3b. Sheepshead minnow NOAEC
4. Estuarine/Marine Invertebrates	Indirect Effect (prey) -Tidewater Goby -Delta Smelt	Survival, growth, and reproduction of individuals or modification of critical habitat/habitat via indirect effects on aquatic prey food supply (*i.e.*, estuarine/marine invertebrates)	4a. Mysid shrimp acute EC_{50} 4b. Mysid shrimp chronic NOAEC
5. Aquatic Plants (freshwater/marine)	Indirect Effect (food/habitat) -Tidewater Goby* -Delta Smelt*	Survival, growth, and reproduction of individuals or modification of critical habitat/habitat via indirect effects on habitat, cover, food supply, and/or primary	5a. Non-vascular plant acute EC_{50} (freshwater algae or diatom, or ECOTOX non-vascular).[1] Data on vascular plants are not available.

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
		productivity (*i.e.,* aquatic plant community)	
9. Terrestrial Plants	<u>Indirect Effect (food/habitat) (non-obligate relationship)</u> -Tidewater Goby -Delta Smelt	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)	6a. Distribution of EC_{25} values for monocots (seedling emergence and vegetative vigor) 6b. Distribution of EC_{25} values for dicots (seedling emergence and vegetative vigor)

*The most sensitive fish species across freshwater and estuarine/marine environments is used to assess effects for these species because they may be found in freshwater or estuarine/marine environments.
[1] Data are only available on one of four species of non-vascular plants (green algae, *Pseudokirchneriella subcapitata).*

2.9.2. Assessment Endpoints for Designated Critical Habitat

As previously discussed, designated critical habitat is assessed to evaluate actions related to the use of diazinon that may alter the PCEs of the assessed species' designated critical habitat. PCEs for the assessed species were previously described in Section 2.7. 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 diazinon 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.

2.10. Conceptual Model

2.10.1. 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 diazinon to the environment. The following risk hypotheses are presumed in this assessment:

The labeled use of diazinon within the action area may:

- directly affect DS and TG by causing mortality or by adversely affecting growth or fecundity;
- indirectly affect DS and TG and/or modify their designated critical habitats by reducing or changing the composition of food supply;
- indirectly affect DS and TG and/or modify their designated critical habitats 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 DS and TG and/or modify their designated critical habitats by reducing or changing the composition of the terrestrial plant community in the species' current range;
- indirectly affect DS and TG and/or modify their designated critical habitats by reducing or changing aquatic habitat in their current range (via modification of water quality parameters, habitat morphology, and/or sedimentation).

2.10.2. Diagrams

The conceptual model is a graphic representation of the structure of the risk assessment. It specifies the diazinon release mechanisms, biological receptor types, and effects endpoints of potential concern. The conceptual models for DS and TG and the conceptual models for the aquatic and terrestrial PCE components of critical habitats are shown in **Figure 2-4** and **Figure 2-5.** 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 the DS and TG and modification to designated critical habitat is expected to be negligible.

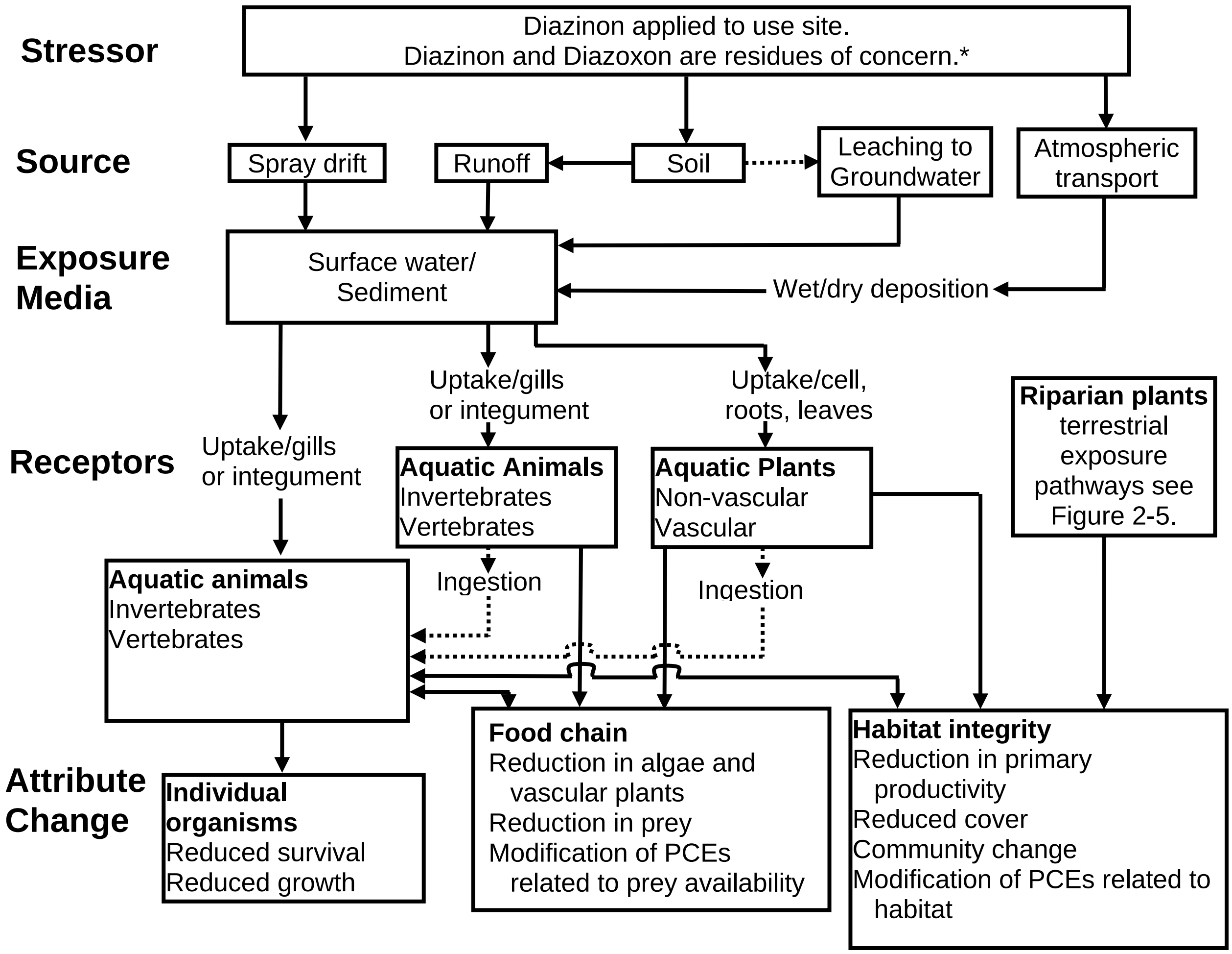

Figure 2-4. Conceptual Model Depicting Stressors, Exposure Pathways, and Potential Effects to Aquatic Organisms from the Use of Diazinon.
Dotted lines indicate exposure pathways that have a low likelihood of contributing to ecological risk for the Delta smelt and Tidewater goby. *While diazoxon is a residue of concern, risk quotients were not calculated including diazoxon residues.

The vapor pressure and Henry's law constant indicate that diazinon is semivolatile and that it will undergo atmospheric transport. Air monitoring data (discussed in Section 3.4.2) shows that diazinon can occur in fog and rain. An assessment of the potential additional exposure due rainfall is included in the uncertainties Section, 6.1.1.a. Tools to evaluate the potential additional exposure due to dry deposition are not available and consequently, this route was not assessed.

For terrestrial exposure, only the effects on habitat integrity as mediated through potential effects on terrestrial plants which border the stream are considered as DS and TG dietary items do not include terrestrial sources.

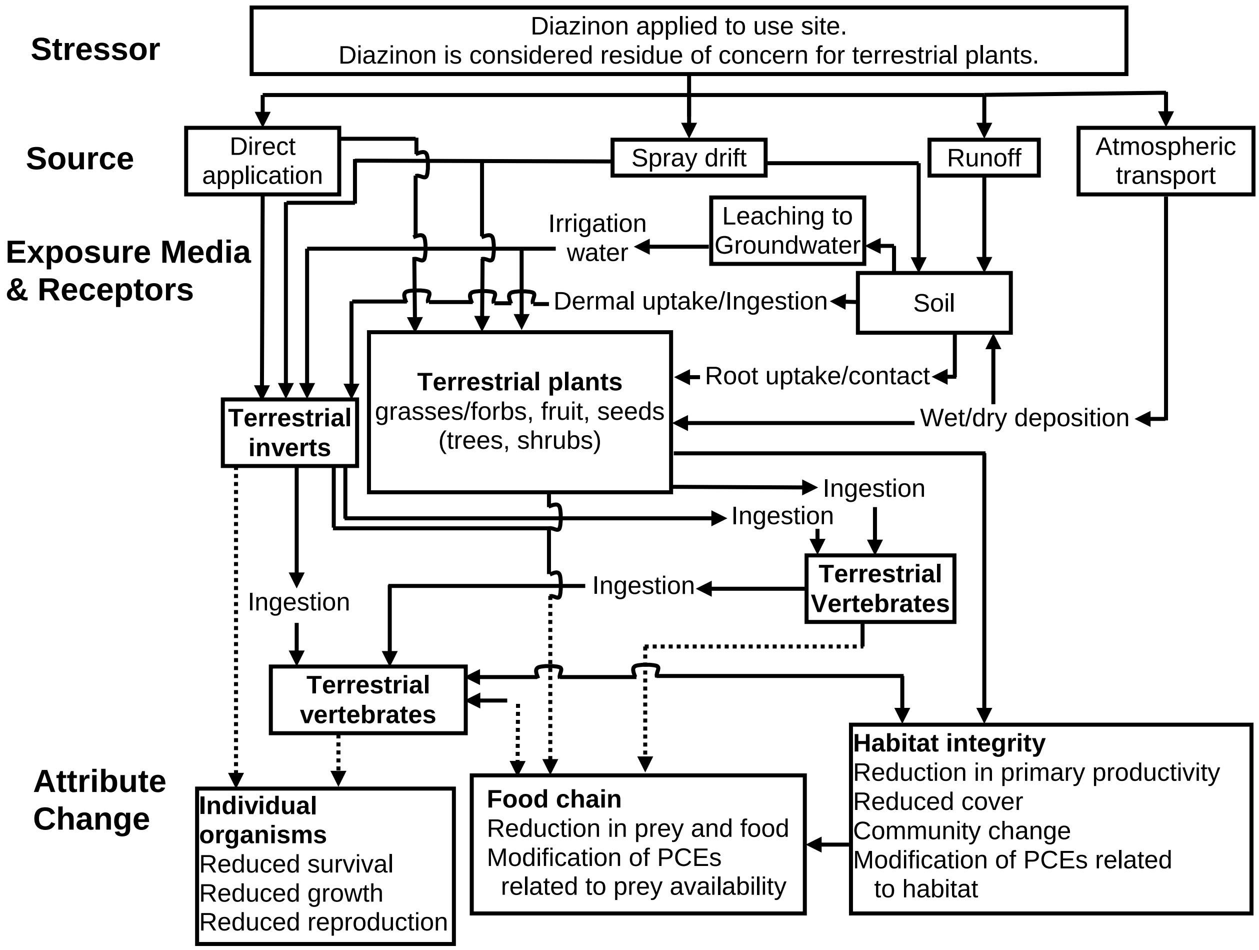

Figure 2-5. Conceptual Model Depicting Stressors, Exposure Pathways, and Potential Effects to Terrestrial Organisms from the Use of Diazinon.
Dotted lines indicate exposure pathways that have a low likelihood of contributing to ecological risk for the Delta smelt and tidewater goby.

2.11. 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 diazinon 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, 2004b), the likelihood of effects to individual organisms from particular uses of diazinon 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**.

2.11.1. Measures of Exposure

The environmental fate properties of diazinon along with monitoring data identifying its presence in surface water, in air and in precipitation in California indicate that spray drift, runoff, volatilization, atmospheric transport and subsequent deposition represent potential transport mechanisms of diazinon to aquatic and terrestrial habitats. In this assessment, transport of diazinon through runoff and spray drift is considered in deriving quantitative estimates of diazinon exposure to DS and TG, their prey and their habitats. Although volatilization of diazinon from treated areas resulting in atmospheric transport and deposition represent relevant transport pathways leading to exposure of the DS and TG and their habitats, adequate tools are unavailable at this time to include the possibility of exposures to these pathways in the calculation of risk quotients. However, monitoring data for diazinon occurrence in rainfall was used to estimate the contribution of diazinon in precipitation to aquatic exposure. (See Section 6.1.1.a).

Measures of exposure are based on aquatic and terrestrial models that predict estimated environmental concentrations (EECs) of diazinon 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). These models were parameterized using relevant reviewed registrant-submitted environmental fate data. Contributions to exposure from diazinon groundwater were assessed using SCIGROW for the maximum application practice crops, lawn and ornamental gardens, only. These models are parameterized using relevant reviewed registrant-submitted environmental fate data. More information on these models is available in **Attachment I**. Monitoring data are also evaluated to determine whether aquatic exposure is being observed in the environmental that could result in a risk concern.

2.11.1.a. Estimating Exposure in the Aquatic Environment

PRZM (v3.12.2; May 12, 2005) and EXAMS (v2.98.04.06; April 25, 2005) are screening simulation models coupled with the input shell PE (v5.0, 2006) to generate daily exposures and 1-in-10 year EECs of diazinon that may occur in surface water bodies adjacent to application sites receiving diazinon through runoff and spray drift. PRZM simulates pesticide application, movement and transformation on an agricultural field and the resultant pesticide loadings to a receiving water body via runoff, erosion and spray drift. EXAMS simulates the fate of the pesticide and resulting concentrations in the water body. The standard scenario used for ecological pesticide assessments assumes application to a 10-hectare agricultural field that drains into an adjacent 1-hectare water body, 2 meters deep (20,000 m^3 volume) with no outlet. PRZM/EXAMS was used to estimate screening-level exposure of aquatic organisms to diazinon. The measure of exposure for aquatic species is the 1-in-10 year return peak or rolling mean concentration. The 1-in-10 year peak is used for estimating acute exposures of direct effects to the DS and TG, as well as indirect effects to the DS and TG through effects to potential prey items, including: algae, aquatic invertebrates, fish and aquatic-phase frogs. The 1-in-10-year 60-

day mean is used for assessing chronic exposure to the DS and TG and their prey items; the 1-in-10-year 21-day mean is used for assessing chronic exposure for aquatic invertebrates, which are also potential prey items.

Given the aquatic toxicity of diazinon and its likelihood of occurring in sediment, the Agency also considered the potential exposures resulting from benthic/sediment concentrations (EECs). Pore water concentrations are commonly used to predict toxicity of non-ionic substances in sediments and characterize exposure to organisms that spend time in or near sediments (DiToro *et al.*, 1991; USEPA, 2003). PRZM/EXAMS also estimates 1-in-10-year peak, 21-day mean, and 60-day mean EECs for pore water. Total sediment concentrations may also be used to predict exposure to organisms. For example, total sediment concentrations may be used to predict exposure from ingested sediment. Total sediment concentrations were characterized based on monitoring data. These estimated EECs can be used to calculate risk quotients to determine possible risks; however, sediment data are not available to evaluate risk using concentration in bulk-sediment and this analysis was not performed in this assessment.

The SCIGROW model (version 2.3) is used to assess pesticide concentration in vulnerable groundwater. The model provides an exposure value which is used to determine the potential risk to the environment The SCI-GROW estimate is based on environmental fate properties of the pesticide (aerobic soil degradation half-life and linear adsorption coefficient normalized for soil organic carbon content), the maximum seasonal application rate, and existing data from small-scale prospective ground-water monitoring studies at sites with sandy soils and shallow groundwater.

Pesticide concentrations estimated by SCI-GROW represent conservative or high-end exposure values because the model is based on ground-water monitoring studies which were conducted by applying pesticides at maximum allowed rates and frequency to vulnerable sites (*i.e.*, shallow aquifers, sandy, permeable soils, and substantial rainfall and/or irrigation to maximize leaching). In most cases, a large majority of the use areas will have groundwater that is less vulnerable to contamination than the areas used to derive the SCI-GROW estimate. For the purposes of this assessment, SCIGROW is being used to estimate the potential relative contribution to diazinon in DS and TG habitats from groundwater recharge.

Monitoring data are summarized in Section 3.4 and aquatic monitoring data are compared to toxicity endpoints to determine if concentrations in the environment occur at concentrations high enough to result in a risk concern.

2.11.1.b. Estimating Exposure in the Riparian Environment

EECs for terrestrial plants inhabiting dry and wetland areas are derived using TerrPlant (version 1.2.2, 12/26/2006). This model uses estimates of pesticides in runoff and in spray drift to calculate EECs. EECs are based upon solubility, application rate and minimum incorporation depth. Runoff is not expected to commonly occur in rice paddies; therefore, only the exposure estimated based on spray drift are used in the assessment.

2.11.2. Measures of Effect

Data identified in Section 2.9 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 are used in assessments is available in **Attachment I**.

2.11.2.a. 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 diazinon, 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 on 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, 2004c) (see **Appendix E**). More information on standard assessment procedures is available in **Attachment I**.

2.11.2.b. 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, 2004b). 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 diazinon 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 USEPA, 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.

2.11.3. Data Gaps

There are many environmental fate data gaps for diazinon. Each data gap is listed briefly below along with how the data gap was handled in the assessment.

- Hydrolysis: Hydrolysis data currently have an unidentified degradate that was increasing in concentration at the end of the study at pH 7 and 9. The maximum amount of applied radioactivity associated with this degradate was 7.5% on day 30 at pH 7. The maximum value would likely have been higher if the study had continued for longer. An additional concern is that diazoxon (a residue of concern) was not monitored in the hydrolysis study. Not enough information is available to determine if the unidentified residue is diazoxon.
- Aqueous Photolysis: Acceptable data are not available to quantify the degradation of diazinon in water due to photolysis. The absence of aqueous photolysis data are a significant uncertainty because 1) the influence of photolysis on the persistence of diazinon cannot be quantified, 2) identity of photolysis degradates are unknown, 3) available data and soil photolysis results indicate that diazinon may undergo photolysis, and 4) some literature studies suggest that diazinon is photo-oxidized in air to diazoxon (Glotfelty *et al.*, 1990; Schomburg *et al.*, 1991). Therefore diazoxon could form in water due to photo-oxidation as well. In the absence of data, diazinon is assumed to be stable to aqueous photolysis in environmental aquatic modeling.
- Photodegradation in air: Diazinon and diazoxon have been observed in air and precipitation, but data are not available to illuminate the formation and decline of diazinon and its transformation products in air. This is a significant source of uncertainty in the risk assessment, as this pathway may be one of the main sources of diazoxon observed in environmental samples of air, precipitation, and water. As risks due to simultaneous exposure to diazinon and diazoxon are not quantitatively assessed in this assessment, this uncertainty does not influence the calculation of risk quotients. This uncertainty is discussed in the risk characterization.
- Aerobic Soil Metabolism: Aerobic soil metabolism data are available on three soils. Results from one study were not used because raw data were missing, the purity was not specified, there were significant unextracted residues, and low recoveries of radioactivity at some sampling points (MRID 118031). The results from one study were used; however, there was some uncertainty in whether the value is representative of a United States soil because the study was conducted using a foreign soil and information are lacking data on whether the soil is comparable to a United States soil (MRID 46867004). Data are normally required on four soils so that variability in the degradation rates can be adequately characterized. Modeling inputs were estimates as the 90^{th} percentile upper confidence bound on the mean of 5.5 and 39 days (MRID 46867004 and 44746001).
- Anaerobic Soil Metabolism: No data are available examining anaerobic soil metabolism. Thus, the extent to which diazinon is subject to biotic degradation in areas where there is low oxygen is uncertain. Additionally, the identities of transformation products formed in anaerobic soil environments are unknown. Data are available on a sandy loam soil for anaerobic aquatic metabolism and the results of this study will be used to characterize the potential for anaerobic soil metabolism. Anaerobic soil metabolism data are not used in the aquatic modeling; therefore, this will not affect the calculation of aquatic EECs.

- Anaerobic Aquatic Metabolism: Data are only available on one sandy loam soil. Data are typically available on two sediments. The available data on a soil will be assumed to represent aquatic environments. Additionally, the value will be multiplied by three to account for the uncertainty in the variation in possible anaerobic aquatic metabolism rates.
- Data are not available to determine the sorption coefficients of diazinon and diazoxon. A K_{oc} was estimated using EPIWEB version 4.1 using a log K_{ow} of 3.81. Some example runs were completed with supplemental sorption coefficients from the open literature to characterize the difference between supplemental measured values and the predicted value. EECs were calculated for one scenario (26 applications at 1.0 lbs a.i./A applied to ornamental) using the mean open literature measured K_{oc} value of 884 L/kg-organic carbon and the estimated K_{oc} of 2184 L/kg-organic carbon used in this assessment to determine aquatic EECs. The EECs estimated with the lower K_{oc} were 1.31 to 1.61 times the EEC estimated using the predicted value (**Table 3-6**). It is possible that these EECs could increase when more reliable data on the true measured K_{oc} are available. This is a major uncertainty in the estimation of EECs.
- Laboratory volatility data are not available. This represents a significant source of uncertainty, as environmental monitoring data indicate that volatilization does occur, though the degree of volatilization cannot be fully quantified. In the absence of data, the volatility of diazinon was characterized using available literature data, and by estimating the potential for volatilization using vapor pressure, Henry's law constant, and estimated sorption coefficients.
- Many terrestrial field dissipation studies are available. One study has not been fully reviewed (MRID 46479601). Terrestrial field dissipation data are used to confirm the results of the laboratory studies, and to ensure that processes are not occurring in the natural environment that are not accounted for in the laboratory studies. In the absence of data, the results from the submitted supplemental terrestrial field dissipation studies will be described in the assessment.

Additionaly data gaps exist for the effects data base. No data are available for assessing the effects of exposures of diazinon to freshwater vascular plants. Generally, data for duckweed (*Lemna gibba*) are used by EFED to assess such effects. Additionally, data are only available for one of four species of non-vascular plants. Given the mode of action of diazinon in combination with the anatomy of plants, as well as the relatively low toxicity of diazinon to non-vascular, aquatic plants (green algae) and to terrestrial plants, this data gap is not of particular concern for this risk assessment. However, this data gap represents an uncertainty in the assessment of potential risk to the DS and TG, their prey and their habitats.

Currently, a chronic definitive toxicity endpoint (*e.g.*, NOAEC) for freshwater fish is not available. The potential for risk due to chronic exposure to diazinon was evaluated using an acute-to-chronic ratio calculated using a LOAEC. Risk to freshwater fish may be underestimated using available data.

Sediment toxicity data on diazinon are not available. The log K_{ow} of diazinon (3.69 to 3.85) indicates that diazinon may be found in sediment and that sediment toxicity data are needed to fully evaluate risk to sediment dwelling organisms (40 CFR Part 158.630). It is possible that risk to aquatic invertebrates in sediments is underestimated in this assessment.

3. Exposure Assessment

Diazinon is formulated as a wettable powder, an emulsifiable concentrate, and as a cattle ear tag (not considered in the aquatic exposure assessment). Application methods include low and high volume ground application, airblast, aerial application (for lettuce only), soil drench, chemigation, soil incorporation, ant mound treatment, water treatment for transplants, and soil in furrow treatment. Risks from ground boom, airblast, and aerial applications are expected to result in the highest off-target levels of diazinon due to generally higher spray drift levels. In particular, ground boom and aerial modes of application tend to use lower volumes that are applied in finer sprays than applications coincident with sprayers and spreaders and thus have an even higher potential for off-target movement via spray drift.

3.1. Modeling Approach for Surface Water

Aquatic exposures are quantitatively estimated for all assessed uses with scenarios that represent high exposure sites for diazinon, using PRZM/EXAMS and PE5.0. The site modeled is the EPA standard pond, wherein a 10 hectare field drains into a 1-hectare pond that is 2 meters deep and has no outlet. Exposure estimates generated using the standard pond are intended to represent a wide variety of vulnerable water bodies that occur in the headwaters of watersheds, including prairie pot holes, playa lakes, vernal pools, miscellaneous other wetlands, man-made and natural ponds, and intermittent and first-order streams. As a group, there are factors that may make such water bodies either more or less vulnerable than the standard surrogate pond. Such water bodies may be either smaller in volume than the standard pond, have larger drainage areas, or both. Static water bodies that have larger ratios of drainage area to water body volume would be expected to potentially have higher peak concentrations than the standard pond. However, to the extent that such water bodies also have greater hydrologic input, they will also tend to have shorter retention times; therefore, lower chronic concentrations than the standard pond (which has no discharge, and therefore infinite retention time). For example, headwater streams might have peak concentrations higher than those in the standard pond, but which persist in the same physical location for only brief periods of time, *i.e.* while rainfall runoff is occurring. As watershed size increases beyond 10 hectares, it becomes less likely that the entire watershed is planted to a single crop, all of which is treated with the pesticide.

3.1.1. Model Inputs

The appropriate PRZM and EXAMS input parameters for diazinon 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 (USEPA, 2009d) and *PE5 User's Manual (USEPA, 2006b). (P)RZM (E)XAMS Model Shell, Version (5).*, November 15, 2006. Input parameters can be grouped by physical-chemical properties and environmental fate data, application information, and use scenarios.

Physical and chemical properties relevant to assess the behavior of diazinon in the environment are presented in **Table 2-1** and **Table 2-2** and application information from the label are described in **Table 2-8**. The input parameters for PRZM and EXAMS are in **Table 3-1**. **Appendix F** contains example model output files.

3.1.1.a. Model Inputs: Environmental Fate Properties of the Chemical

Some environmental fate studies were reclassified and some of the model input parameters were altered from values used in previous assessments. These changes are briefly discussed below.

- Previous modeling multiplied a water solubility value of 40 mg/L times ten. The input parameter guidance has been modified so that the water solubility no longer needs to be multiplied by ten. The water solubility of 65.5 mg/L was used instead of the 40 mg/L value because an acceptable submitted study was available to validate the measured value.
- Previous modeling used a vapor pressure of 1.40×10^{-4} Torr. A value of 7.22×10^{-5} Torr was used instead because an acceptable submitted study was available to validate the measured value.
- Previous modeling used an aqueous photolysis half-life of 37 days. This study was reclassified as invalid in 2012 because the methodology in the study was not adequate to accurately quantify diazinon and oxypyrimidine. The temperature fluctuated between 12 and 49°C, and the material balance was low (82%). The aqueous photolysis rate was assumed to be stable for this assessment. This was identified as a datagap in the recently completed problem formulation generated in support of reregistration review of diazinon (USEPA, 2008, D349527).
- The previous aerobic soil metabolism half-life used in modeling was 38.7 days. This value is the upper confidence bound on the mean of two half-lives of 37.4 and 38.0 days (MRID 40028701 and 44746001). MRID 40028701 was reclassified as unacceptable in 2008 due to a highly variable material balance, up to 36.2 % unextracted residues, and the soil being amended with glucose which could alter the metabolism rate (DER 02/20/2008). MRID 46867004 also was reviewed since the previous assessment was completed (DER 05/05/2011). Therefore, the model input value used in this assessment was calculated as the 90% upper confidence bound on the mean of half-lives of 5.5 and 39 days using MRID 46867004 and 44746001.
- The hydrolysis rate was recalculated assuming that an unidentified residue was a residue of concern. This was recommended in the recent problem formulation completed for diazinon (USEPA, 2008, D349527). This increased the estimated half-life from 138 days to 317 days at pH 7. Therefore, diazinon was assumed to be stable to hydrolysis to minimize the need to alter the aerobic aquatic and anaerobic aquatic metabolism rates to account for hydrolysis.
- A Henry's law constant of 1.13×10^{-7} atm-m^3/mole was used in this assessment because it was a measured value (USNLM, 2009). The previously reported value was 1.40×10^{-6} atm-m^3/mole.
- Previously a mean K_{oc} value of 616 L/kg$_{oc}$ was used as an input based on MRID 00118032. In this assessment a K_{oc} value (2,184 L/kg$_{oc}$) was estimated using EPIWEB version 4.1 because MRID 0118032 was reclassified as invalid because due to the identity of radioactivity measured in soil and water not being determined in the study and numerous other deficiencies. Modeling was conducted using the mean K_{oc} (884 L/kg$_{oc}$) from

supplemental open literatures studies as well to see what the difference in EECs would be with the predicted K_{oc} versus the measured values.

- Previously the aerobic aquatic metabolism rate was assumed to be two times the aerobic soil rate because aerobic aquatic metabolism data were not available. The anaerobic aquatic metabolism rate was assumed to be stable because data were not available. In this assessment, data were available and were used in the assessment. The 90th percentile confidence bound on the mean of two half-live values adjusted to 25^{o}C (9.9 and 11.6 days at 20^{o}C and 7.0 and 8.2 days at 25^{o}C) was used as the input for aerobic aquatic metabolic half-life. The final input value was 9 days. The single anaerobic aquatic metabolism value (half-life was 24.5 days at 20^{o}C and 17.3 days at 25^{o}C) was multiplied by three to arrive at the input of 52 days because only one value was available. Temperature adjustments were made according to recommendations in an Environmental Fate And Effects Division (EFED) Water Quality Tech Team Advisory Note (USEPA, 2010b).

Modeling inputs that are not specific to uses and crops are provided in **Table 3-1**.

Table 3-1. Summary of PRZM/EXAMS Environmental Fate Inputs Used to Estimate Aquatic Exposure to Diazinon

Fate Property	Diazinon Value	MRID (or source)	Comment
Molecular Weight (g/mole)	304.35	(AERU, 2009)	--
Henry's Law constant (atm-m^3/mole)	1.13 x 10^{-7}	(USNLM, 2009)	--
Vapor Pressure (Torr)	7.22 x 10^{-5}	MRID 42970809	--
Solubility in Water (mg/L)	65.5	MRID 42970808	--
Organic-carbon water normalized distribution coefficient (K_{OC}, L/kg OC)	2184 (estimated) 884 (measured)	EPIWEB Version 4.1	Estimated as no acceptable data were available. The measured value is from supplemental open literature studies that contained deficiencies such that the values may not be accurate. However, as there are many measured values, the results from the estimated and measured K_{oc} values were characterized.
Chemical Application Method (CAM)	1 for surface applied 2 for foliar applied	Label	Default values based on pe5 User Guide
Incorporation Depth (cm)	0 when not incorporated 4 cm when incorporated	--	Default values based on pe5 User Guide
Application rate in kg a.i./hectare and frequency	See **Table 3-6**	--	Calculated from lbs a.i./A using the following equation: (lbs a.i./A) x (1 kg/2.205 lbs) x (2.47 A/hectare)=kg a.i./ha.
Application Efficiency	0.95 for aerial 0.99 for ground 0.99 for airblast	--	Default values based on input parameter guidance

Fate Property	Diazinon Value	MRID (or source)	Comment
Spray Drift Fraction	0.05 for aerial 0.03 airblast 0.01 for ground 0 for soil incorporation 0 for mound treatment	--	Default values based on input parameter guidance
Application Date and Number of Applications	See **Table 3-6**	--	--
Post-harvest foliar pesticide disposition (IPSCND)	1 surface applied	--	Default values based on pe5 User Guide
Hydrolysis	0 (Stable)	MRID 40931101	The hydrolysis rate for parent only was 139 days and for parent+ an unidentified residue that could be residue of concern was 317 days. As these rates are very slow compared to aquatic metabolism rates, stability was assumed so that the aquatic metabolism rates would not need to be corrected for hydrolysis.
Aqueous Photolysis Half-life (days)	0 (Stable)	No data available	--
Water Half-life (Aerobic Aquatic Metabolism (water column in days)	9	MRID 46386604	90% upper confidence bound of the mean of 2 half-lives for diazinon. Half-lives were measured at 20°C and adjusted to 25°C.
Benthic half-life (Anaerobic Aquatic Metabolism in days)	74	MRID 46386604	Value in one soil-water system times three. Half-lives were measured at 20°C and adjusted to 25°C.
Soil half-life (Aerobic Soil Metabolism Half-lives in days)	48	MRID 46867004, 44746001	90% upper confidence bound of the mean of 2 half-lives for diazinon.

1 – Inputs determined in accordance with EFED *Guidance for Selecting Input Parameters in Modeling the Environmental Fate and Transport of Pesticides*, Version 2.1, October 22, 2009 (USEPA, 2009d).
2 – A value of 0 was used for input for the soil incorporation depth for both CAM 1 and CAM 2. CAM 1 has a default soil incorporation depth of 4 cm.

As part of the data submitted for consideration in estimating the foliar degradation rate, the registrant also submitted data which supported a revised estimate of the foliar wash-off coefficient. In the absence of data, current EFED policy recommends a wash-off coefficient of 0.5, which represents the fraction of chemical that washes off with each 1 cm of rainfall. An analysis of two relevant studies indicates that a wash-off coefficient of 0.91 is more appropriate. However, the estimates for both studies were based on two point estimates, so no error term or determination of variability in the data could be made. Therefore, the default foliar washoff rate was used in modeling. A more complete description of how the studies were assessed is in the report titled *Review and Estimation of Foliar Dissipation Half-life of Diazinon* (Munoz *et al.*, 2011).

3.1.1.b. Model Inputs: Label Application Rates and Intervals

Currently registered uses of diazinon considered for the aquatic exposure assessment within California include uses on a variety of agricultural (vegetables, cole crops, fruit, melons, garlic, row crops, and others) crops and non agricultural uses (nursery stock). A complete list of all uses being assessed is available in **Table 3-2**. Below is a brief summary of assumptions used to estimate exposure.

Application Rate. The maximum application rate on the labels was used to estimate exposure. When some labels had a lower maximum application rate relative to other labels, both rates were included in **Table 3-2.** When a group of rates were very similar, a representative rate was chosen to represent all the rates. For example, if rates ranged from 3.9 – 4.1 lbs a.i./A an application rate of 4.1 lbs a.i./A was used to represent that group as the results would be very similar. Application rates were converted to kg a.i./ha for use in PRZM/EXAMs.

Type of application. Diazinon may be applied at dormant times, preplant, at planting, to transplants, and post-emergence. It may be applied to soil or foliage as a broadcast, in furrow treatment, or soil incorporated application. The most conservative EECs resulting from the possible types of applications were reported. Chemical Application Method (CAM) values of 1 are used to represent direct applications to soil. A CAM value of 2 is used to represent foliar applications; and a CAM value of 4 is used to represent applications to soil with incorporation. In cases where CAM 4 is modeled, a default value of 4 cm is used as the incorporation depth. Labels suggest using a range of incorporation depths for different crops and pests, ranging from 1 to 8 inches (2.5-20 cm). In cases where CAM 2 is modeled, it is necessary to identify an IPSCND value, which represents the deposition of diazinon in the post-season. For this modeling effort, an IPSCND of 1 is chosen to accompany CAM 2 selections. This value represents conversion of diazinon remaining on foliage to surface application to the top soil layer. Some labels specify that a high volume or low volume of spray can be used. Both high and low volume sprays were determined to be applied at greater than 1 or 2 gallons per acre, indicating that while they were low volume applications in comparison to the high volume applications they were not ultra low volume applications that would require additional modeling. Applications could also occur using chemigation; ground applications are assumed to be representative of application using chemigation.

Application Interval and Maximum Applied per Season. The minimum application interval was not specified for most crops on the labels. When an application interval was not specified an application interval of three days was assumed for modeling.

Some labels for some crops do not specify a maximum number of applications per season or year. This occurs with foliar applications to lettuce, melons, strawberries, and ornamental nursery stock. In the case of preplant applications, it was assumed that only one application would occur, unless the crop had multiple crop cycles, in which case the number of crop cycles was used as the maximum number of applications. For those uses that did not have a maximum number of applications specified for foliar applications, a default maximum of 26 applications was assumed. More realistic scenarios of a single application or two applications were also modeled to better understand the potential for risk with the uncertainty in the label.

Table 3-2. Diazinon Use Scenarios Assumed for the Aquatic Exposure Assessment[b]

Uses	Application type**	Application Timing	Maximum application rate / application lbs a.i./A (kg a.i./ha)	Number of applications/ year	App. Occurred In[a]
Almonds	Airblast Ground	Dormant	3.024 (3.389)	1	January, May, June, August, December
			3.0(3.4)	1	
			2.81 (3.15)	1	
			0.77 (0.86)	4	
Tree Fruit 1: Apple, Cherry, Pear	Airblast Ground	Dormant Foliar	2.0 (2.2)	2	January - December
			0.51 (0.57)	1 foliar 1 dormant	
			0.625 (0.700)	2	
			0.09 (0.10)	2	
Tree Fruit2 : Apricot, Nectarine, Plum, Prune, Peach	Airblast Ground	Dormant Foliar	2.016 (2.259)	2	December – April, June
			0.51 (0.57)	1 foliar 1 dormant	
			0.504 (0.565)	2	
			0.5 (0.6)	2	
Fig	Airblast Ground	Foliar	0.5 (0.6)	1	May and July
Beans: Beans, succulent (Lima, snap)	Soil Incorporated (max depth of 8 inches)	Preplant	3.984 (4.465)	2[e]	April – early August
	Ground		4.032 (4.518)	1	
Row crop: Carrot, peas	Ground	Preplant	4.10 (4.60)	1	January - December
	Soil in Furrow Drench Treatment (incorporate to max depth of 8 inches)	At plant	2.0 (2.2)	1	
Row Crop: Beets	Ground Soil Incorporation (maximum depth not specified)	Preplant	4.097 (4.591)	1	January - December
Pepper	Ground	Preplant	4.032 (4.518)	1/crop cycle	Not available
Berries: Blackberry, Caneberry, Boysenberry, Dewberry, Loganberry, Raspberry	Airblast Ground	Dormant Foliar Before or Near bud Break	2.0485 (2.296)	1	March – May and July - December
	Airblast Ground	At Bud Break	1.02 (1.14)	1	
Blueberry	Airblast Ground	Foliar	1.008 (1.130)	2	July, August, September
			0.51 (0.57)	1-2	
	Mound treatment	Ground	14.4	1-2	
			2.8		
Cole Crops: Broccoli, Brussel Sprouts,	Soil Incorporated (8 inch max soil depth)	Preplant	4.1 (4.6)	1	January - December

Uses	Application type**	Application Timing	Maximum application rate / application lbs a.i./A (kg a.i./ha)	Number of applications/ year	App. Occurred In[a]
Cabbage, Cauliflower, Collard, Kale, Mustard[e]	Ground				
	Ground Water Treatment	Transplant	1.0 (1.12)	1	
			0.25 (0.28)	1	
	Water treatment		116[d]	1	
Leafy vegetables: endive, Spinach	Ground	Preplant	4.10 (4.60)	1	January - December
Lettuce	Soil Incorporation (max depth 8 inches) Ground Aircraft	Preplant	2.05 (2.30)	2[e]	January - December
	Aircraft	Foliar	0.51 (0.57)	4b	
	Aircraft Ground	Foliar	0.50 (0.56)	26	
Garlic and Leek	Ground	Preplant	4.03 (4.51)	1	Not available
Melons: Musk, water, winter, honeydew, cantaloupe,	Soil Incorporated (max depth 8 inches) Ground	Preplant Foliar	4.10 (4.60)	1	January – May and September - November
			4.10 (4.60)	26	
	Ground	Foliar	0.77 (0.86)	1	
			0.77 (0.86)	26	
Onions: Onion, Green onion, Scallions, Spring onion, Radish, Shallot	Soil incorporation (max depth 8 inches) Ground	Preplant	4.10 (4.60)	1	December – April and June - December
Rutabega	Ground	Preplant	4.03 (4.51)	1	Not available
outdoor ornamentals: herbaceous plants, nonflowering plants, woody shrubs and vines, trees, shade trees, and misc nursery stock	Ground	Nursery Stock	3.98	3[c]	January - December
	Ground		1.02 (1.14)	1	
	Ground		1.0 (1.1)	1a/cc	
	Ground		1.0 (1.1)	26	
Strawberry	Ground Soil Incorporation (max 2 inch depth)	Foliar Pretransplant	1.02 (1.14)	26	December – April and September
	Ground	Foliar Pretransplant	1.0 (1.1)	26	
	Ground	Foliar Bloom	1.0 (1.1)	1/cc	
			0.51 (0.57)	1 (assumed)	
			0.5 (0.6)	2b	

Uses	Application type**	Application Timing	Maximum application rate / application lbs a.i./A (kg a.i./ha)	Number of applications/ year	App. Occurred In[a]
Tomato	Chemigation Soil Incorporated (max of 8 inch depth) Ground	Preplant	4.0 (4.5)	1	April – June November
	Ground	Foliar	0.77 (0.86)	5/cc	

NS=not specified; NA=not applicable; cc=crop cycle

a Application dates were obtained by examining the CA PUR usage data and information available from crop profiles.

b No minimum retreatment intervals were specified and a three day interval was assumed except for one scenario for the following uses: miscellaneous nursery stock with three applications where a 14 day application interval is specified; preplant use on beans where a 182 day application interval was assumed, use on tree fruit with a dormant and foliar application where a 280 day interval was assumed, and a preplant use on lettuce where a 92 day interval was assumed. The intervals on beans and lettuce were chosen to account for use with multiple crop cycles.

c Estimated from a reported application rate of 0.007 lbs a.i./inch diameter of ant mound. Reported diameter ranges of ant mounds ranged from 8 to 18 inches (Pest Control Solutions, 2012) in diameter with 20 to 1000 plus mounds per acre (Texas Imported Fire Ant Research and Management Project, 2012). Assuming an 8 inch diameter and 500 mounds per acre estimates a maximum application rate of 28 lbs a.i./A. Assuming an 8 inch diameter and 100 mounds per acre estimates a maximum application rate of 5.6 lbs a.i./A. The low end of an application rate would assume an average 8 inch diameter and 20 mounds per acre resulting in an application rate of 1.12 lbs a.i./A. In this assessment an application rate of 28 lbs a.i./A was assumed.

d Estimated from a reported application rate for transplants of 0.003 lbs a.i./plant x 38,720 plants/acre = 116 lbs a.i./A (Kahn *et al.*).

e Assumed that two applications were possible because two crops may be planted a year.

3.1.1.c. Model Inputs: Scenarios and Application Dates

Scenarios are used to specify soil, climatic, and agronomic inputs in PRZM, and are designed to result in high-end water concentrations associated with a particular crop or pesticide within a geographic region. Each PRZM scenario is specific to a location. Soil and agronomic data specific to the location are built into the scenario, and a specific climatic weather station providing 30 years of daily weather values is associated with the location. **Table 3-3** identifies the use sites associated with each PRZM scenario and **Table 3-4** specifies the location, soil type, curve number, and time of year with the most rainfall for each PRZM scenario. The scenarios that included irrigation were for almond, fruit, onion, and tomato.

Table 3-3. Summary of Use Sites Associated with Each PRZM Scenario

Modeling Scenario	Uses
CAalmond_WirrigSTD.txt	Almonds, Filbert
CAfruit_WirrigSTD.txt	Apple, Cherry, Pear, Apricot, Nectarine, Plum, Prune, Peach, Fig
CARowCropRLF_V2.txt	Beans, succulent (Lima, snap), Carrot, Peas, Beets, Pepper
CAWineGrapesRLF_V2.txt	Blackberry, Caneberry, Boysenberry, Dewberry, Loganberry, Raspberry, Blueberry
CAcolecropRLF_V2.txt	Broccoli, , Cabbage, Cauliflower, Collard, Kale, Mustard[e]
CAlettuceSTD.txt	Leafy Vegetables: Endive, Spinach, Brussel Sprouts, Lettuce
CAGarlicRLF_v2.txt	Garlic and Leek

Modeling Scenario	Uses
CAmelonRLF_V2.txt	Musk, Water, Winter, Honeydew, Cantaloupe,
CAonion_WirrigSTD.txt	Onion, Green onion, Scallions, Spring onion, Radish, Shallot
CAnurserySTD_V2.txt	Outdoor Ornamentals: Herbaceous Plants, Nonflowering Plants, Woody Shrubs and Vines, Trees, Shade Trees, and Other Miscellaneous Nursery Stock
CAstrawberry-noplasticRLF_V2.txt	Strawberry
CAtomato_WirrigSTD.txt	Tomato
CApotato	Rutabega

Table 3-4. Characteristics of PRZM/EXAMS Scenarios Used to Estimate Concentrations of Diazinon in the Aquatic Environment.[1]

Modeling Scenario	Location of Meteorological File	Soil	Hydrologic Soil Group (SCS Curve Number)	Crop Present (MM/day – MM/ day)	Most Rainfall occurs in (average annual precipitation)
CAalmond_WirrigSTD.txt	Sacramento, CA	Manteca fine sandy loam	C(84, 79, 83)	01/16 – 09/13	December - February
CAfruit_WirrigSTD.txt	Fresno County, CA	Exeter loam	C (84, 79, 82)	01/16 – 08/01	January - March
CARowCropRLF_V2.txt	Santa Maria, CA	Mocha	B (86, 78, 82)	01/01 – 08/04	November – March (14.01 inches)
CAWineGrapesRLF_V2.txt	San Francisco, A	Haire	C (84, 79, 82)	03/01 – 08/01	December - February
CAcolecropRLF_V2.txt	Santa Maria, CA	Marimel Series, Silty Clay Loam	C (92, 88, 89)	01/01 – 03/01	November – March (14.01 inches)
CAlettuceSTD.txt	Santa Maria, CA	Placentia Series, Sandy loam	D (94, 89, 94)	02/16 – 05/12	November – March (14.01 inches)
CAGarlicRLF_v2.txt	Fresno, CA	Cerini Series	C (91, 87, 88)	10/30 – 07/30	January – March (11.23 inches)
CAmelonRLF_V2.txt	Southern San Joaquin Valley (*primarily Fresno County*)	Cerini Series	C (91, 87, 88)	05/16 – 08/02	January – March (11.23 inches)
CAonion_WirrigSTD.txt	Kern County in the San Joaquin Valley	Cievo Clay	D (92, 85, 86)	01/16 – 06/15	October - April (6.49 inches)
CAnurserySTD_V2.txt	San Diego County, CA	Cieneba Series. Sandy Loam	C (82, 82, 87)	03/01 – 11/01	November – March (10.8 inches)
CAstrawberry-noplasticRLF_V2.txt	Santa Maria Valley region	Oceano Series	A (92, 89, 90)	01/01 – 07/01	November – March (14.01 inches)
CAtomato_WirrigSTD.txt	San Joaquin County	Stockton clay	D (91, 87, 88)	03/01 – 07/01	January – March (11.23 inches)
CApotatoRLF_V2.txt	Bakersfield, CA	Lawkalb, coarse loam	C (86, 81, 85)	02/16 – 06/15	December - March

1- Information on the scenarios was obtained from *Pesticide Root Zone Model Field and Orchard Crop Scenario Metadata* (April 5, 2006) and Metatdata files for RLF and Nursery Scenarios.

Application Timing

The date of first application was developed using a summary of individual applications from the California Pesticide Use Reporting Database (CA PUR), the date of crop emergence and harvest for the scenario, information on the months with maximum rainfall for the scenario location, and information from USDA crop profiles. A sample of the distribution of diazinon applications to almonds and broccoli from the CAPUR data for 2010 used to pick application dates is shown in **Figure 3-1** and **Figure 3-2**. Similar tables for the various uses reported in the CAPUR database are available in **Appendix G**. The figure indicates that diazinon could be applied to broccoli at any time of the year and applications to almonds mainly occur from December to January. Dates when applications occurred in California are reported in **Table 3-2**. Explanations on the choice of the applications are provided as an example for almonds and broccoli. Usage data indicate that diazinon was applied to broccoli in California throughout the year; however, the label allows for applications preplant and at transplant. The crop is present on the field in the January 1 – March 1 timeframe, and most rainfall occurs between November and March in the PRZM scenario. For preplant applications to cole crops an application date of December 15^{th} was assumed (about two weeks prior to crop emergence) and for transplant an application date of January 15^{th} was chosen (a couple of weeks after crop emergence). For almonds, usage data indicated that most applications occur in January with some occurring in December, May, and August. The label allows for use on almonds during the dormant season only. Dormant season for almonds is from December 10 – March 20 (California Department of Pesticide Regulation, 2004). The crop is present in the scenario January 16^{th} through September 13^{th} and most rainfall occurs between December and February. Applications were assumed to occur on December 10^{th} and January 22^{nd}. December 10^{th} was selected to explore the variability in EECS due to changes in application dates and January 22^{nd} was chosen because usage data indicated this was a date with a high number of applications.

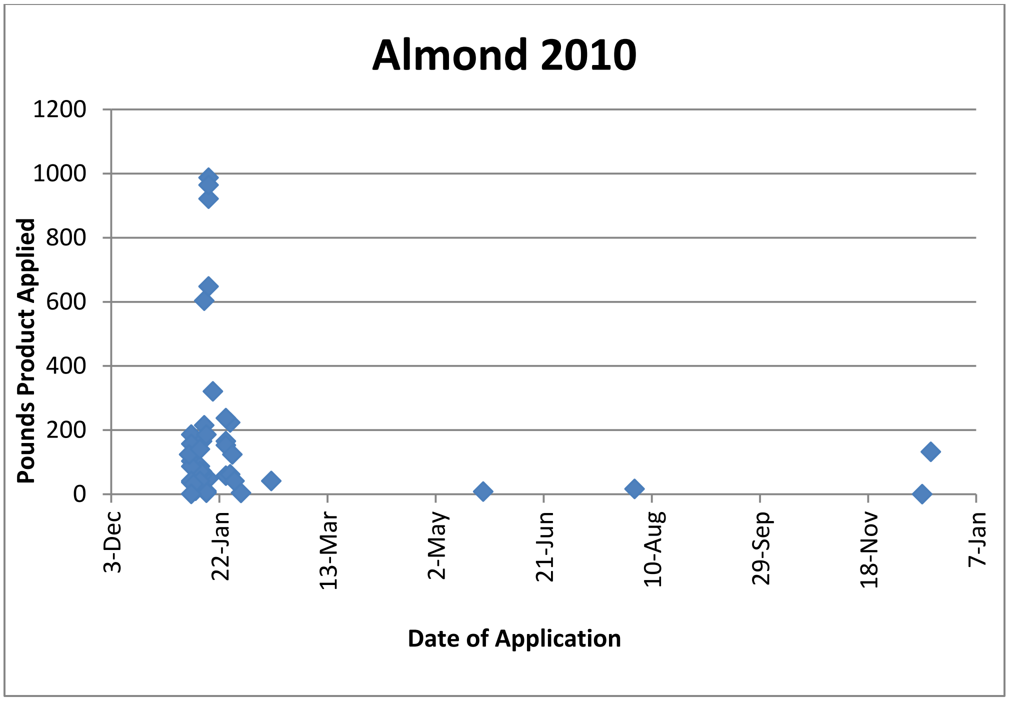

Figure 3-1. Summary of Application Dates of Diazinon to Almonds in 2010 from CA PUR data.

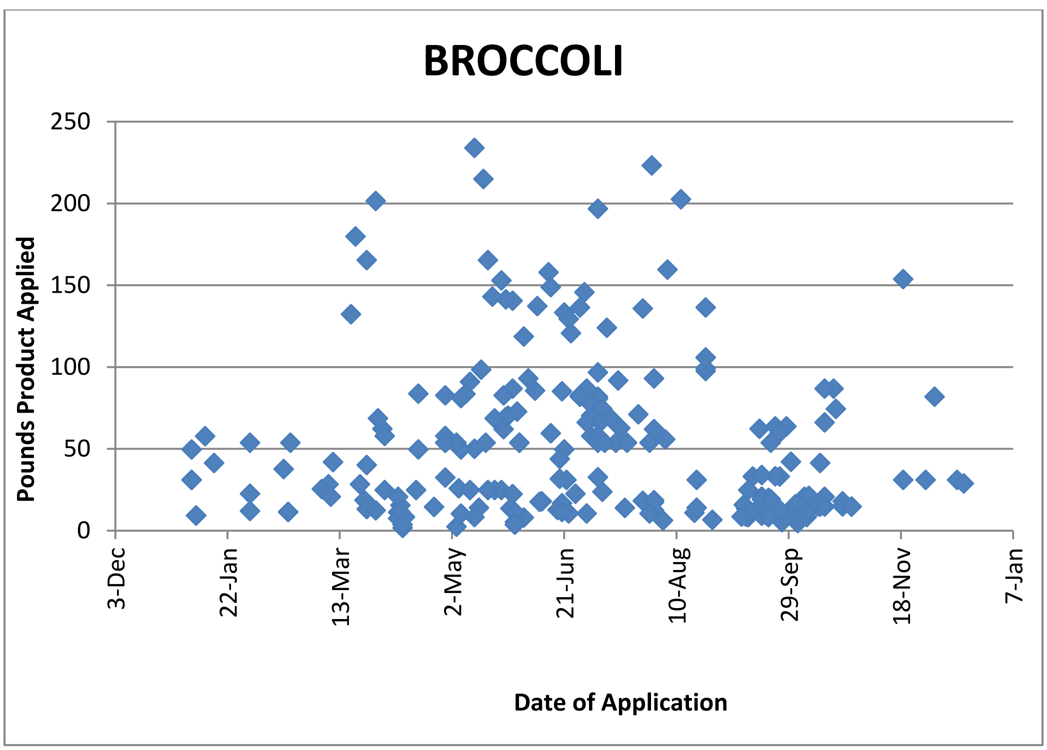

Figure 3-2. Summary of Application Dates of Diazinon to Almonds and Broccoli in 2010 from CA PUR data.

3.1.1.d. Groundwater Modeling

The input parameters for the groundwater exposure assessment are in **Table 3-5** and results are shown in **Table 3-7**. For the groundwater assessment the following use patterns were modeled:

- Cole crop transplant use, 116 lbs a.i./A, 1 application
- Ant mound control in blueberries, 14.4 lbs a.i./A, 2 applications
- Melons, 4.1 lbs a.i/A, 26 applications
- Melons, 4.1 lbs a.i./A, 1 application

These use patterns were chosen to represent high end exposure and a high end exposure that is more reasonable as three of the use patterns assume very high application rates or numbers of applications due to lack of information specified on labels. Estimated groundwater concentrations range from 0.07 to 52 µg/L based on the use scenarios. In general, groundwater-surface water interactions are not generally considered in FIFRA risk assessments.

Table 3-5. Diazinon Input Parameters and Results for Sci-Grow (version 2.3) for Diazinon

Parameter	Value	Comments
K_{oc}	2184 L·kg^{-1}	Estimated using EPIweb version 4.1
Aerobic soil metabolism half-life	22.25	Mean value from two soils (MRID 46867004 and 44746001)

3.1.2. Results for Aquatic Modeling

3.1.2.a. Surface Water

Table 3-6 summarizes the EECs for surface water. Surface water EECs ranged from 0.14 to 496.3 µg/L. Pore water EECs ranged from 0.06 to 115.3 µg/L. The highest EECs were observed for uses on ant mounds and on cole crops that were on a per plant basis where high end assumptions had to be made to convert the rate to a lbs a.i./A. These assumed use rates could be very different than those commonly used. The next highest EECs were observed for uses on melons and strawberries with 26 applications assumed and an assumption of a three day interval. This is another high end use scenario that may not commonly occur. Although such a high number of applications might not be likely to occur so close together, such an application scenario would be legal, and in keeping with existing label restrictions. Excluding the use scenarios with 26 applications results in the highest EEC of 28.60 µg/L associated with preplant use on leafy vegetables. Example output files are available in **Appendix F**. EECs were also calculated for one scenario (26 applications at 1.0 lbs a.i./A applied to ornamental) using the mean open literature measured K_{oc} value of 884 L/kg-organic carbon rather than the estimated K_{oc} of 2184 L/kg-organic carbon. The EECs estimated with the lower K_{oc} were 1.31 to 1.61 times the EEC estimated using the predicted value (**Table 3-6**). It is possible that these EECs could increase when more reliable data on the true measured K_{oc} are available. This is a major uncertainty in the estimation of EECs.

Table 3-6. Surface Water Estimated Environmental Concentrations (EECs) for Diazinon (µg/L) (Estimated Using PRZM/EXAMs)

Use Group[b]	Date of First App (DD-MM)	CAM, App Type (IPSCND)	Max app rate /app in lbs a.i./A (kg a.i./ha)	# of app/ yr	Water column EEC in µg/L			Pore Water EEC in µg/L		
					Peak	21-day	60-day	Peak	21-day	60-day
Almonds	10-12D	1 AB (NA)	0.77 (0.86)	4	12.56	7.32	4.54	2.75	2.72	2.56
	22-01D	1 AB (NA)	3.024 (3.389)	1	10.58	6.27	4.11	2.06	2.03	1.86
	10-12D	1 AB (NA)			10.87	6.78	4.18	2.54	2.52	2.37
		1 G (NA)			10.29	5.96	3.84	2.08	2.08	1.94
	22-01D	1 AB (NA)	3.0(3.4)	1	10.62	6.29	4.12	2.07	2.04	1.87
	10-12D	1 AB (NA)	2.81 (3.15)	1	10.11	6.30	3.89	2.36	2.34	2.20
	10-12 D	1 G (NA)	0.77 (0.86)	4	11.24	6.65	4.16	2.27	2.25	2.11
Tree Fruit 1	01-01D	1 AB (NA)	2.0 (2.2)	2	10.93	6.95	4.42	2.20	2.18	2.05
	01-01D	1 G (NA)	2.0 (2.2)	2	8.92	5.34	3.16	1.59	1.57	1.49
	10-12D	1 AB (NA)	2.0 (2.2)	2	9.30	5.67	3.49	2.53	2.47	2.31
	21-06 F	2 AB (1)	2.0 (2.2)	2	5.68	2.59	1.09	0.58	0.55	0.45
	15-02 D+F (280 day interval)	1 AB (NA)	0.51 (0.57)	1 F/ 1D	1.14	0.66	0.38	0.25	0.24	0.23
	15-02 D+F	2 AB (NA)	0.51 (0.57)	2	1.18	0.69	0.38	0.25	0.25	0.24
	01-01 D	1 AB (NA)	0.625 (0.700)	2	3.48	2.21	1.40	0.70	0.69	0.65
	01-01 D	1 AB (NA)	0.09 (0.10)	2	0.50	0.32	0.20	0.10	0.10	0.09
Tree Fruit 2	01-01 D	1 AB (NA)	2.016 (2.259)	2	11.23	7.13	4.53	2.26	2.24	2.11
	15-02 D+F	2 AB (NA)	0.51 (0.57)	2	1.18	0.69	0.38	0.25	0.25	0.24
Fig	30-07 F	2 AB (2)	0.5 (0.6)	1	0.90	0.34	0.14	0.07	0.07	0.06
Beans	15-12 PP	1 G (NA)	4.032 (4.518)	1	14.48	7.93	4.61	3.22	3.18	2.97
	01-02 PP	4 SI (NA)	3.984 (4.465)	2[a]	4.33	2.67	1.54	0.90	0.89	0.87
Row crop	15-12 PP	1 G (NA)	4.10 (4.60)	1	14.75	8.07	4.69	3.28	3.24	3.02
	15-12 PP	4 SI (NA)	4.097 (4.591)	1	9.11	4.91	2.86	2.00	1.97	1.84
	15-12 AP	4 SI (NA)	2.0 (2.2)	1	4.36	2.35	1.37	0.96	0.95	0.88
Berries	15-12 D	1 AB (NA)	2.0485 (2.296)	1	10.55	6.37	3.79	2.59	2.56	2.42
	15-08 F	2 AB (1)			3.50	1.79	0.89	0.84	0.82	0.73
	01-08 F	2 AB (1)	1.02 (1.14)	1	1.74	0.88	1.44	0.34	0.34	0.33
Blueberry	28-07 F	2 AB (1)	1.008 (1.13)	2	3.09	1.69	0.87	0.61	0.61	0.59
	01-08 F	2 AB (1)	0.51 (0.57)	2	1.56	0.85	0.44	0.31	0.31	0.30
	01-01 M	1 G (NA)	14.4 (16.1)	2	129.5	78.19	53.89	29.96	29.62	28.32
	01-01 M	1 G (NA)	2.8 (3.1)	2	24.86	15.05	10.38	5.77	5.71	5.44
Cole Crops	15-12 PP	1 G (NA)	4.1 (4.6)	1	20.17	11.34	7.51	5.18	5.12	4.81
	15-12 PP	4 SI (NA)			12.26	6.81	4.51	3.08	3.04	2.86
	15-01 T	1 G (NA)	1.0 (1.1)	1	4.50	2.86	1.97	1.07	1.06	1.00
	15-01 T	1 G (NA)	0.25 (0.28)	1	1.13	0.72	0.49	0.27	0.26	0.25
	15-01 T	1 G (NA)	116 (130)	1	496.3	308.3	212.5	115.3	113.4	107.7
Leafy vegetables	15-12 PP	1 G (NA)	4.10 (4.60)	1	28.60	18.26	12.47	6.91	6.84	6.42

Use Group[b]	Date of First App (DD-MM)	CAM, App Type (IPSCND)	Max app rate /app in lbs a.i./A (kg a.i./ha)	# of app/ yr	Water column EEC in µg/L			Pore Water EEC in µg/L		
					Peak	21-day	60-day	Peak	21-day	60-day
Lettuce	16-02 F	2 A (1)	0.50 (0.56)	26	27.28	18.95	14.31	8.12	8.01	7.48
	16-02 F	2 G (1)			21.51	13.48	9.18	5.19	5.13	4.78
	01-08 PP	4 SI (NA)	2.05 (2.30)	2[c]	8.44	5.17	2.99	1.88	1.86	1.67
	01-08 PP	1 A (NA)			16.06	9.93	6.47	3.88	3.84	3.46
	01-08 PP	1 G (NA)			14.86	9.23	5.40	3.40	3.36	3.01
	16-02 F	2 A (1)	0.51 (0.57)	4b	13.87	8.49	4.98	2.57	2.55	2.40
	16-02 F	2 G (1)			11.54	6.86	3.94	2.05	2.03	1.92
Garlic and Leek	15-10 PP	1 G (NA)	4.03 (4.51)	1	7.99	4.04	2.18	2.71	2.57	1.79
Melons	01-08 F	2 G (1)	0.77 (0.86)	26	30.97	18.98	13.07	8.57	8.17	6.76
	01-05 PP	1 G (NA)	4.10 (4.60)	1	3.26	1.79	0.86	0.43	0.42	0.35
	01-08 F	2 G (1)			3.79	2.16	1.48	1.04	1.02	0.94
	01-05 PP	4 SI (NA)			2.40	1.47	0.69	0.35	0.34	0.28
	01-08 F	2 G (1)	4.10 (4.60)	26	165.90	101.73	69.95	45.84	43.69	36.18
	01-08 F	2 G (1)	0.77 (0.86)	1	0.71	0.40	0.28	0.19	0.19	0.18
Onions	02-01 PP	1 G (NA)	4.10 (4.60)	1	4.23	2.56	1.64	0.87	0.86	0.79
	02-01 PP	4 SI (NA)			3.05	1.93	1.23	0.63	0.63	0.58
Rutabega	02-02 PP	1 G (NA)	4.03 (4.51)	1	21.54	11.21	5.74	2.85	2.81	2.58
Nursery Stock and Ornamentals	15-10 (NS)	2 G (NA)	1.0 (1.1)	26	85.95 112.18[d]	45.55 73.33[d]	29.65 42.56[d]	21.31 30.75[d]	20.90 30.10[d]	16.76 21.28[d]
	15-09 PP	1 G (NA)	3.984 (4.465)	3 (14 day int.)	19.01	9.67	5.19	4.29	4.18	3.06
	01-11 (NS)	2 G (NA)	1.02 (1.14)	1	3.48	1.95	1.10	1.48	1.45	1.05
Strawberry	01-01 F	2 G (1)	1.02 (1.14)	26	122.00	81.68	58.66	30.16	29.77	27.67
	01-01 F	2 G (1)	1.02 (1.14)	1	9.03	5.66	3.84	1.84	1.82	1.72
	15-12 PP	4 SI (NA)	1.02 (1.14)	1	6.26	3.59	2.22	1.31	1.29	1.21
	01-01 F	2 G (1)	0.5 (0.6)	26	64.31	42.99	30.88	15.87	15.66	14.56
	01-01 F	2 G (1)	0.5 (0.6)	2b	9.76	6.22	4.22	2.01	1.98	1.87
Tomato	15-02 PP	1 G (NA)	4.0 (4.5)	1	14.64	7.13	4.71	3.07	3.04	2.87
	15-02 PP	4 SI (NA)			8.83	4.56	2.91	1.94	1.92	1.81
	15-06 F	2 G (1)	0.77 (0.86)	5/cc	2.96	1.83	1.15	0.66	0.66	0.62

F=foliar; D=dormant; PP=preplant; T=transplant; AP=at plant; 1F/1D= 1 foliar application and 1 dormant application; M=mount treatment

[a] Two applications were assumed because there may be two crop cycles per year. Snap beans are normally planted in August and February. A date of February 1 was chosen for the first application and an interval of 182 days was chosen to coincide with an August application (Agular *et al.*, Not Reported). These dates are not consistent with when the crop is present in the scenario (January through August).

[b] See **Table 3-2** for an explanation of crops in the use group.

[C] Two applications were assumed because there may be two crop cycles per year. Lettuce seasons vary by region in California. In central California planting occurs in August to September and again November to December. Application dates were chosen as August 1st with a 92 day interval (Smith *et al.*, 2011).

[d] Values in blue were calculated using aK_{oc} of 884 L/kg-organic carbon. All other values were calculated using an estimated KOC of 2184 L/kg-organic carbon.

[e] A 14 day interval was specified on the label and used in modeling.

3.2. Modeling Approach for Groundwater

For the groundwater assessment, high end use scenarios based on conservative assumptions on use were modeled along with a maximum use scenario that is specified on a label. The resulting estimated groundwater EECs range from 0.07 to 2.10 µg/L (**Table 3-7**). These values are within the range of surface water EECs and were always lower than the surface water EEC for the same scenario. The lowest groundwater EEC (0.07 µg/L) is high enough to result in an LOC exceedance if the water is not diluted prior to exposure of aquatic invertebrates. Thus, groundwater discharge may have the potential to contribute significantly to aquatic exposure in areas where groundwater is the primary source of water, *e.g.* seep-fed wetlands. Risk quotients were only calculated for surface water exposure because surface water EECs are higher than the corresponding groundwater EECs for the same use pattern. An example output file is included in **Appendix F**.

Table 3-7. Estimated Concentrations of Diazinon in Groundwater (Estimated Using Sci-Grow version 2.3)

Use	Application Rate (lbs a.i./A)	Number of Applications	Estimated Concentration in Groundwater
Cole Crop	116	1	2.10
Melons	4.1	26	1.93
Ant mound control for blueberries	14.4	2	0.52
Melons	4.1	1	0.07

3.3. Modeling Approach for Terrestrial Plants

TerrPlant (Version 1.1.2) is used to calculate EECs for non-target terrestrial plant species inhabiting dry and semi-aquatic areas. Parameter values for application rate, drift assumption and incorporation depth are based upon the use and related application method (**Table 3-2**). A runoff value of 0.02 is utilized based on diazinon's solubility, which is classified by TerrPlant as to range between 10 to 100 mg/L. For aerial and ground application methods, drift is assumed to be 5% and 1%, respectively. For ant mound applications and transplant water, spray drift is assumed to be zero. EECs relevant to terrestrial plants consider pesticide concentrations in drift and in runoff. These EECs are listed by use in **Table 3-8**. An example output from TerrPlant v.1.2.2 is available in **Appendix H**. The highest use rate for a range of use rates was modeled for each range of rates. For example, rates near 4.0 lbs a.i./A range from 3.984 – 4.10 lbs a.i./A; however, only the highest rate was modeled and was assumed for all crops with a rate in that range. Rates less than 0.77 lbs a.i./A were not modeled because risk to terrestrial plants were not found for uses with higher use rates.

Table 3-8. TerrPlant Inputs and Resulting EECs for Plants Inhabiting Dry and Semi-aquatic Areas Exposed to Diazinon via Runoff and Drift

Crop Group	Max. App. Rate (lbs a.i./ A)	Application Method[1]	Drift Fraction	Spray Drift EEC (lbs a.i./A)	Dry Area EEC (lbs a.i./A)	Semi-aquatic area EEC (lbs a.i./A)
Cole crops (transplant	116	Ground	0	NA	2.32	23.2

Crop Group	Max. App. Rate (lbs a.i./ A)	Application Method[1]	Drift Fraction	Spray Drift EEC (lbs a.i./A)	Dry Area EEC (lbs a.i./A)	Semi-aquatic area EEC (lbs a.i./A)
use)						
Ant mound treatments in blueberry orchards	14.4	Ground	0	NA	0.288	2.88
Lettuce	2.05	Aerial	0.05	0.1025	0.1435	0.5125
Row crops, leafy vegetables, melons, onion, cole crops, garlic, rutabaga, and tomato, beans, ornamental	4.10	Ground	0.01	0.041	0.123	0.861
Almonds	3.02	Ground	0.01	0.0302	0.0906	0.6342
Lettuce, berries, tree fruit, row crop	2.05	Ground	0.01	0.0205	0.0615	0.4305
Berries, ornamentals, strawberry, cole crops	1.02	ground	0.01	0.0102	0.0306	0.2142
Almond, melons, tomato, tree fruit, blueberry, lettuce, fig, strawberry, cole crops,	0.77	ground	0.01	0.0077	0.0231	0.1617

3.4. Existing Monitoring Data

There are a large number of studies and data available on diazinon residues in air, surface water, drinking water, ground water, tissue, rain, and snow. Most of the available monitoring data include samples collected at sites that are not chosen based on pesticide usage and are called nontargeted monitoring studies. Generally, targeted monitoring data are collected with a sampling program designed to capture, both spatially and temporally, the maximum use of a particular pesticide. Typically, sampling frequencies employed in monitoring studies are insufficient to document peak exposure values. The lack of targeted data coupled with the fact that these data are not temporally or spatially correlated with pesticide application times and/or areas limit the utility of these data in estimating exposure concentrations for risk assessment purposes. Therefore, model-generated values are used for estimating acute and chronic exposure values for calculating risk quotients and the non-targeted monitoring data are used for characterizations.

3.4.1. Conclusions from Previous Assessments on Monitoring Data

A critical step in the process of characterizing EECs is comparing the modeled estimates with available surface water monitoring data. EFED finalized the Environmental Fate and Ecological Risk assessment for diazinon in 2000 (USEPA, 2000, D154949, D 159643, D 183157). That assessment contained an aquatic exposure assessment (including drinking water) as well as an ecological risk assessment. The data included in that risk assessment and the conclusions associated with the data are briefly described below. For more detailed information, see USEPA (2000, D 154949, D 159643, D 183157). Since the risk assessment was completed, EFED has obtained additional diazinon monitoring data; therefore, the additional California-specific data below are summarized below. These data include United States Geological Survey's (USGS) National Water Quality Assessment (NAWQA), several USGS reports from California-specific studies which were prepared in cooperation with the California Department of Pesticide Regulation (CDPR), the CDPR Surface Water Database and a total maximum daily load (TMDL) monitoring report from the Central Valley.

A number of National and California-specific surface water monitoring studies are discussed in the Environmental Fate and Ecological Risk Assessment supporting the IRED for diazinon (USEPA, 2000, D 154949, D 159643, D 183157). Sources of monitoring data used in that assessment included: NAWQA (USGS, 2010) and National Stream Water Quality Network (NASQAN) (USGS, 2007) programs, the Permit Compliance System (PCS) database for National Pollutant Discharge Elimination System (NPDES) permits (USEPA, 2012c), National Survey of Pesticide in Drinking Water (NPS) (USEPA, 1990), California State, and the open literature. The major conclusions resulting from consideration of these data are outlined below.

- Non-agricultural uses of diazinon, including homeowner uses, appear to have significantly affected surface water quality before the year 2000.

- Monitoring data indicate widespread occurrence of diazinon in surface water nationally. Diazinon was the most frequently detected insecticide in surface water in the NAWQA program. Diazinon was detected in every major river basin, including the Mississippi, Columbia, Rio Grande, and Colorado, in the USGS NASQAN study.

- Diazinon is widely used in California, and for this reason, a great deal of surface water monitoring was conducted by several agencies from 1992 to 1998. Prior to the IRED publication, diazinon had been detected in the San Joaquin River, the Sacramento River, the Merced River, the Russian River, the Tuolumne River, Orestimba Creek, and the Stanislaus River.

- Diazinon residues have been found in large rivers and major aquifers throughout the United States.

- Dormant spray use of diazinon has resulted in surface-water contamination in California.

3.4.2. Surface Water Monitoring Results

3.4.2.a. USGS NAWQA Surface Water Data

Surface water monitoring data from the USGS NAWQA program were obtained on February 13, 2012. A total of 28,781 water samples across various sites throughout the United States were analyzed for diazinon between 1993 and 2010. There were 7144 detections of diazinon in the United States and concentrations ranged from not detected to 3.8 µg/L. After 2004, the highest detected concentration was 0.359 µg/L. Sites with detections were classified as mixed (36%), urban (29%) agricultural land use (12%), residential (6%), cropland (5%) and other (<1%). In California, there were detections in 67% of samples (1591 of 2345) collected at 67 sites located in 10 counties (Colusa, Merced, Orange, Riverside, Sacramento, San Bernardino, San Joaquin, Stanislaus, Sutter, and Yolo) between 1992 and 2004. In California, measured concentrations ranged from not detected to 3.8 µg/L. Between 2004 to 2010, the highest detection in California was 0.359 µg/L. The highest concentrations were detected in urban, agricultural, mixed, and residential land use sites in both time periods with detections at similar levels across the land cover classes. The long term method detection level is 0.003 µg/L (Gilliom *et al.,* 2007). A more detailed summary of NAWQA monitoring data for California is available in USEPA (2007b).

A total of 1261 samples across sites throughout the United States were analyzed for diazoxon between 2002 and 2009. Diazoxon was detected in 25 samples (2%) at sites associated with other, agricultural, and urban areas. All detections occurred between 2003 to 2005 with 22 detections between 2004 and 2005. Concentrations ranged from not detected to 0.06 µg/L with the highest detected being detected in 2004. The limit of quantitation ranged from 0.006 to 0.045 µg/L based on the range of less than values reported in the dataset.

3.4.2.b. USGS NAWQA Sediment

A total of 110 bottom sediment samples across sited throughout the United States were analyzed for diazinon, and it was detected in three samples at concentrations ranging from not detected to 3.5 µg/kg-sediment dry weight. It was detected in samples collected in 1992 and 1995 in sites associated with agriculture, urban, and mixed uses. The limit of quantitation ranged from 0.1 to 80 µg/kg-sediment dry weight based on the range of less than values reported in the dataset. Diazinon was not looked for in sediment collected in California.

A total of four sediment samples collected in Georgia were analyzed for diazoxon in 2010. Diazoxon was not detected. The limit of quantitation was 3 µg/kg sediment dry weight based on the less than values reported in the dataset.

3.4.2.c. USGS monitoring of California surface waters

Since 2000, USGS, in cooperation with the CDPR, has published several reports involving monitoring of California water bodies for diazinon. These studies, which are briefly described below, have included monitoring in the San Joaquin River Basin and the Sacramento River and its tributaries. Earlier results of these studies were summarized in the diazinon TRED.

i. San Joaquin River Basin

The San Joaquin River Basin drains an area in Sierra Nevada and the San Joaquin Valley, and the Coast. Relevant diazinon use for this basin includes dormant season applications (December – February) to stone fruits and almonds (Agular *et al.*, Not Reported) and field crops and orchards in the spring and summer (Smith *et al.*, 2011).

In January-February 2000 and again in January-February 2001, USGS sampled several sites within the San Joaquin River Basin, on a weekly basis during non-storm periods, and more frequently during storm events. These sampling periods coincided with dormant season applications of diazinon to orchards. In 2000, 13 major river and minor tributary sites were sampled, while in 2001, eight sites were sampled, with some overlap between the sites from one year to the next. During both time periods and for the majority of the sample sites, the highest concentrations of diazinon were observed during storm runoff events. In the first study, diazinon was detected in 82-100% of samples per site with a maximum observed concentration of 0.834 µg/L for all sites. In the second study, diazinon was detected in 95-100% of samples per site with a maximum observed concentration of 0.435 µg/L for all sites sites (Agular *et al.*, Not Reported; California Department of Pesticide Regulation, 2012).

During April to August 2001, 12 sites within the San Joaquin Valley were sampled weekly for monitoring of diazinon (Smith *et al.*, 2011). Some of the sites sampled during this study overlapped with those studied in previous USGS studies (Agular *et al.*, Not Reported; California Department of Pesticide Regulation, 2012). During April-August, diazinon was detected in 30% of samples at some sites and 100% of samples at other sites. Median concentrations at the sample sites ranged from <0.005 to 0.011 µg/L, with 90 percent of all measured concentrations <0.06 µg/L. The maximum measured concentration for all sites was 0.325 µg/L (Smith *et al.*, 2011).

ii. Sacramento River

The Sacramento River and its tributaries drain land in northern California. Two studies were completed by the USGS to monitor water concentrations of diazinon resulting from dormant season applications of diazinon to orchards. The first study was targeted to monitor diazinon concentrations in runoff resulting from three winter storms which occurred during January 30-February 25, 2000 (Munoz *et al.*, 2011). Sites (n=17) on the Sacramento River and its tributaries were sampled for five consecutive days for each of the three storms. The peak measured concentration of diazinon was 2.89 µg/L, while the median (n=138) was 0.044 µg/L. Observed diazinon concentrations were greatest in samples collected from small streams draining areas with agricultural or urban landcovers (Munoz *et al.*, 2011). The second study was targeted to monitor diazinon concentrations in runoff resulting from two winter storms during January 24-February 14, 2001 (USEPA, 2006a). These storms occurred after dormant spray applications of diazinon to orchards located within the Sacramento Valley. Different sized tributaries as well as portions of the Sacramento River were sampled, representing 21 different sites receiving runoff from areas with both agricultural and urban landcovers. The maximum observed concentration of diazinon was 1.38 µg/L, with median concentrations for the first and second storms of 0.055 and 0.026 µg/L, respectively. Observed diazinon concentrations were greatest in samples collected from small streams draining areas with agricultural landcovers (USEPA, 2006a).

3.4.2.d. California Department of Pesticide Regulation (CDPR) Data

CDPR maintains a database of monitoring data on pesticides in CA surface waters. The sampled water bodies include rivers, creeks, urban streams, agricultural drains, the San Francisco Bay delta region, and storm water runoff from urban areas. The database contains data from 51 different studies by federal (including the USGS NAWQA program), state and local agencies as well as groups from private industry and environmental interests. Data are available from 1990-2005 for 27 counties for several pesticides and their degradates. Data on diazinon and diazoxon are included in this database (USEPA, 2002). For the purpose of this assessment, diazinon and diazoxon monitoring data from 1991-2010 were accessed from the CDPR database and are discussed below. Concentrations of diazinon in surface waters measured in California are shown in **Figure 3-3**. It appears that there is a trend where concentrations in surface waters have decreased in California since many of the uses were phased out in 2004. The maximum detected concentration was in 1994 at was 46.63 µg/L.

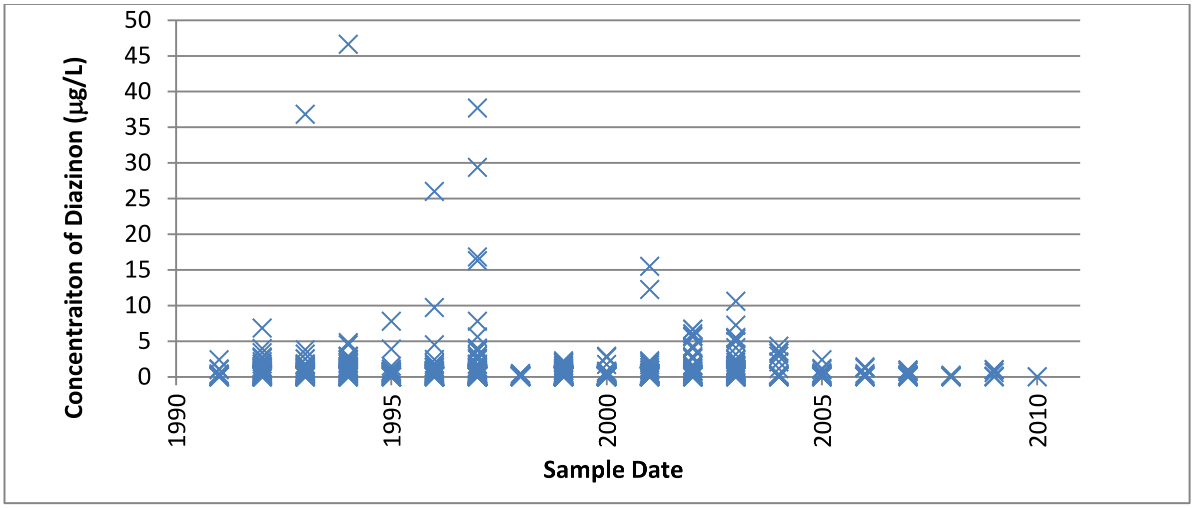

Figure 3-3. CDPR reported concentrations of diazinon in surface waters in CA (includes detections only) between 1991 and 2010

From 2004 to 2010, 11,149 samples from CA surface waters were analyzed for diazinon. Of these, diazinon was detected in 32% of samples, at a maximum concentration of 4.3 µg/L detected in 2004. These samples included several different sites from 40 counties, including counties where TG and DS core areas and critical habitat are located. When considering all samples analyzed during this time period (including non-detections), diazinon was detected at concentrations (*i.e.*, >0.0105 µg/L) sufficient to exceed the risk to listed species LOCs for aquatic invertebrates (indirect effects to TG and DS) in 3118 samples, which represents 28% of samples. Diazinon was not detected at concentrations >4.5 µg/L, and were not sufficient to exceed the acute listed species LOC (RQ≥0.05) for freshwater fish (direct effects on the TG and DS) (**Figure 3-4**); however, detection were made just be low this value. Finally, several detections were also higher than the concentration of 0.064 µg/L where direct chronic effects could occur.

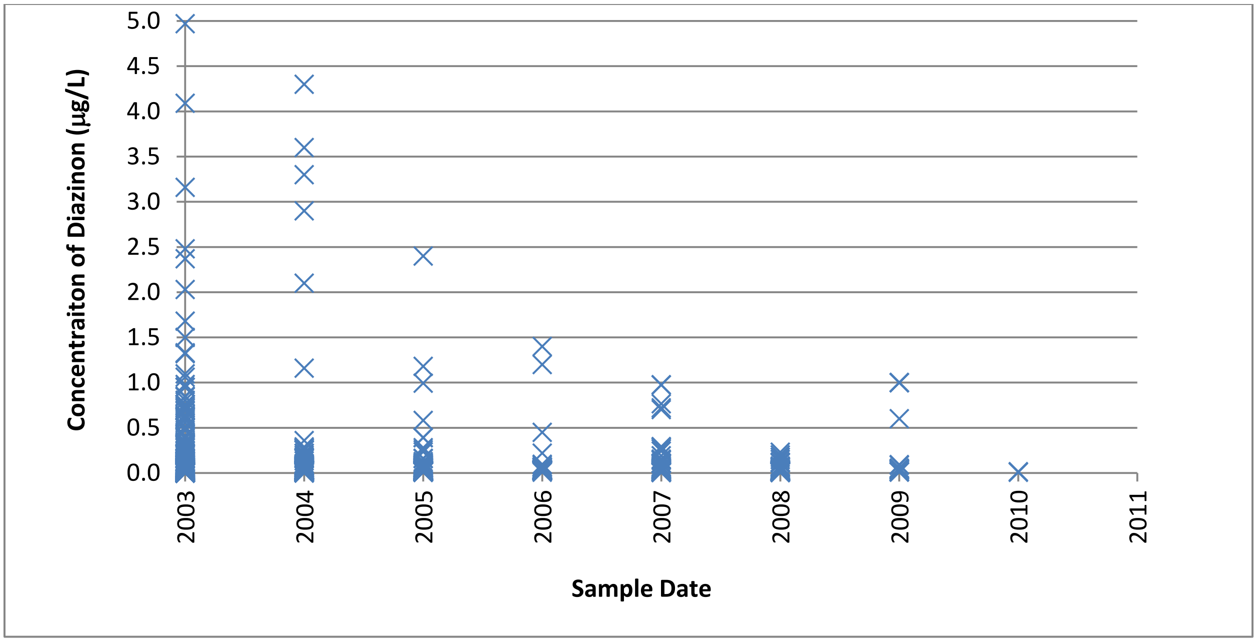

Figure 3-4. CDPR reported concentrations of diazinon in surface waters in CA (includes detections only) between 2004 and 2010

In California, 773 samples were analyzed to determine whether they contained diazoxon between 1991 and 1995. Diazoxon was detected in five samples at 0.06, 0.08, 0.21, 0.39, and 0.43 µg/L. The limit of quantitation ranged from 0.05 to 0.1 µg/L. Detections occurred in Merced and San Joaquin counties.

3.4.2.e. TMDL monitoring in California's Central Valley

Additional water monitoring data are available in a study entitled "*TMDL Monitoring of Pesticides in California's Central Valley Waterways. John Muir Institute for the Environment, University of California at Davis.*" This study was conducted by the Aquatic Ecosystems Laboratory of the John Muir Institute at UC-Davis under a contract from the Regional Water Quality Control Board, Central Valley Region (NMFS, 2008). The purpose of the study was "to monitor selected sites in the Sacramento River Basin, the eastern Sacramento-San Joaquin Delta tributary area, and the San Joaquin River Basin over two storm events during the winter of 2005-06 to further characterize and define sources of diazinon, chlorpyrifos, and other pesticides that may cause surface water contamination and toxic conditions to aquatic life." In part, the results of the study would be used by the study sponsor to support development of Total Maximum Daily Loads (TMDLs) for pesticides in Central Valley watersheds.

Locations for sample collection were taken from three general regions in the Sacramento-San Joaquin Watershed, the Sacramento River and its tributaries, the San Joaquin and its tributaries, and the Sacramento-San Joaquin Delta. The sites in the Sacramento River Watershed were located in Sutter, Butte, and Sacramento Counties, those for the Delta in San Joaquin and those in the San Joaquin River Watershed are in Stanislaus and Merced Counties. The two sites along the Sacramento River were selected to assess progress in meeting water quality objectives for the basin. Other sites were chosen based on documented pesticide use in the watershed, pesticide-caused toxicity observed in the stream or river, and the inclusion of targeted pesticide on a 303(d) impaired water body lists. Data were reported for concentrations of diazinon at 12 sites. The detection frequency ranged 50-100% and 6 of the 12 sites had detections over 0.1 µg/L (**Table** 3-9).

Table 3-9. Results from monitoring for diazinon in the Central Valley of California in the winter of 2006 (NMFS, 2008)

Site	Number of Samples	Percent Detections	Maximum Concentration (µg/L)
Sacramento River Watershed Sites			
Angel Canal/Commanche Creek	4	100	0.360
Gilsizer Slough	4	100	0.778
Live Oak Slough	4	100	0.738
Morrison Slough	4	100	0.294
Sacramento River (Alamar)	9	56	0.009
Sacramento River (Freeport)	9	56	0.003
Delta Sites			
Littlejohn Creek	4	100	0.044
Lone Tree Creek	4	100	0.246
Mormon Sough	4	50	0.014
Pixley Slough	4	100	0.116
San Joaquin River Watershed Sites			
Del Puerto Creek	4	50	0.015
Orestimba Creek	2	50	0.009

Available county level pesticide use data for California were employed to infer the predominant uses of diazinon in the counties sampled by the John Muir Institute. Data for 2005 provide information on the extent of use in the counties where monitoring data were collected in this study. All six counties in the study show considerable usage of diazinon during January and February, which is considered the dormant spray season as the trees are leafless at this time of year. In addition to the crops identified in **Table 3-10**, there were small amounts of diazinon applied in these six counties to apricots, pears, and walnuts (total <350 lbs). Other diazinon uses in these six counties include: 3 lbs used for 'landscape maintenance', 24 lbs used in green houses, 33 lbs for outdoor nursery plants, and 91 lbs used around structures. Consequently, the CDPR usage data suggest that the occurrence of diazinon in this monitoring study is associated with the dormant spray application to deciduous orchard crops.

Table 3-10. Pounds Diazinon Applied in January and February in Six Counties in California in 2005 Using CDPR pesticide use reporting data

County	Pounds Diazinon Applied				
	Almonds	Apples	Cherries	Peaches and nectarines	Prunes and plums
Butte	2409	4510	961	1822	2177
Merced	1218	0	16	16	83
Sacramento	0	4566	116	20	16
San Joaquin	12022	8	1408	0	4
Sutter	14080	0	102	1666	184
Stanislaus	12	0	0	10687	14396

3.4.1. USGS NAWQA Groundwater Data

In 882 groundwater samples taken at 492 sites by the USGS's NAWQA program in California between 1993 and 2011, three samples had detectable concentrations of diazinon: 0.002, 0.006, and 0.008 µg/L. All of the samples were collected in 1994 in Fresno County. Neither of these counties is within the Critical Habitat of the DS or TG.

3.4.2. Atmospheric Monitoring Data

Diazinon is one of the most frequently detected organophosphate pesticides in air and in precipitation. The majority of monitoring studies involving diazinon have been in California; however, diazinon has been detected throughout the United States. Available air and precipitation monitoring data for diazinon in California are reported in **Table 3-11**.

Table 3-11. Diazinon detections in air and precipitation samples taken in California.

Location	Year	Sample type	Maximum Conc.*	Detection frequency	Source
CA, MD	1970s-1990s	Air	0.306	NA	Reported in Majewski and Capel, 1995
Sequoia National Park, CA	1996	Air	0.00024	41.7%	LeNoir *et al.* 1999
Sacramento, CA (Franklin Field Airport)	1996-1997	Air	0.0191	37.1 %	Majewski and Baston 2002
Sacramento, CA (Sacramento Metropolitan Area)	1996-1997	Air	0.0122	46.5 %	Majewski and Baston 2002
Sacramento, CA (Sacramento International Airport)	1996-1997	Air	0.112	38.5 %	Majewski and Baston 2002
Fresno County, CA	1997	Air	0.290	NA	State of California, 1998 a
Fresno County, CA	1998	Air	0.160	NA	State of California, 1998 b
Sequoia national Park, CA	1995-1996	Rain	0.019	57 %	McConnell *et al.* 1998
San Joaquin River Basin, CA	2001	Rain	0.908	100%	Zamora et al. 2003
San Joaquin Valley, CA	2002-2004	Rain	2.22	93%	Majewski et al. 2005
CA, MD	1970s-1990s	Fog	76.3	NA	Reported in Majewski and Capel, 1995
Parlier, CA	1986	Fog	18.0	NA	Glotfelty *et al.* 1990
Monterey, CA	1987	Fog	4.80	NA	Schomburg *et al.* 1991
Sequoia national Park, CA	1995-1996	Snow	0.014	62.5 %	McConnell *et al.* 1998

*For Air, $\mu g/m^3$; for rain, snow and fog, µg/L

The magnitude of detected concentrations of diazinon in air and in precipitation can vary based on several factors, including proximity to use areas and timing of applications. In air, diazinon has been detected at concentrations up to 0.306 $\mu g/m^3$. Measured concentrations of diazinon in rain in California have been detected at concentrations up to 2.22 µg/L. In fog, diazinon has been detected up to 76.3 µg/L (Majewski and Capel, 1995). These data are characterized further in subsequent sections.

3.4.2.a. Deposition Data

In a study of diazinon loads in winter precipitation and runoff to the San Joaquin River Basin, precipitation samples were collected from a January 2001 storm event. In order to observe the influences of dormant season applications of diazinon, four sampling sites were placed near areas dominated by orchards. Concentrations of diazinon measured in rainfall ranged from 0.175 to 0.870 µg/L. The authors concluded that diazinon in precipitation could contribute significantly to the overall diazinon load entrained in runoff (Zamora *et al.*, 2003).

In a 3.5 year study (from 2001-2004) in the central San Joaquin Valley, wet and dry deposition of pesticides, including diazinon, were monitored at six sites, including some with agricultural and urban land uses. When comparing wet and dry deposition, wet deposition represented a larger source of diazinon. Diazinon was detected in 93% of rain samples (n=137), with mean and maximum concentrations of 0.149 and 2.220 µg/L, respectively (Majewski *et al.*, 2006).

3.4.2.b. Monitoring data from lakes assumed to only receive atmospheric deposition of diazinon

Studies are available involving monitoring of diazinon concentrations in California lakes which are removed from agricultural areas and are presumed to receive inputs of diazinon from atmospheric deposition only. Two 1997 studies (Fellers *et al.* 2004; LeNoir *et al.* 1999) measured diazinon concentrations in lake water in Kings Canyon and Sequoia National Parks (located in the Sierra Nevada Mountains in California). Fellers *et al.* (2004) reported a maximum concentration of 0.0034 µg/L, and LeNoir *et al.* (1999) reported a maximum concentration of 0.0741 µg/L in lake water. The authors attributed these detections to dry deposition and/or gas exchange from air samples of diazinon originating from agricultural sites located in California's Central Valley, which is upwind of the lakes.

4. Effects Assessment

This assessment evaluates the potential for diazinon to directly or indirectly affect DS and TG 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 its 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 DS and TG are based on toxicity information for freshwater fish (which are more sensitive to diazinon than estuarine/marine fish based on available data).

As described in the Agency's Overview Document (USEPA, 2004b), the most sensitive endpoint for each taxon is used for risk estimation. For this assessment, evaluated taxa include freshwater fish, marine/estuarine fish, freshwater invertebrates, marine/estuarine invertebrates, and aquatic 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 diazinon.

4.1. Ecotoxicity Study Data Sources

The available information indicates that aquatic organisms are more sensitive to the technical grade (TGAI) than the formulated products of diazinon; therefore, the focus of this assessment is on the TGAI of diazinon. Data are not available on the multi a.i. products.

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, 2009a). Open literature data presented in this assessment were obtained from the 2000 diazinon IRED (USEPA, 2000, D154949, D159643, D183157), the California red-legged frog assessment, as well as information obtained from ECOTOX in September, 2011. The September 2011 ECOTOX search included all open literature data for diazinon and diazoxon since ECOTOX was last searched for similar data in 2006 to support the California red-legged frog assessment. 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.

Open literature toxicity data considered in this assessment are in reported in **Appendix K**.

Data that pass the ECOTOX screen are evaluated along with the registrant-submitted data, and may be incorporated qualitatively or quantitatively into this endangered species assessment. 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 2.9. 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 sub-lethal 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 [(either 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 J** and **K**, respectively. **Appendix J** 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 endangered species risk assessment.

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 diazinon. A summary of the available aquatic and terrestrial ecotoxicity information and the incident information for diazinon are provided in Sections 4.2 through 4.5.

4.2. Toxicity of Diazinon to Aquatic Organisms

Table 4-1 summarizes the most sensitive aquatic toxicity endpoints, based on an evaluation of both the submitted studies and the open literature, as previously discussed. A brief summary of submitted and open literature data considered relevant to this ecological risk assessment for the DS and TG is presented below. Additional information on degradates is provided in **Appendix I**. All endpoints are expressed in terms of the active ingredient unless otherwise specified. The available information indicates that non-target animals are more sensitive to the technical grade (TGAI) than the formulated products of diazinon (Section 4.3 and **Appendix A**); therefore, the focus of this assessment is on the TGAI of diazinon. Based on the most sensitive toxicity endpoints for each of the taxa evaluated, diazinon is classified as very highly toxic to aquatic invertebrates and moderately to highly toxic to fish on an acute exposure basis. Chronic exposure to diazinon resulted in reduced growth in fish and reproductive effects in aquatic invertebrates. Green algae (Pseudokirchneriella subcapitata) were more sensitive aquatic non-vascular plant tested; no data are available to assess the toxicity of diazinon to vascular aquatic plants.

Table 4-1. Summary of Acute and Chronic Aquatic Toxicity Estimates using Technical Grade Diazinon

Species	Acute Toxicity		Chronic Toxicity		
	96-hr LC_{50} (µg/L) / Dose-response slope	MRID	NOAEC / LOAEC (µg/L)	Affected Endpoint	MRID
Rainbow trout (*Oncorhynchus mykiss*)	90 / Slope=4.5	40094602 (Johnson and Finley 1980)	<0.064[1]	--	--
Brook trout (*Salvelinus fontinalis*)	770	ROODI007 (Allison and Hermanutz 1977)	NOAEC <0.55 LOAEC = 0.55	reduced growth	ROODI007 (Allison and Hermanutz 1977)
Water flea (*Ceriodaphnia dubia*)	48-hour EC_{50} = 0.21 / Slope=6.31	Banks *et al.* 2005	0.043[2]	--	--
Water flea *(Daphnia magna)*	0.83	000109022 (Vilkas 1976)	NOAEC = 0.17 LOAEC = 0.32	mortality	407823-02 (Supernant 1988)
Striped mullet *(Mugil cephalus)*	150 / Slope = 4.5	40228401 (Mayer 1986)	NOAEC=0.039[3]	--	--
Sheepshead Minnow *(Cyprinodon variegates)*	1500	40228401 (Mayer 1986)	NOAEC = 0.39 LOAEC = 0.56	Impaired reproduction	442448-01 (Sousa 1997)
Mysid shrimp *(Americamysis bahia)*	EC_{50}=4.2 / Slope = 6.01	40625501 (Surprenant 1988)	NOAEC = 0.23 LOAEC = 0.42	Reduced growth (dry weight)	442448-01 (Sousa 1997)
Freshwater Green Algae *(Pseudokirchneriella subcapitata)*	EC_{50} = 3,700 (decreased growth)	40509806 Hughes; review dated 1988	--	--	--
Duckweed *(Lemna gibba)*	--	--	--	--	--

[1] Estimated NOAEC using acute-to-chronic ratio for brook trout of >1,400 (acute=770; chronic<0.55; 770/0.55>1,400).
[2] Estimated NOAEC using acute-to-chronic ratio for *Daphnia magna* of 4.88 (acute =0.83; chronic=0.17; 0.83/0.17=4.88)
[3] Estimated NOAEC using acute-to-chronic ratio for sheepshead minnow of 3846 (acute=1500; chronic=0.39; 1500/0.39=3846).

Toxicity to fish and aquatic invertebrates is categorized using the system shown in **Table 4.2** (USEPA, 2004b). 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

A summary of acute and chronic freshwater fish data, including data from the open literature, is provided below in Sections 4.2.1a and 4.2.1b.

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

Diazinon toxicity has been evaluated in numerous freshwater fish species, including rainbow trout (*Oncorhynchus mykiss*), brook trout (*Salvelinus fontinalis*), bluegill sunfish (*Lepomis macrcochirus)*, fathead minnow (*Pimephales promelas*), tilapia, zebrafish (*Danio rario*), goldfish (*Carassius auratus*), and carp (*Cyprinus carpio*). The results of these studies demonstrate a wide range of sensitivity to diazinon. The range of acute freshwater fish LC_{50} values for diazinon spans one order of magnitude, from 90 to 7,800 µg/L; therefore, diazinon is categorized as very highly (LC_{50} < 100 µg/L) to moderately (LC_{50} >1,000 to 10,000 µg/L) toxic to freshwater fish on an acute exposure basis. The freshwater fish acute LC_{50} value of 90 µg/L is based on a static 96-hour toxicity test using rainbow trout (MRID 40094602). No sublethal effects were reported as part of this study.

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

The chronic effects of diazinon on fathead minnows and brook trout were determined in flow-through systems with constant toxicant concentrations (Allison and Hermanutz, 1977). Fathead minnows exposed to the lowest concentration tested (3.2 µg/L) from 5 days after hatch through spawning had a significantly higher incidence of scoliosis than the control (p=0.05). Hatch of their progeny was reduced by 30% at this concentration. Yearling brook trout exposed to 4.8 µg/L and above began developing scoliosis and lordosis within a few weeks. Growth of brook trout was substantially inhibited during the first 3 months at 4.8 µg/L and above. Neurological symptoms were evident in brook trout at 2.4 µg/L and above early in the tests, but were rarely observed after 4 or 5 months of exposure. Exposure of mature brook trout for 6 to 8 months to concentrations ranging from 9.6 µg/L to the lowest tested (0.55 µg/L) resulted in equally reduced growth rates for their progeny. Transfer of progeny between concentrations indicated that effects noted for progeny of both species at lower concentrations were the result of parental exposure alone and not the exposure of progeny following fertilization. At this time, there are no definitive data for diazinon that meet guideline testing requirements for establishing a chronic NOAEC in freshwater fish. However, the registrant is in the process of completing these studies in response to a data call-in. Based on the information discussed above, the NOAEC is less than the lowest concentration tested using brook trout (NOAEC <0.55 μg/L).

Since rainbow trout are the most sensitive species on an acute exposure basis and no chronic toxicity data are available for rainbow trout, the acute to chronic ratio (ACR) for brook trout was used to estimate the chronic toxicity for rainbow trout. For brook trout, the acute and chronic toxicity estimates are 770 μg/L and < 0.55 μg/L, respectively, yielding an ACR of > 1,400; applying this ratio to rainbow trout results in an estimated NOAEC<0.064 μg/L. Note that this results in a less than value as the ACR is a greater than value. A NOAEC may not be determined using available data and this is a significant uncertainty in the risk assessment. However, definitive acute and chronic toxicity data are available for the estuarine/marine sheepshead minnow (*Cyprinodon variegates*; discussed in Section 4.2.3.b) and based on these data, the ACR for estuarine/marine fish is 3846. Had this value been used to estimate a NOAEC for rainbow trout, the resulting value would be 0.023 μg/L.

4.2.1.c. Freshwater Fish: Sublethal Effects and Additional Open Literature Information

In Atlantic salmon (*Salmo salar*), neuroendocrine-mediated olfactory functions were affected at 1.0 μg/L diazinon (Moore and Waring, 1996). The reproductive priming effect of the female pheromone prostaglandin $F_{2\alpha}$ on the levels of expressible milt in males was reduced after exposure to diazinon at 0.5 μg/L. Overall, the relationship between reduced olfactory response of males to the female priming hormone in the laboratory and reduction in salmon reproduction (*i.e.*, the ability of male salmon to detect, respond to, and mate with ovulating females) in the wild is not established.

In a study of Chinook salmon (*Oncorhynchus tshawytscha*) antipredator behavior by Scholz *et al* (2000), diazinon exposure resulted in significant effects of swimming and feeding behavior at concentrations of 1 μg/L; fish remained more active and fed more frequently in the presence of an alarm stimulus (skin extract) relative to controls. The effect of diazinon on Chinook salmon homing success was also examined in the Scholz *et al* (2000) study. Significantly fewer salmon returned after exposure to 10 μg/L diazinon. However, there is considerable uncertainty regarding the extent to which diminished olfactory response as it relates to predator avoidance and homing behavior will affect the survival and reproduction of fish. In this study, Chinook salmon survival was not impaired.

The primary unanswered question is how serious of an impact does the temporary loss of olfactory function and associated altered behavior have on the homing, migratory patterns, feeding activity and avoidance of predators for the exposed organisms, and more importantly, on the ability of the exposed population to reproduce, grow and ultimately survive in the wild. Thus, the impact of sublethal effects on the long-term survival of an exposed aquatic population is very difficult to determine from laboratory studies, and therefore complex long-term field studies are needed to address this issue.

Although these studies raise concern about the effects of diazinon on olfactory-mediated functions in freshwater and anadromous fish, these effects are difficult to quantify because they are not clearly tied to the assessment endpoints for the DS and TG (*i.e.*, survival, growth, and reproduction of individuals). Furthermore, there is uncertainty associated with extrapolating effects observed in the laboratory to more variable exposures and conditions in the field. Therefore, potential sublethal effects on fish are evaluated qualitatively and not used as part of the quantitative risk characterization. Additionally, the non-definitive NOAEC used to assess risk in this assessment for growth is 0.064 µg/L and is lower than the concentration that caused these sublethal effects.

4.2.2. Toxicity to Freshwater Invertebrates

A summary of acute and chronic freshwater invertebrate data, including data published in the open literature, is provided below in Sections 4.2.2.a through 4.2.2.b. Although Section 2.5 indicates that a risk assessment on sediment-dwelling invertebrates is relevant to diazinon given its range of K_{ow} values (3.69 - 3.81) and its estimated K_{oc} (2184 L/kg_{oc}), at this time, sediment toxicity data are not available to evaluate the potential effects of the compound on benthic invertebrates.

4.2.2.a. Freshwater Invertebrates: Acute Exposure Studies

Diazinon is classified as very highly toxic to aquatic invertebrates. Toxicity estimates, EC_{50} and LC_{50} values, for freshwater invertebrates ranged from 0.21 to 35 µg/L. Although the original ecological risk assessment of diazinon reported a 96-hr LC_{50} as low as 0.2 µg/L for scuds (*Gammarus fasciatus*), a reanalysis of the raw data indicated that the 96-hr LC_{50} value was off by an order of magnitude and that the correct value is 2 µg/L (MRID 40094602, USEPA memo to Pesticide Re-evaluation Division (PRD) dated 10/05/2005). Data were located through ECOTOX indicating that diazinon is very highly toxic to *Ceriodaphnia dubia* (48-hr EC_{50}= 0.21 µg/L) (Banks *et al.*, 2005). .

4.2.2.b. Freshwater Invertebrates: Chronic Exposure Studies

The most sensitive measured chronic toxicity endpoint for freshwater invertebrates is based on a 21-day flow-through study on waterfleas (*Daphnia magna*), which showed significant effects on survival (100% mortality) at diazinon concentrations greater than 0.17 µg/L; the NOAEC and LOAEC for this study are 0.17 and 0.32 µg/L, respectively (MRID 40782302). However, the most sensitive acute toxicity value for invertebrates is for *C. dubia* and there are not measured chronic toxicity data available for this species. Therefore, the acute-to-chronic ratio for *D. magna* was used to estimate a chronic toxicity value for *C. dubia*. The acute (48-hr EC_{50}) and chronic (NOAEC) values for *D. magna* are 0.83 and 0.17 µg/L, respectively, and result in an ACR of 4.88. Using this ACR, the chronic toxicity estimate for *C. dubia* is 0.043 µg/L.

4.2.3. Toxicity to Estuarine/Marine (E/M) Fish

A summary of acute and chronic E/M fish data, including data published in the open literature is provided below in Sections 4.2.3.a through 4.2.3.b.

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

Acute toxicity testing with the sheepshead minnow (*Cyprinodon variegates*) resulted in a 96-hr LC_{50} of 1,500 µg/L; diazinon is categorized as moderately toxic to estuarine/marine fish on an acute exposure basis. However, since the acute toxicity endpoint for striped mullet (LC_{50}=150 µg/L) is more sensitive than that of the sheepshead minnow and since striped mullet are an anadromous species the most sensitive acute toxicity data, *i.e.,* the striped mullet, are used to represent the acute sensitivity of estuarine/marine fish to diazinon for risk assessment purposes; therefore, diazinon is categorized as highly toxic to estuarine/marine fish on an acute exposure basis.

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

The chronic toxicity of diazinon to estuarine/marine fish was determined using Sheepshead minnow; the 28-day NOAEC and LOAEC values are 0.39 and 0.56 µg/L, respectively. Chronic exposure resulted in impaired reproduction (Accession No. R00D0008). However, the most sensitive acute toxicity value is for striped mullet and there are no chronic toxicity data available for striped mullet; therefore, an acute-to-chronic ratio for sheepshead minnow (acute=1500 µg/L; chronic=0.39 µg/L: ACR=3846) was used to derived a chronic toxicity value for striped mullet, *i.e*., NOAEC of 0.039 µg/L.

4.2.4. Toxicity to Estuarine/Marine Invertebrates

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

The 96-hour mysid shrimp (*Americamysis bahia*) LC_{50} for diazinon is 4.2 µg/L (MRID 40625501). Thus, diazinon is categorized as very highly toxic to estuarine/marine shrimp species on an acute basis. Similar to what was discussed in Section 4.2.2, although Section 2.5 indicates that a risk assessment on sediment-dwelling invertebrates is relevant to diazinon given its range of K_{ow} values (3.69 - 3.81) and its estimated K_{oc} (2184 L/kg_{oc}), at this time, sediment toxicity data are not available to evaluate the potential effects of the compound on benthic estuarine/marine invertebrates

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

In a 28-day exposure study with mysid shrimp, the NOAEC and LOAEC values were 0.23 and 0.42 µg/L, respectively (MRID 44244801). Chronic exposure resulted in impaired growth (weight) of mysids relative to controls.

4.2.5. Toxicity to Aquatic Plants

Aquatic plant toxicity studies are used as one of the measures of effect to evaluate whether diazinon may affect primary production. Aquatic plants may also serve as dietary items of DS and TG larvae. 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.

Two types of studies are used to evaluate the potential of diazinon to affect primary productivity. Laboratory studies are used to determine whether diazinon may cause direct effects to aquatic plants. In addition, the threshold concentrations, described in Section 4.2.5.a and 4.2.5.b, are used to further characterize potential community level effects to DS and TG resulting from potential effects to aquatic plants in 4.2.6.

4.2.5.a. Toxicity to Freshwater Non-vascular Plants

A single aquatic plant study is available for determining the toxicity of diazinon to aquatic plants. Toxicity testing with green algae (*Pseudokirchneriella subcapitata*) resulted in a 7-day EC_{50} of 3,700 µg/L (MRID 40509806). A reanalysis of the data to estimate an EC_{05} was conducted using the Probit procedure of the Statistical Analysis System (SAS®; Release 9.1; SAS® Institute, Inc., Cary, NC); the probit-estimated EC_{05} is 66 µg/L; the probit dose-response slope is relatively shallow at 0.90.

4.2.5.b. Toxicity to Freshwater Vascular Plants

No data are available to assess the toxicity of diazinon to aquatic vascular plants; however, the toxicity data for nonvascular plants suggests that plants are not particularly sensitive to diazinon. The mode of action of diazinon in animals is as an inhibitor of the enzyme acetylcholinesterase, which hydrolyzes the neurotransmitter acetylcholine. Additionally, as discussed below, mesocosm studies further substantiate that aquatic plants are not sensitive to diazinon.

4.2.6. Aquatic Field/Mesocosm Studies

Mesocosm studies with diazinon provide measurements of primary productivity that incorporate the aggregate responses of multiple species in aquatic communities. Because various aquatic species vary widely in their sensitivity to diazinon, the overall response of the aquatic community may be different from the responses of the individual species measured in laboratory toxicity tests. Mesocosm studies allow observation of population and community recovery from diazinon effects and of indirect effects on higher trophic levels. In addition, mesocosm studies, especially those conducted in outdoor systems, incorporate partitioning, degradation, and dissipation, factors that are not usually accounted for in laboratory toxicity studies, but that may influence the magnitude of ecological effects.

Diazinon has been the subject of a mesocosm study where 450-m^2 ponds were monitored following 6 applications of diazinon, alternating between spray drift events and simulated runoff events separated by 1-wk intervals (MRID 42563901). Nominal treatment concentrations were equivalent to 5.7, 11.4, 22.9, 45.8 and 91.5 µg a.i./L of pond water. Diazinon was shown to have strongly affected the zooplankton taxon Cladocera, where abundance was significantly reduced in all treatments in 5 (36%) of 14 sample periods. Tricoptera abundance was also significantly reduced in all treatments for 29% of the sample periods. Dipterans were also significantly affected. The overall impact of diazinon on the aquatic community was that many aquatic invertebrates were affected at treatment concentrations greater than 11 µg a.i./L; however, most taxa other than Cladocera recovered after treatment. Although significant reductions were observed in macroinvertebrate abundance throughout the study period, fish and plants were generally unaffected by the diazinon treatments. Under the study conditions tested, mesocosms treated with multiple applications of diazinon did not reveal any statistically significant direct or indirect effects on fish even though there were significant fluctuations in aquatic macroinvertebrates due to diazinon.

4.3. Toxicity of Diazinon to Terrestrial Organisms

Based on an evaluation of both the submitted studies and the open literature, a brief summary of submitted and open literature data on terrestrial organisms considered relevant to this ecological risk assessment (*e.g.*, terrestrial plants) is presented below.

4.3.1. Toxicity to Terrestrial 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 diazinon, 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.

For Tier II seedling emergence tests, carrot is the most sensitive dicot (EC_{25} = 9.03 lbs a.i./A) and oat is the most sensitive monocot (EC_{25} = 5.26 lbs a.i./A) (MRID 40803001; **Table 4-3)**. For Tier II vegetative vigor tests, cucumber is the most sensitive dicot (EC_{25} = 3.23 lbs a.i./A) and onion is the most sensitive monocot (EC_{25} ≥7.0 lbs a.i./A) (MRID 40803002; **Table 4-4**).

Table 4-3. Nontarget Terrestrial Plant Seedling Emergence Toxicity (Tier II)

Species	% ai	EC_{25}/EC_{05} (lbs ai/A) Endpoint Affected	MRID/ Author/Year	Study Classification[1]
Monocot- Oat *(Avena sativa)*	87.7	5.26/0.17 shoot height	40803001/Pan-Agricultural Labs/1988	Core

Species	% ai	EC_{25}/EC_{05} (lbs ai/A) Endpoint Affected	MRID/ Author/Year	Study Classification[1]
Dicot- Root Crop- Carrot *(Daucus carota)*	87.7	9.03/1.58 shoot height	40803001/Pan-Agricultural Labs/1988	Core

[1] Core (study satisfies guideline). Supplemental (study is scientifically sound, but does not satisfy guideline)

Table 4-4. Nontarget Terrestrial Plant Vegetative Vigor Toxicity (Tier II)

Species	% ai	EC_{25}/EC_{05} (lbs ai/A) Endpoint Affected	MRID/ Author/Year	Study Classification[1]
Monocot- Onion *(Allium cepa)*	87.7	>7.0/7.0 shoot height	40803002/Pan-Agricultural Labs/1988	Core
Dicot- Cucumber *(Cucumis sativus)*	87.7	3.23/1.27 shoot height	40803002/Pan-Agricultural Labs/1988	Core

[1] Core (study satisfies guideline).

4.4. Evaluation of Aquatic Ecotoxicity for Degradates

Comparison of available toxicity information for oxypyrimidine (**Table 4-5**) indicates lesser aquatic toxicity than the parent for freshwater fish, invertebrates, and aquatic plants. Specifically, the available degradate toxicity data for oxypyrimidine indicate that it is practically nontoxic to freshwater fish (rainbow trout 96-hr LC_{50}>101 mg a.i./L) (MRID 46364312; Grade 1993a) and invertebrates (48-hr EC_{50}>102 mg a.i./L) (MRID 46364313; Grade 1993b) with no mortality at the maximum concentrations tested. In addition, available aquatic plant degradate toxicity data for oxypyrimidine indicate that oxypyrimidine is practically nontoxic to nonvascular aquatic plants (green algae) with non-definitive EC_{50} values (EC_{50}>109 mg a.i./L) (Grade 1993c; MRID 46364314) at concentrations 29 times higher than the lowest reported aquatic plant EC_{50} value for parent diazinon.

Table 4-5. Acute and subacute toxicity values for terrestrial and aquatic animals exposed to diazinon, diazoxon, or oxypyrimidine.

Species	Diazinon		Diazoxon		Oxypyrimidine	
	Acute Oral mg/kg bw	Subacute Dietary mg/kg diet	Acute Oral mg/kg bw	Subacute Dietary mg/kg diet	Acute Oral mg/kg bw	Subacute Dietary mg/kg diet
Bobwhite Quail	5.2 (Fink 1972)	245 (Hill *et al.* 1975)	4.99 (Rodgers 2005e)	72.3 (Rodgers 2005f)	>2060 (Rodgers 2005d)	>4910 (Rodgers 2005c)
Mallard Duck	1.44 (Fletcher and Pederson 1988)	32 (Fletcher and Pederson 1988)	--* (Rodgers 2005h)	104 (Rodgers 2005g)	--* (Rodgers 2005b)	>4990 (Rodgers 2005a)
	96 hr-LC_{50} (mg/L)				96 hr-LC_{50} (mg/L)	
Rainbow Trout	0.09 (Johnson and Finley 1980)	NA	no data	NA	>101 (Grade 1993a)	NA
Yellow-	7.488	NA	0.760	NA	No data	NA

legged frog	Sparling and Fellers 2007		Sparling and Fellars 2007			
	48-hr LC_{50} (mg/L)				48-hr LC_{50} (mg/L)	
Water flea	0.00021 (Banks 2005)	NA	no data	NA	>102 (Grade 1993b)	NA
	EC_{50} (mg./L)				EC_{50} (mg/L)	
Green algae	3.7 (Hughes1988)	NA	no data	NA	>109 (Grade 1993c)	NA

*mallard ducks regurgitated the test solution therefore dosage is unknown.
NA= not applicable

Similarly, oxypyrimidine was practically nontoxic to birds on an acute oral and subacute dietary exposure basis (**Table 4-5**) and was, once again, orders of magnitude less toxic than the parent to birds. Therefore, given the lesser toxicity of oxypyrimidine to both terrestrial and aquatic animals, as compared to the parent, concentrations of this degradate are not assessed. GS-31144 and demethyl oxypyrimidine (minor degradates) have a very similar structure to oxypyrimidine and were also assumed to have a lesser aquatic toxicity than the parent for freshwater fish, invertebrates, and aquatic plants.

With respect to the intermediate degradate diazoxon, acute and subacute toxicity testing with birds indicate that the compound is minimally as toxic (LD_{50}=4.99 mg a.i./kg bw) (Rodgers 2005e; MRID 46579604) as the parent (LD_{50}= 5.2 mg a.i./kg bw) on an acute oral exposure basis and is more toxic (LC_{50} = 72 mg a.i./kg diet) (Rodgers 2005f; MRID 46579602) than the parent (LC_{50}=245 mg a.i./kg diet) on a subacute dietary exposure basis (**Table 4-5**). Toxicity testing with aquatic-phase amphibians indicates that diazoxon (96-hr LC_{50}=0.76 mg/L) is an order of magnitude more toxic than the parent compound (96-hr LC_{50}=7.49 mg/L) (Fendinger *et al.*, 1989). **Appendix I** contains more detailed descriptions of studies assessing the toxicities of oxypyrimidine and diazoxon to aquatic and terrestrial organisms.

4.5. Incident Database Review

A review of the Ecological Incident Information System (EIIS, version 2.1) was completed on February 14, 2012. A review of the Avian Monitoring Information System (AIMS) for ecological incidents involving diazinon was completed on February 16, 2012. There were 477 incidents in the EIIS systems. The majority (86%) of incidents involved terrestrial animals; incidents involving plants and aquatic animals represented 8.2% and 4.4% of the total reported incidents, respectively. As discussed earlier, a number of use restrictions have been imposed on diazinon subsequent to the interim reregistration eligibility decision. Although there are a total of 477 incidents, of which 86% are associated with effects on terrestrial animals [reported in the EIIS database] there has been a downward trend in the number of reported incidents since risk mitigation measures were imposed beginning in 2003. However, the lack of incident reports cannot be interpreted to mean the lack of incidents.

Figure 4-1 depicts the yearly number of reported incidents by incident type and illustrates that terrestrial incidents predominated while aquatic incidents, representing roughly 4.4% of the total reported incidents, were considerably less frequent. As indicated in the IRED (USEPA, 2004a), terrestrial incidents, primarily involving bird deaths, continued to show an increasing trend until 2002, after which time the number of reported incidents dropped precipitously. Since 2003 only eight incidents have been reported, the majority which have involved birds. Of the 157 terrestrial incidents where the treatment site is reported, the majority (74%) occurred from residential and turf uses, both of which are now cancelled. Additionally, of the reported terrestrial incidents, roughly 19% were from misuse while 9% were associated with a registered use

The last reported incidents involving aquatic animals both took place in 2007 and involved the death of 1000 fish (I021339-001 and IO21178-001). For aquatic incidents where the treatment site is reported, roughly 38% have been associated with residential uses while 23% have been associated with orchard uses. The most recent aquatic incidents (reported in 2007) were associated with grain storage and industrial sites. Additional summary information on incident data from the EIIS is contained in **Appendix M**.

California accounted for roughly 12% of the overall terrestrial incidents, 24% of the overall aquatic incidents and 9% of the overall plant incidents associated with diazinon in the EIIS. The most recent aquatic incident associated with diazinon in California occurred in 2003; however, the use site was not reported. Aquatic incident reports from California were reported from Glenn, Monterey, Riverside, San Joaquin and Trinity counties with a single incident report from each county.

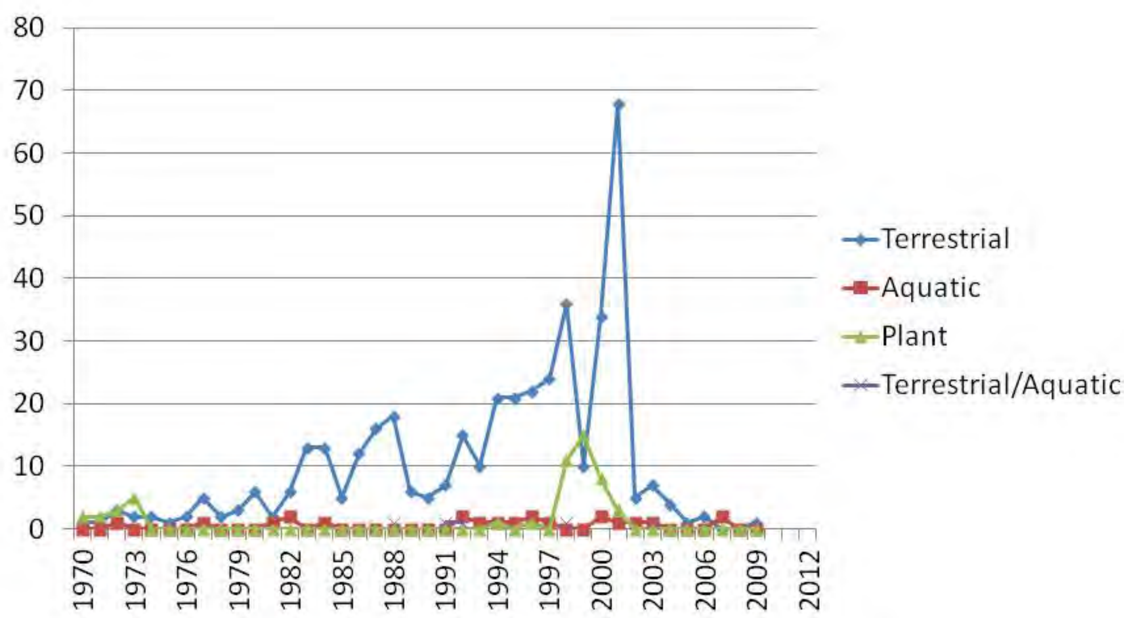

Figure 4-1. Total number of reported ecological incidents per year involving plants, aquatic animals, terrestrial animals and terrestrial/aquatic animals combined associated with the use of diazinon. The y-axis shows the number of incidents and the x-axis shows the year.

The AIMS database includes a total of 498 bird kill incidents associated with diazinon. New York, Michigan and California accounted for 39%, 19% and 13% of the total reported incidents. All of the data reported in the AIMS are reported as sourced through the EIIS.

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 DS and TG or for modification to their designated critical habitat from the use of diazinon 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 (**Appendix E**). For acute exposures to the aquatic listed animals, the LOC is 0.05. The LOC for chronic exposures to animals, as well as acute exposures to plants, is 1.0.

Acute and chronic risks to aquatic organisms are estimated by calculating the ratio of exposure to toxicity using 1-in-10 year EECs in **Table 3-6** based on the label-recommended diazinon usage scenarios summarized in **Table 3-2** and the appropriate aquatic toxicity endpoint from **Table 4-1**. Acute risks to terrestrial plants are estimated based the appropriate toxicity endpoints from **Table 4-3** and **Table 4-4**.

5.1.1. Exposures in the Aquatic Habitat

5.1.1.a. Freshwater and Estuarine/Marine Fish

Acute risk to fish is based on 1-in-10-year peak EECs in the standard pond and the lowest acute toxicity value for freshwater and estuarine/marine fish. Chronic risk is based on the 1-in-10 year 60-day EECs and the lowest chronic toxicity value for freshwater and estuarine/marine fish. Risk quotients for freshwater fish are shown in **Table 5-1.**

Resulting acute RQ values for freshwater and estuarine/marine fish exceed the acute risk to listed species LOC (0.05) across all of the uses modeled except applications to blueberries and fig. Some uses patterns on some labels did not result in acute RQs for either freshwater and estuarine/marine fish that exceed the acute risk listed species LOC for tree fruit, berries, cole crops, melons, onion, outdoor ornamentals, and tomato.

Table 5-1 summarizes the chronic RQs. All chronic RQs for fish exceed chronic risk LOCs of 1.0. A NOAEC for freshwater fish for evaluating risk due to chronic exposure is not available. Risk quotients are a greater than value and risk to freshwater fish may be underestimated.

Table 5-1. Acute and Chronic RQs for Both Freshwater and Estuarine Fish*

Use Groups	Date of First Application (DD-MM)	App. Type	Max app rate /app lbs a.i./A	# of app/ year	Water column EEC in µg/L		Acute Risk Quotient		Chronic Risk Quotient	
					Peak	60-day	Fresh[1]	Estuarine[2]	Fresh[3]	Estuarine[4]
Almonds	10-12 D	AB	0.77	4	12.56	4.54	0.14	0.08	>71	116
	22-01 D	AB	3.024	1	10.58	4.11	0.12	0.07	>64	105
	10-12 D	AB			10.87	4.18	0.12	0.07	>65	107
		G			10.29	3.84	0.11	0.07	>60	98
	22-01 D	AB	3.0	1	10.62	4.12	0.12	0.07	>64	106
	10-12 D	AB	2.81	1	10.11	3.89	0.11	0.07	>61	100
	10-12 D	G	0.77	4	11.24	4.16	0.12	0.07	>65	107
Tree Fruit 1	01-01 D	AB	2.0	2	10.93	4.42	0.12	0.07	>69	113
	01-01 D	G	2.0	2	8.92	3.16	0.10	0.06	>49	81
	10-12 D	AB	2.0	2	9.30	3.49	0.10	0.06	>55	90
	21-06 F	AB	2.0	2	5.68	1.09	0.06	0.04	>17	28
	15-02 D+F	AB	0.51 (0.57)	1 F/ 1D	1.18	0.38	0.01	0.01	>5.9	9.7
	01-01 D	AB	0.625	2	3.48	1.40	0.04	0.02	>22	36
	01-01 D	AB	0.09	2	0.50	0.20	0.01	0.00	>3.1	5.2
Tree Fruit 2	01-01 D	AB	2.016	2	11.23	4.53	0.12	0.07	>71	116
	01-01 D	AB	0.51	1F/ 1D	1.18	0.38	0.06	0.04	>37	60
Fig	30-07 F	AB	0.5	1	0.90	0.14	0.01	0.01	>2.2	3.6
Beans	15-12 PP	G	4.032	1	14.48	4.61	0.16	0.10	>72	118
	15-12 PP	SI	3.984	2	4.33	1.54	0.05	0.03	>24	40
Row crop	15-12 PP	G	4.10	1	14.75	4.69	0.16	0.10	>73	120
	15-12 PP	SI	4.097	1	9.11	2.86	0.10	0.06	>45	73
	15-12 AP	SI	2.0	1	4.36	1.37	0.05	0.03	>21	35
Berries	15-12 D	AB	2.0485	1	10.55	3.79	0.12	0.07	>59	97
	15-08 F	AB			3.50	0.89	0.04	0.02	>14	23
	01-08 F	AB	1.02	1	1.74	1.44	0.02	0.01	>23	37
Blueberry	28-07 F	AB	1.008	2	3.09	0.87	0.03	0.02	>14	22
	01-08 F	AB	0.51	2	1.56	0.44	0.02	0.01	>6.8	11
	01-01 M	G	14.4	2	129.50	53.89	1.44	0.86	>842	1381
	01-01 M	G	2.8	2	24.86	15.05	0.28	0.17	>235	386
Cole Crops	15-12 PP	G	4.1	1	20.17	7.51	0.22	0.13	>117	193
	15-12 PP	SI			12.26	4.51	0.14	0.08	>70	116
	15-01 T	G	1.0	1	4.50	1.97	0.05	0.03	>31	51
	15-01 T	G	0.25	1	1.13	0.49	0.01	0.01	>7.7	13
	15-01T	G	116	1	496.30	212.50	5.5	3.3	>3320	5449

Use Groups	Date of First Application (DD-MM)	App. Type	Max app rate /app lbs a.i./A	# of app/ year	Water column EEC in µg/L		Acute Risk Quotient		Chronic Risk Quotient	
					Peak	60-day	Fresh[1]	Estuarine[2]	Fresh[3]	Estuarine[4]
Leafy vegetables	15-12 PP	G	4.10	1	28.60	12.47	0.32	0.19	>195	320
Lettuce	16-02 F	A	0.50	26	27.28	14.31	0.30	0.18	>224	367
	16-02 F	G			21.51	9.18	0.24	0.14	>143	235
	15-12 PP	SI	2.05	1	8.44	2.99	0.09	0.06	>47	77
	15-12 PP	A			16.06	6.47	0.18	0.11	>101	166
	15-12 PP	G			14.86	5.4	0.17	0.10	>84	138
	16-02 F	A	0.51	4b	13.87	4.98	0.15	0.09	>78	128
	16-02 F	G			11.54	3.94	0.13	0.08	>62	101
Garlic and Leek	15-10 PP	G	4.03	1	7.99	2.18	0.09	0.05	>34	56
Melons	01-08 F	G	0.77	26	30.97	13.07	0.34	0.21	>204	335
	01-05 PP	G	4.10	1	3.26	0.86	0.04	0.02	>13	22
	01-08 F	G			3.79	1.48	0.04	0.03	>23	38
	01-05 PP	SI			2.40	0.69	0.03	0.02	>11	18
	01-08 F	G	4.10	26	165.90	69.95	1.84	1.11	>1093	1794
	01-08 F	G	0.77	1	0.71	0.28	0.01	0.0047	>4.3	7.1
Onions	02-01 PP	G	4.10	1	4.23	1.64	0.05	0.03	>26	42
	02-01 PP	SI			3.05	1.23	0.03	0.02	>19	32
Rutabega	02-02 PP	G	4.03	1	21.54	5.74	0.24	0.14	>90	147
outdoor ornamentals	15-10 (NS)	G	1.0	26	85.95	29.65	0.96	0.57	>463	760
	15-09 (Plant Present)	G	3.984	3	19.01	5.19	0.21	0.13	>81	133
	01-11 (NS)	G	1.02	1	3.48	1.10	0.04	0.02	>17	28
Strawberry	01-01 F	G	1.02	26	122.00	58.66	1.36	0.81	>917	1504
	01-01 F	G	1.02	1	9.03	3.84	0.10	0.06	>60	98
	15-12 PP	SI	1.02	1	6.26	2.22	0.07	0.04	>35	57
	01-01 F	G	0.5	26	64.31	30.88	0.71	0.43	>482	792
	01-01 F	G	0.5	2b	9.76	4.22	0.11	0.07	>66	108
Tomato	15-02 PP	G	4.0	1	14.64	4.71	0.16	0.10	>74	121
	15-02 PP	SI			8.83	2.91	0.10	0.06	>45	75
	15-06 F	G	0.77	5/cc	2.96	1.15	0.03	0.02	18	29

Abbreviations: A=air; AB=airblast; G=ground; SI=soil incorporation; cc=crop cycle; App=applications; F=foliar; PP=preplant; D=dormant; AP=at plant; M=ant mound treatment

*Values in blue are equal to or greater than the corresponding listed species LOC. A full listing of each crop associated with the use group is shown in **Table 3-2**.

[1]based on acute rainbow trout LC_{50}=90 µg/L (MRID 40094602)

[2]based on acute striped mullet LC_{50}=150 µg/L (MRID 40228401)

[3]based on ACR of 1,400 for brook trout (MRID R00DI007 and R00DI007) applied to rainbow trout 96-hr LC_{50} of 90 µg/L (MRID 40094602) resulting in a NOAEC<0.064 µg/L

[4]based on ACR of 3,846 for sheepshead minnow (MRID 40228401 and MRID R00D0008) applied to striped mullet 96-hr LC_{50} of 150 µg/L resulting in a NOAEC of 0.039 µg/L

5.1.1.b. Freshwater and Estuarine/Marine Invertebrates

For assessing risks of indirect acute effects to the DS and TG through effects to prey (invertebrates) in freshwater and estuarine/marine aquatic habitats, 1-in-10 year peak EECs in the standard pond are used with the lowest acute toxicity value for invertebrates. For chronic risks, 1-in-10 year peak 21-day EECs and the lowest chronic toxicity value for invertebrates are used to derive RQs. RQs were calculated for the water column and pore water. Water column EECs were used in conjunction with water column toxicity tests to estimate risk. Pore water concentrations were used in conjunction with water column toxicity tests as well using assumptions of the equilibrium partitioning model to assess the potential for risk to sediment-dwelling organisms. RQ values exceed the acute and chronic risk LOCs (RQ≥0.05 and RQ≥1.0, respectively) for virtually all of the uses evaluated (**Table 5-2**) for both freshwater and estuarine/marine invertebrates. A couple of use patterns do not result in LOC exceedances for sediment (fig and tree fruit applications at 0.09 lbs a.i./A with two applications).

Table 5-2. Risk Quotient (RQ) Values for Acute and Chronic Exposures to Freshwater Invertebrates (Prey of DS and TG)*

Use Group	Date of First App	App Type	Max app rate /app (lbs a.i./A)	# of app/ year	Water column EEC in µg/L		Pore Water EEC in µg/L		Freshwater Invertebrate RQ				Estuarine/Marine Invertebrate RQ			
									Water Column		Pore Water		Water Column		Pore Water	
					Peak	21-day	Peak	21-day	Acute[1]	Chronic[2]	Acute[1]	Chronic[2]	Acute[3]	Chronic[4]	Acute[3]	Chronic[4]
Almonds	D	AB	0.77	4	12.56	7.32	2.75	2.72	60	170	13	63	3.0	32	0.65	12
		AB	3.024	1	10.58	6.27	2.06	2.03	50	146	10	47	2.5	27	0.49	8.8
		AB			10.87	6.78	2.54	2.52	52	158	12	59	2.6	29	0.61	11
		G			10.29	5.96	2.08	2.08	49	139	10	48	2.4	26	0.50	9.0
		AB	3	1	10.62	6.29	2.07	2.04	51	146	10	47	2.5	27	0.49	8.9
		AB	2.81	1	10.11	6.30	2.36	2.34	48	146	11	54	2.4	27	0.56	10
		G	0.77	4	11.24	6.65	2.27	2.25	54	155	11	52	2.7	29	0.54	10
Tree Fruit 1	D	AB	2	2	10.93	6.95	2.20	2.18	52	162	10	51	2.6	30	0.52	9.5
		G	2	2	8.92	5.34	1.59	1.57	42	124	7.6	37	2.1	23	0.38	6.8
		AB	2	2	9.30	5.67	2.53	2.47	44	132	12	57	2.2	25	0.60	11
	F	AB	2	2	5.68	2.59	0.58	0.55	27	60	2.7	13	1.4	11	0.14	2.4
	D	AB	0.51	1F/ 1D	1.18	0.69	0.25	0.25	5.6	16	1.2	5.8	0.28	3.00	0.06	1.09
		AB	0.625	2	3.48	2.21	0.70	0.69	17	51	3.3	16	0.8	10	0.17	3.0
		AB	0.09	2	0.50	0.32	0.10	0.10	2.4	7.3	0.48	2.3	0.12	1.4	0.02	0.43
Tree Fruit 2	D	AB	2.016	2	11.23	7.13	2.26	2.24	53	166	11	52	2.7	31	0.54	10
		AB	0.51	1F/ 1D	5.66	3.90	1.18	1.16	27	91	5.6	27	1.3	17	0.28	5.1
Fig	F	AB	0.5	1	0.90	0.34	0.07	0.07	4.3	7.8	0.35	1.6	0.21	1.5	0.02	0.30
Beans	PP	G	4.032	1	14.48	7.93	3.22	3.18	69	184	15	74	3.4	34	0.8	14
		SI	3.984	2	4.33	1.54	0.90	0.89	21	36	4.3	21	1.0	6.7	0.21	3.9
Row crop	PP	G	4.1	1	14.75	8.07	3.28	3.24	70	188	16	75	3.5	35	0.78	14
		SI	4.097	1	9.11	4.91	2.00	1.97	43	114	10	46	2.2	21	0.48	8.6
	AP	SI	2	1	4.36	2.35	0.96	0.95	21	55	4.6	22	1.0	10	0.23	4.1
Berries	D	AB	2.0485	1	10.55	6.37	2.59	2.56	50	148	12	59	2.5	28	0.62	11
	F	AB			3.50	1.79	0.84	0.82	17	42	4.0	19	0.83	7.8	0.20	3.6
	F	AB	1.02	1	1.74	0.88	0.34	0.34	8.3	21	1.6	7.9	0.41	3.8	0.08	1.5
Blueberry	F	AB	1.008	2	3.09	1.69	0.61	0.61	15	39	2.9	14	0.73	7.3	0.15	2.6
		AB	0.51	2	1.56	0.85	0.31	0.31	7.4	20	1.5	7.1	0.37	3.7	0.07	1.3
	M	G	126	2	129.50	78.19	29.96	29.62	617	1818	143	689	31	340	7.1	129
	M	G	28	2	24.86	15.05	5.77	5.71	118	350	27	133	5.9	65	1.4	25
Cole Crops	PP	G	4.1	1	20.17	11.34	5.18	5.12	96	264	25	119	4.8	49	1.2	22
		SI			12.26	6.81	3.08	3.04	58	158	15	71	2.9	30	0.73	13
	Transp	G	1	1	4.50	2.86	1.07	1.06	21	67	5.1	25	1.1	12	0.25	4.6

Use Group	Date of First App	App Type	Max app rate /app (lbs a.i./A)	# of app/ year	Water column EEC in µg/L		Pore Water EEC in µg/L		Freshwater Invertebrate RQ				Estuarine/Marine Invertebrate RQ			
									Water Column		Pore Water		Water Column		Pore Water	
					Peak	21-day	Peak	21-day	Acute[1]	Chronic[2]	Acute[1]	Chronic[2]	Acute[3]	Chronic[4]	Acute[3]	Chronic[4]
	lant	G	0.25	1	1.13	0.72	0.27	0.26	5.4	17	1.3	6.1	0.27	3.1	0.06	1.1
		G	116	1	496.3	308.3	115.3	113.4	2363	7170	549	2637	118	1340	27	493
Leafy vegetables	PP	G	4.1	1	28.60	18.26	6.91	6.84	136	425	33	159	6.8	79	1.6	30
Lettuce	F	A	0.5	26	27.28	18.95	8.12	8.01	130	441	39	186	6.5	82	1.9	35
		G			21.51	13.48	5.19	5.13	102	313	25	119	5.1	59	1.2	22
	PP	SI	2.05	2	8.44	5.17	1.88	1.86	40	120	9.0	43	2.0	22	0.45	8.1
		A			16.06	9.93	3.88	3.84	76	231	18	89	3.8	43	0.92	17
		G			14.86	9.23	3.4	3.36	71	215	16	78	3.5	40	0.81	15
	F	A	0.51	4b	13.87	8.49	2.57	2.55	66	197	12	59	3.3	37	0.61	11
		G			11.54	6.86	2.05	2.03	55	160	10	47	2.7	30	0.49	8.8
Garlic and Leek	PP	G	4.03	1	7.99	4.04	2.71	2.57	38	94	13	60	1.9	18	0.64	11
Melons	F	G	0.77	26	30.97	18.98	8.57	8.17	147	441	41	190	7.4	83	2.0	36
	PP	G	4.1	1	3.26	1.79	0.43	0.42	16	42	2.1	10	0.78	7.8	0.10	1.8
	F	G			3.79	2.16	1.04	1.02	18	50	4.9	24	0.90	9.4	0.25	4.4
	PP	SI			2.40	1.47	0.35	0.34	11	34	1.6	7.8	0.57	6.4	0.08	1.5
	F	G	4.1	26	165.90	101.73	45.84	43.69	790	2366	218	1016	40	442	11	190
		G	0.77	1	0.71	0.40	0.19	0.19	3.4	9.4	0.92	4.4	0.17	1.8	0.05	0.83
Onions	PP	G	4.1	1	4.23	2.56	0.87	0.86	20	60	4.1	20	1.0	11	0.21	3.7
		SI			3.05	1.93	0.63	0.63	15	45	3.0	15	0.73	8.4	0.15	2.7
Rutabega	PP	G	4.03	1	21.54	11.21	2.85	2.81	103	261	14	65	5.1	49	0.68	12
Nursery Stock and Ornamentals	NS	G	1	26	85.95	45.55	21.31	20.90	409	1059	101	486	20	198	5.1	91
	Plant Present	G	3.984	3	19.01	9.67	4.29	4.18	91	225	20	97	4.5	42	1.0	18
	NS	G	1.02	1	3.48	1.95	1.48	1.45	17	45	7.1	34	0.83	8	0.35	6.3
Strawberry	F	G	1.02	26	122.00	81.68	30.16	29.77	581	1900	144	692	29	355	7.2	129
		G	1.02	1	9.03	5.66	1.84	1.82	43	132	8.8	42	2.1	25	0.44	7.9
	PP	SI	1.02	1	6.26	3.59	1.31	1.29	30	84	6.2	30	1.5	16	0.31	5.6
	F	G	0.5	26	64.31	42.99	15.87	15.66	306	1000	76	364	15	187	3.8	68
		G	0.5	2b	9.76	6.22	2.01	1.98	46	145	10	46	2.3	27	0.48	8.6
Tomato	PP	G	4	1	14.64	7.13	3.07	3.04	70	166	15	71	3.5	31	0.73	13
		SI			8.83	4.56	1.94	1.92	42	106	9.2	45	2.1	20	0.46	8.3
	F	G	0.77	5/cc	2.96	1.83	0.66	0.66	14	42	3.2	15	0.70	7.9	0.16	2.9

Abbreviations: A=air; AB=airblast; G=ground; SI=soil incorporation; cc=crop cycle; App=applications; F=foliar; PP=preplant; D=dormant; AP=at plant; M=ant mound treatment
* Values in blue are equal to or greater than the corresponding listed species LOC. A full listing of each crop associated with the use group is shown in **Table 3-2**.
[1]based on acute *C. dubia* LC_{50}=0.21 µg/L
[2] based on ACR of 4.88 for *D. magna* applied to *C. dubia* NOAEC=0.043 µg/L
[3]based on acute mysid LC_{50}=4.2 µg/L
[4]based on chronic mysid NOAEC=0.23 µg/L

5.1.1.c. Aquatic Plants

Risk to aquatic non-vascular plants is based on 1-in-10-year peak EECs in the standard pond and the lowest toxicity value (EC_{50}=3,700 µg/L). Data are only available for one non-vascular plant species. Typically, data are available on four species. Risk quotients are shown in **Table 5-3**. Resulting RQ values do not exceed the acute risk LOC (RQ≥1.0) for aquatic plants from diazinon applications to any of the uses modeled. No toxicity data on vascular plants are available to assess the risks of diazinon to vascular aquatic plants.

Table 5-3. Risk Quotient (RQ) Values for Aquatic Nonvascular Plants (Dietary item of DS and TG)*

Uses Represented [1]	Date of First App (DD-MM)	App Type	Max app rate /app (lbs a.i./A)	# of app/ year	Water column peak EEC in µg/L	Risk Quotient for Aquatic Nonvascular Plants[1]
Almonds	10-12 D	AB	0.77	4	12.56	0.0034
	22-01 D	AB	3.024	1	10.58	0.0029
	10-12 D	AB			10.87	0.0029
		G			10.29	0.0028
	22-01 D	AB	3	1	10.62	0.0029
	10-12 D	AB	2.81	1	10.11	0.0027
	10-12 D	G	0.77	4	11.24	0.0030
Tree Fruit 1	01-01 D	AB	2	2	10.93	0.0030
	01-01 D	G	2	2	8.92	0.0024
	10-12 D	AB	2	2	9.30	0.0025
	21-06 F	AB	2	2	5.68	0.0015
	15-02 D	AB	0.51	2	1.18	0.0003
	01-01 D	AB	0.625	2	3.48	0.0009
	01-01 D	AB	0.09	2	0.50	0.0001
Tree Fruit 2	01-01 D	AB	2.016	2	11.23	0.0030
	01-01 D	AB	0.51	2	5.66	0.0015
Fig	30-07 F	AB	0.5	1	0.90	0.0002
Beans	15-12 PP	G	4.032	1	14.48	0.0039
	15-12 PP	SI	3.984	2	4.33	0.0012
Row crop	15-12 PP	G	4.1	1	14.75	0.0040
	15-12 PP	SI	4.097	1	9.11	0.0025
	15-12 AP	SI	2	1	4.36	0.0012
Berries	15-12 D	AB	2.0485	1	10.55	0.0029
	15-08 F	AB			3.50	0.0009
	01-08 F	AB	1.02	1	1.74	0.0005
Blueberry	28-07 F	AB	1.008	2	3.09	0.0008
	01-08 F	AB	0.51	2	1.56	0.0004
	01-01 M	G	14.4	2	129.50	0.0350
		G	2.8	2	24.86	0.0067
Cole Crops	15-12 PP	G	4.1	1	20.17	0.0055
	15-12 PP	SI			12.26	0.0033
	15-01 T	G	1	1	4.50	0.0012
	15-01 T	G	0.25	1	1.13	0.0003
	15-01 T	G	116	1	496.30	0.1341
Leafy vegetables	15-12 PP	G	4.1	1	28.60	0.0077

Uses Represented [1]	Date of First App (DD-MM)	App Type	Max app rate /app (lbs a.i./A)	# of app/ year	Water column peak EEC in µg/L	Risk Quotient for Aquatic Nonvascular Plants[1]
Lettuce	16-02 F	A	0.5	26	27.28	0.0074
	16-02 F	G			21.51	0.0058
	15-12 PP	SI	2.05	1	8.44	0.0023
	15-12 PP	A			16.06	0.0043
	15-12 PP	G			14.86	0.0040
	16-02 F	A	0.51	4b	13.87	0.0037
	16-02 F	G			11.54	0.0031
Garlic and Leek	15-10 PP	G	4.03	1	7.99	0.0022
Melons	01-08 F	G	0.77	26	30.97	0.0084
	01-05 PP	G	4.1	1	3.26	0.0009
	01-08 F	G			3.79	0.0010
	01-05 PP	SI			2.40	0.0006
	01-08 F	G	4.1	26	165.90	0.0448
	01-08 F	G	0.77	1	0.71	0.0002
Onions	02-01 PP	G	4.1	1	4.23	0.0011
	02-01 PP	SI			3.05	0.0008
Rutabega	02-02 PP	G	4.03	1	21.54	0.0058
Nursery Stock and Ornamentals	15-10 (NS)	G	1	26	85.95	0.0232
	15-09 (Plant Present)	G	3.984	3 (14 day int.)	19.01	0.0051
	01-11 (NS)	G	1.02	1	3.48	0.0009
Strawberry	01-01 F	G	1.02	26	122.00	0.0330
	01-01 F	G	1.02	1	9.03	0.0024
	15-12 PP	SI	1.02	1	6.26	0.0017
	01-01 F	G	0.5	26	64.31	0.0174
	01-01 F	G	0.5	2b	9.76	0.0026
Tomato	15-02 PP	G	4	1	14.64	0.0040
	15-02 PP	SI			8.83	0.0024
	15-06 F	G	0.77	5/cc	2.96	0.0008

Abbreviations: A=air; AB=airblast; G=ground; SI=soil incorporation; cc=crop cycle; App=applications; F=foliar; PP=preplant; D=dormant; AP=at plant; M=ant mound treatment

* A full listing of each crop associated with the use group are shown in **Table 3-2**.

[1] Based on only available non-vascular plant EC_{50} = 3700 µg/L for green algae (MRID 40509806).

5.1.2. Exposures in the Terrestrial Habitat

5.1.2.a. Terrestrial Plants

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. Risk quotients are shown in **Table 5-4** and **Table 5-5**. RQs for applications to cole crops on a per plant basis (116 lbs a.i./A) exceed the LOC for nonlisted plants. For all other uses, RQs did not exceed the LOC.

Table 5-4. RQs* for Nonlisted Monocots Inhabiting Dry and Semi-Aquatic Areas Exposed to Diazinon via Runoff and Drift

Use	App rate (lbs a.i./A)	App method	Drift Value (%)	Risk Quotients[1,2]		
				Spray drift	Dry area	Semi-aquatic area
Per plant application for cole crops	116	Transplant Water	0	Not applicable	<0.44	<4.41
Ant mound use in blueberries	14.4	Ground	0	Not applicable	<0.55	<0.1
Lettuce	2.05	Aerial	0.05	<0.1	<0.1	<0.1

* Values in blue are equal to or greater than the corresponding nonlisted species LOC.
[1] For monocots, the seedling emergence EC_{25} is 5.26 lbs a.i./A and the corresponding NOAEC is 0.17 lbs a.i./A. The vegetative vigor EC_{25} is >7 lbs a.i./A and the corresponding NOAEC is 7 lbs a.i./A.

Table 5-5. RQs* for Nonlisted Dicots Inhabiting Dry and Semi-Aquatic Areas Exposed to Diazinon via Runoff and Drift

Use	Application rate (lbs a.i./A)	App method	Drift Fraction	Risk Quotient		
				Spray drift	Dry area	Semi-aquatic area
Per plant application for cole crops	116	Transplant Water	0	Not applicable	0.26	2.57
Ant mound use in blueberries	14.4	Ground	0	Not applicable	<0.1	0.32
Lettuce	2.05	Aerial	0.05	<0.1	<0.1	<0.1

* Values in blue are equal to or greater than the corresponding nonlisted species LOC.
[1] For dicots, the seedling emergence EC_{25} is 9.03 lbs a.i./A and the corresponding NOAEC is 1.58 lbs a.i./A. The vegetative vigor EC_{25} is 3.23 lbs a.i./A and the corresponding NOAEC is 1.27 lbs a.i./A.

5.1.3. Primary Constituent Elements of Designated Critical Habitat

For diazinon 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 risk quotients and a comparison to the Level of Concern. The final No Effect/May Affect determination is made after the spatial analysis is completed at the end of the risk description, Section 5.2.3. In this section, a discussion of any potential overlap between areas where potential usage may result in LAA effects 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 diazinon'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 diazinon. Based on the LOC exceedances identified above, a preliminary determination of 'may effect' is made for diazinon usage relative to the DS, TG and their associated critical habitat. A summary of the risk estimation results are provided in **Table 5-6** for direct and indirect effects to the listed species assessed here and for the PCEs of their designated critical habitat.

Table 5-6. Risk Estimation Summary for Diazinon Direct and Indirect Effects on Delta Smelt, Tidewater Goby, and Designated Critical Habitat (PCEs)

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)	Acute: RQs exceed LOCs for mound treatments in blueberry orchards, applications on a per plant basis for cole crops, foliar applications to melons with 26 applications, ornamentals with 26 applications, and strawberries with 26 applications. Chronic: RQs exceed LOCs for all use patterns.	<u>Indirect Effects</u>: TG and DS	TG and DS
	Listed Species (Yes)	Acute: RQs exceed LOC for almonds, tree fruit, beans, row crops, dormant uses on berries, ant mound treatments for blueberries, cole crops, leafy vegetables, lettuce, garlic and leek, melons with 26 applications, onions for ground applications only, rutabaga, outdoor ornamentals, strawberry, and tomato. Chronic: RQs exceed LOCs for all use patterns.	<u>Direct Effects</u>: TG and DS	TG and DS
Freshwater Invertebrates	Non-listed Species (Yes)	Acute and Chronic: RQs exceed LOC for all use	<u>Indirect Effects</u>:	TG and DS

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
	Listed Species (Yes)	patterns.	TG and DS <u>Direct Effects</u>: Not applicable	TG and DS
Estuarine/Marine Fish	Non-listed Species (Yes)	Acute: Acute RQs exceed the LOC for use on ant mounds in blueberry orchards, the per plant application to cole crops, 26 applications to melons, ornamentals, and strawberries. Chronic: All RQs exceed LOCs for all use patterns.	<u>Indirect Effects</u>: TG and DS	TG and DS
	Listed Species (Yes)	Acute: RQs exceed LOC for all but some uses on tree fruit, figs, some uses on beans, some uses on row crops, some uses on berries, transplant applications on cole crops (excluding per plant application rate), some uses on melons, onions, some uses on ornamentals, soil incorporation uses for strawberries, and some uses for tomatoes. Chronic: All RQs exceed LOCs for all use patterns.	<u>Direct Effects</u>: TG and DS	TG and DS
Estuarine/Marine Invertebrates	Non-listed Species (Yes)	Acute: Acute RQs exceed LOC almost all uses but select uses on tree fruit, fig, select uses on berries, select uses on blueberry, select uses for cole crops, select uses on melons. Chronic: All RQs exceed the LOC for all uses patterns evaluated.	<u>Indirect Effects</u>: TG and DS <u>Direct Effects:</u> Not applicable	TG and DS
	Listed Species (Yes)	Acute and Chronic: RQs exceed LOC for all use patterns.		TG and DS
Vascular Aquatic Plants	Non-listed Species (Uncertain)	No Data	<u>Indirect Effects</u>: Uncertain	Uncertain
Non-Vascular Aquatic Plants	Non-listed Species	RQs do not exceed LOCs. Data are only available on one	<u>Indirect Effects</u>:	Uncertain

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
	(Uncertain)	of four species.	Uncertain	
Terrestrial Plants – Monocots[1]	Non-listed Species (Yes)	RQ exceeds LOC for the per plant application rate to cole crops only	Indirect Effects: TG and DS	TG and DS
Terrestrial Plants – Dicots[1]	Non-listed Species (Yes)	RQ exceeds LOC for the per plant application rate to cole crops only	Indirect Effects: TG and DS	TG and DS

[1] Only non-listed LOCs were evaluated because none of the assessed species have an obligate relationship with terrestrial monocots and dicots.

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 Sections 5.2.1 through 5.3.1. Discussion will start with the potential for direct effects, followed by a discussion of the potential for indirect effects. These discussions do not consider the spatial analysis. The section will end with a discussion on the potential for modification to the critical habitat from the use of diazinon. Finally, in Section 5.2.3, 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. Delta Smelt and Tidewater Goby

5.2.1.a. Direct Effects

Acute exposures

All use patterns except applications to fig and blueberries (ant mound uses in blueberry orchards do have exceedances) have at least some RQs that exceed the acute risk to listed species LOC by factors ranging from 1 to 110X for direct effects to DS and TG. Uses of diazinonon on tree fruit, row crops, berries, cole crops, melons, onions, ornamentals, and tomato have acute RQs that are both lower and higher than the acute risk listed species LOC, depending on the type of specific use pattern. For melons, the only use pattern that exceeds the acute listed species LOC are uses with 26 applications assumed. For melons, the only use pattern that exceeds the acute listed species LOC are uses with 26 applications assumed.

A source of uncertainty in the derivation of RQs is the estimation of exposure. As discussed above (Section 3.2.1) concentrations of diazinon have been detected in California surface waters at levels high enough to result in direct effects to TG and DS (maximum concentration was 46.63 µg/L (California Department of Pesticide Regulation, 2012 ; USGS, 2010). This detection occurred in the Sacramento River in 1994. More recent detections in California range from below the level of detection (<LOD) to 4.3 µg/L based on data from NAWQA and CDPR surface water data between 2004 to present (California Department of Pesticide Regulation, 2012; USGS, 2010). These concentrations are just below concentrations that would result in an acute LOC exceedance (4.5 µg/L) and much higher than levels that would result in a chronic risk concern (<0.064 µg/L). Additionally, these data are not targeted monitoring data and thus, would underestimate exposure and do not represent possible exposure across the habitats of the DS and TG.

An analysis of the likelihood of individual direct mortality (**Table 5-7**) for each assessed use indicates that based on the highest RQ value (5.51 for freshwater fish) for direct effects on the DS and TG and with an assumed dose-response slope of 4.5, the likelihood is 1 in 1. At the endangered species LOC, *i.e.*, RQ=0.05, the likelihood of individual mortality is 1 in 1.2×10^8. The results of the likelihood of individual direct mortality based on RQs for estuarine/marine fish are also shown in **Table 5-7**. Although many of the current uses are estimated to exceed the acute risk to listed species LOC for DS and TG, the likelihood of individual mortality may be is significantly lower for some of the uses. Methods for calculating the likelihood of individual direct mortality are in Section 2.11.2.b and examples are provided in **Appendix O**.

Table 5-7. Likelihood of Individual Effect for Each Use of Diazinon for the DS and TG

Use Group	Date of First Application (DD-MM)	App Type	Max app rate /app in lbs a.i./A	#of app/ year	Freshwater Fish		Estuarine/Marine Fish	
					Acute RQ	Likelihood of Individual Effect (1 in…)[1]	Acute RQ	Likelihood of Individual Effect (1 in…)[2]
Almonds	10-12 D	AB	0.77	4	0.14	1.64×10^4	0.08	2.51×10^6
	22-01 D	AB	3.024	1	0.12	5.85×10^4	0.07	9.88×10^6
	10-12 D	AB			0.12	5.85×10^4	0.07	9.88×10^6
		G			0.11	1.25×10^5	0.07	9.88×10^6
	22-01 D	AB	3.0	1	0.12	5.85×10^4	0.07	9.88×10^6
	10-12 D	AB	2.81	1	0.11	1.25×10^5	0.07	9.88×10^6
	10-12 D	G	0.77	4	0.12	5.85×10^4	0.07	9.88×10^6
Tree Fruit 1	01-01 D	AB	2.0	2	0.12	5.85×10^4	0.07	9.88×10^6
	01-01 D	G	2.0	2	0.10	2.94×10^5	0.06	5.22×10^7
	10-12 D	AB	2.0	2	0.10	2.94×10^5	0.06	5.22×10^7
	21-06 F	AB	2.0	2	0.06	5.22×10^7	0.04	NA
	15-02 D+F	AB	0.51	2	0.01	NA	0.01	NA
	01-01 D	AB	0.625	2	0.04	NA	0.02	NA
	01-01 D	AB	0.09	2	0.01	NA	<0.01	NA
Tree Fruit 2	01-01 D	AB	2.016	2	0.12	5.85×10^4	0.07	9.88×10^6
	01-01 D	AB	0.51	4	0.06	5.22×10^7	0.04	NA
Fig	30-07 F	AB	0.5	1	0.01	NA	0.01	NA
Beans	15-12 PP	G	4.032	1	0.16	5.85×10^3	0.10	2.94×10^5
	15-12 PP	SI	3.984	2	0.05	4.18×10^8	0.03	NA
Row crop	15-12 PP	G	4.10	1	0.16	5.85×10^3	0.10	2.94×10^5
	15-12 PP	SI	4.097	1	0.10	2.94×10^5	0.06	5.22×10^7
	15-12 AP	SI	2.0	1	0.05	4.18×10^8	0.03	NA
Berries	15-12 D	AB	2.0485	1	0.12	5.85×10^4	0.07	9.88×10^6
	15-08 F	AB			0.04	NA	0.02	NA
	01-08 F	AB	1.02	1	0.02	NA	0.01	NA
Blueberry	28-07 F	AB	1.008	2	0.03	NA	0.02	NA
	01-08 F	AB	0.51	2	0.02	NA	0.01	NA
	01-01 M	G	14.4	2	1.44	1.31	0.86	2.60
		G	2.8	2	0.28	156	0.17	3.74×10^3
Cole Crops	15-12 PP	G	4.1	1	0.22	648	0.13	2.99×10^4
	15-12 PP	SI			0.14	1.64×10^4	0.08	2.51×10^6
	15-01 T	G	1.0	1	0.05	4.18×10^8	0.03	NA
	15-01 T	G	0.25	1	0.01	NA	0.01	NA
	15-01 T	G	116	1	5.51	1.00	3.31	1.01
Leafy vegetables	15-12 PP	G	4.10	1	0.32	8.00	0.19	1.71×10^3
Lettuce	16-02 F	A	0.50	26	0.30	10.0	0.18	3.49×10^3
	16-02 F	G			0.24	378	0.14	1.64×10^4
	15-12 PP	SI	2.05	2	0.09	5.79×10^5	0.06	5.22×10^7
	15-12 PP	A			0.18	2.49×10^3	0.11	1.25×10^5
	15-12 PP	G			0.17	3.74×10^3	0.10	2.94×10^5
	16-02 F	A	0.51	4b	0.15	9.56×10^3	0.09	7.91×10^5
	16-02 F	G			0.13	2.99×10^4	0.08	2.51×10^6

Use Group	Date of First Application (DD-MM)	App Type	Max app rate /app in lbs a.i./A	#of app/ year	Freshwater Fish		Estuarine/Marine Fish	
					Acute RQ	Likelihood of Individual Effect (1 in…)[1]	Acute RQ	Likelihood of Individual Effect (1 in…)[2]
Garlic and Leek	15-10 PP	G	4.03	1	0.09	7.91×10^{5}	0.05	4.18×10^{8}
Melons	01-08 F	G	0.77	26	0.34	6.00	0.21	874
	01-05 PP	G	4.10	1	0.04	NA	0.02	NA
	01-08 F	G			0.04	NA	0.03	NA
	01-05 PP	SI			0.03	NA	0.02	NA
	01-08 F	G	4.10	26	1.84	1	1.11	NA
	01-08 F	G	0.77	1	0.01		0.005	NA
Onion	02-01 PP	G	4.10	1	0.05	4.18×10^{8}	0.03	NA
	02-01 PP	SI			0.03		0.02	NA
Rutabega	02-02 PP	G	4.03	1	0.24	378	0.14	1.64×10^{4}
Nursery Stock and Ornamentals	15-10 (NS)	G	1.0	26	0.96	2	0.57	7.35
	15-09 (Plant Present)	G	3.984	3 (14 day int.)	0.21	874	0.13	2.99×10^{4}
	01-11 (NS)	G	1.02	1	0.04		0.02	NA
Strawberry	01-01 F	G	1.02	26	1.36	1	0.81	2.94
	01-01 F	G	1.02	1	0.10	2.94×10^{5}	0.06	5.22×10^{7}
	15-12 PP	SI	1.02	1	0.07	9.88×10^{6}	0.04	NA
	01-01 F	G	0.5	26	0.71	4	0.43	20.2
	01-01 F	G	0.5	2b	0.11	1.25×10^{5}	0.07	9.88×10^{6}
Tomato	15-02 PP	G	4.0	1	0.16	5.85×10^{3}	0.10	2.94×10^{5}
	15-02 PP	SI			0.10	2.94×10^{5}	0.06	5.22×10^{7}
	15-06 F	G	0.77	5/cc	0.03	NA	0.02	NA

Abbreviations: A=air; AB=airblast; G=ground; SI=soil incorporation; cc=crop cycle; App=applications; F=foliar; PP=preplant; D=dormant; AP=at plant; M=ant mound treatment

[1] based on acute rainbow trout 96-hr LC_{50}=90 µg/L and default slope of 4.5 (MRID 40094602).

[2] based on acute 96-hr LC_{50} for striped mullet of 150 µg/L and a default slope of 4.5 (MRID 40228401)

In order to characterize the conservativeness of the endpoint selected to represent direct effects to DS and TG (*e.g.*, rainbow trout LC_{50} = 90 $\mu g \cdot L^{-1}$), a genus sensitivity distribution is derived using the available acute toxicity data for freshwater fish based on registrant-submitted and open literature data. This distribution is described in **Appendix L** and includes data from registrant-submitted studies and open literature. The lower 95[th] percentile of the fish distribution (472 $\mu g \cdot L^{-1}$) indicates that the use of the lowest available toxicity value (90 $\mu g \cdot L^{-1}$) is likely a conservative estimate of the toxicity of diazinon to freshwater vertebrates. When considering estimated aquatic exposure concentrations (maximum peak EEC = 496 µg/L for use on a per plant basis for cole crops), use on diazinon on cole crops is sufficient to exceed the LOC for all of the fish in the sensitivity distribution. Aquatic EEC_S of 50 µg/L and above would have LOC exceedances for five of eight species. EECs of 10 µg/L are sufficient to exceed the acute LOC for only the most sensitive species. The highest monitored concentration after 2004 (4.3 µg/L) is high enough to result in RQ exceedances when compared to the most sensitive species (1 of 8) in the distribution.

Based on the above information, there is a potential for acute direct effects to the DS and TG for diazinon uses except for fig and blueberries (use of diazinon on ant mounds in blueberry orchards does have the potential for acute direct effects).

Chronic exposures

All of the uses sites have at least one RQ that exceeds the chronic risk LOC for direct effects to the DS and TG.

Chronic RQs are based on the level where no effects were observed (the NOAEC) in laboratory toxicity tests. A NOAEC is not available for freshwater fish as reduced growth was observed at the lowest tested concentration of 0.55 µg/L for brook trout. Therefore, it is not possible to fully characterize the potential for risk due to chronic exposure. All risk quotients calculated for freshwater fish are greater than values. Additionally, the acute toxicity endpoints indicated that rainbow trout were more sensitive than brook trout. Therefore, a greater than ACR (96-hr LC_{50}/NOAEC=770/<0.55 >1400) was used to estimate a nondefintitive less than NOAEC for rainbow trout and the value was used to calculate RQs (NOAEC <0.064 µg/L). There is some uncertainty both with using an ACR to estimate the endpoint for rainbow trout and in using a LOAEC instead of a NOAEC to estimate that ACR. RQs are still exceeded when the measured LOAEC of 0.55 µg/L is used to calculate greater than RQs for all but the following uses:

- Tree fruit, 0.051 lbs a.i./A, dormant and foliar application
- Tree fruit, 0.09 lbs a.i./A, two applications
- Fig
- Blueberry, 0.51 lbs a.i./A, two applications
- Cole crops, 0.25 lbs a.i./A, one application
- Melons, 0.77 lbs a.i./A, one application

Given that a NOAEC is not available to fully determine the concentrations that effects may occur due to chronic exposure and estimated toxicity indicates that risk due to chronic exposure is likely, direct risk due to TG and DS cannot be discounted for any of the evaluated uses of diazinon.

As discussed in Section 4.2.1.b., had the ACR for estuarine/marine fish (ACR=3846) been used to estimate a NOAEC for rainbow trout, the result would be a NOAEC of 0.023 µg/L. If chronic RQ values had been calculated based on this estimated NOAEC, RQs would range from 6.09 (figs) to 9239 (cole crops).

Chronic RQs for estuarine/marine species were also calculated using an estimated endpoint because striped mullet were shown to be more sensitive than the sheepshead minnow for which chronic toxicity data were available. For the sheepshead minnow (NOAEC=0.39 µg/L) effects on reproduction were observed at 0.56 µg/L. The ACR for the sheepshead minnow of 3846 (96-hr LC_{50}=1500, NOAEC=0.39, ACR=1500÷0.39=3846) results in an estimated NOAEC for striped mullet of 0.039 µg/L. The chronic risk LOC would be exceeded for all uses using these estimated endpoints, the ratio of the EEC to the estimated endpoints range from 3.63 to 5449.

There are two significant uncertainties regarding the potential for direct effects for these uses. First, it is assumed that the actual exposure concentration where effects are exhibited lies somewhere between the NOAEC and the LOAEC. Second, a NOAEC is not available for freshwater fish. Given the uncertainty associated with the actual level where effects occur, risks of chronic exposures of the DS and TG to diazinon cannot be discounted. Based on the LOC exceedances and the two uncertainties described above, there is a potential for direct effects to the DS and TG from chronic exposure in aquatic habitat resulting from diazinon use as modeled in this assessment.

5.2.1.b. Indirect Effects

i. Potential Loss of Prey

As discussed in **Attachment II**, the diet of DS is composed primarily of zooplankton, particularly copepods. The diet of the TG consists of macroinvertebrates such as mysid, shrimp, gamarid, amphipods, ostracods, and aquatic insects. Food items of the smallest tidewater gobies, 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 invertebrates as well as unicellular aquatic plants are considered as prey groups for determining indirect effects to the DS and TG caused by direct effects to its prey.

Aquatic invertebrates

The range of RQs for acute (2.37 to 2363 in the water column and 0.35 to 549 in pore water) and chronic (7.34 to 7170 in the water column and 1.62 to 2637 in pore water) risk estimates for freshwater aquatic invertebrates indicate that all uses of diazinon can potentially result in effects to invertebrates serving as prey to DS and TG when it resides in freshwater. For brackish waters, the corresponding ranges for estuarine invertebrates are 0.12 to 118 for acute water column and 1.37 to 1340 for chronic water column RQs. For estuarine/marine invertebrates the pore water RQs are lower but many still exceed the chronic LOC. Acute pore water RQs for estuarine/marine invertebrates range from 0.02 to 27.5 and chronic RQs range from 0.30 to 493.

Based on an analysis of the likelihood of individual mortality using the highest RQ value for aquatic freshwater invertebrates (diazinon use on cole crops; RQ= 2363) and a probit dose-response slope of 6.34, the likelihood of individual mortality is 100%. At the lowest acute RQ value for the water column (*i.e.*, RQ=2.37 for use on tree fruit at 0.09 lbs a.i./A), the likelihood of individual mortality is 1 in 1.

In order to characterize the conservativeness of the endpoint selected to represent indirect effects to the DS and TG through direct effects to its aquatic prey (*e.g.*, water flea EC_{50} = 0.21 $\mu g \cdot L^{-1}$) genus sensitivity distributions are derived using the available acute toxicity data for freshwater fish and invertebrates, respectively, based on registrant-submitted and open literature data (see

Appendix L for information on sensitivity distributions). The lower 95th percentile of the invertebrate distribution (0.69 µg·L^{-1}) indicates that the use of the lowest available toxicity value (0.21 µg·L^{-1}) is more conservative than the lower 95th percentile of the distribution. When considering the distribution, estimated aquatic concentrations resulting from all uses are at levels sufficient to exceed the acute risk LOC for >90% of invertebrate species. When considering invertebrate sensitivity distributions in the context of available monitoring data, the highest concentration of diazinon observed in California surface waters (46.63 µg·L^{-1}) is sufficient to exceed the invertebrate LOC for approximately eight of nine available species (California Department of Pesticide Regulation, 2012). This detection occurred in the Sacramento River in 1994. More recent detections in Sacramento and San Joaquin County (relevant to the range of the DS and TG) range from below the level of detection (<LOD) to 0.01 based on data from NAWQA and CAPR surface water data between 2004 to present (California Department of Pesticide Regulation, 2012; USGS, 2010). These concentrations are high enough to result in an LOC exceedance for listed species for freshwater aquatic invertebrates. These results indicate that diazinon concentrations in the Sacramento River have been high enough to result in effects to listed aquatic invertebrates. Actual exposure in DS and TG habitat may be higher than the monitoring results because the monitored results are not from targeted monitoring data and do not represent possible exposure across the habitats of the DS and TG.

An analysis of the likelihood of individual direct mortality (**Table 5-9**) for each assessed use indicates that the likelihood of indirect effects to DS and TG via direct effects on aquatic invertebrate prey is 1 in 1, *i.e.*, 100%. At the endangered species LOC, *i.e.*, RQ=0.05, the likelihood of individual mortality is 1 in 1.26×10^{16} based on a slope of 6.34 for freshwater aquatic invertebrates and a slope of 6.01 for estuarine/marine invertebrates. Methods for calculating the likelihood of individual indirect mortality to aquatic invertebrate forage organisms are in Section 2.11.2.b and examples in **Appendix O**.

Table 5-9. Likelihood of Individual Effect for Each Use of Diazinon for Aquatic Invertebrates

Uses Group[3]	Date of First Application (DD-MM)	App Type	Max app rate /app in lbs a.i./A	#of app/ year	Freshwater		Estuarine/Marine	
					Acute RQ	Likelihood of Individual Effect (1 in…)[1]	Acute RQ	Likelihood of Individual Effect (1 in…)[2]
Almonds	10-12 D	AB	0.77	4	59.8	1	2.99	1.00
	22-01 D	AB	3.024	1	50.4	1	2.52	1.01
	10-12 D	AB			51.8	1	2.59	1.01
		G			49.0	1	2.45	1.01
	22-01 D	AB	3.0	1	50.6	1	2.53	1.01
	10-12 D	AB	2.81	1	48.1	1	2.41	1.01
	10-12 D	G	0.77	4	53.5	1	2.68	1.01
Tree Fruit 1	01-01 D	AB	2.0	2	52.1	1	2.60	1.01
	01-01 D	G	2.0	2	42.5	1	2.12	1.03
	10-12 D	AB	2.0	2	44.3	1	2.21	1.02
	21-06 F	AB	2.0	2	27.1	1	1.35	1.28
	15-02 D+F	AB	0.51	2	5.62	1	0.28	2240
	01-01 D	AB	0.625	2	16.6	1	0.83	3.19
	01-01 D	AB	0.09	2	2.37	1	0.12	5.85×10^4

Uses Group[3]	Date of First Application (DD-MM)	App Type	Max app rate /app in lbs a.i./A	#of app/ year	Freshwater		Estuarine/Marine	
					Acute RQ	Likelihood of Individual Effect (1 in…)[1]	Acute RQ	Likelihood of Individual Effect (1 in…)[2]
Tree Fruit 2	01-01 D	AB	2.016	2	53.5	1	2.67	1.01
Fig	30-07 F	AB	0.5	1	4.27	1	0.21	1.32×10^4
Beans	15-12 PP	G	4.032	1	69.0	1	3.45	1.00
	15-12 PP	SI	3.984	2	20.62	1	1.03	1.88
Row crop	15-12 PP	G	4.10	1	70.2	1	3.51	1.00
	15-12 PP	SI	4.097	1	43.4	1	2.17	1.02
	15-12 AP	SI	2.0	1	20.8	1	1.04	1.85
Berries	15-12 D	AB	2.0485	1	50.3	1	2.51	1.01
	15-08 F	AB			16.7	1	0.83	3.19
	01-08 F	AB	1.02	1	8.26	1	0.41	100
Blueberry	28-07 F	AB	1.008	2	14.7	1	0.73	4.86
	01-08 F	AB	0.51	2	7.41	1	0.37	212
	01-01 M	G	14.4	2	616	1	30.8	1.00
			2.8		118	1	5.92	1.00
Cole Crops	15-12 PP	G	4.1	1	96.0	1	4.80	1.00
	15-12 PP	SI			58.4	1	2.92	1.00
	15-01 T	G	1.0	1	21.4	1	1.07	1.75
	15-01 T	G	0.25	1	5.36	1	0.27	316
	15-01 T	G	116	1	2363	1	118	1.00
Leafy vegetables	15-12 PP	G	4.10	1	136	1	6.81	1.00
Lettuce	16-02 F	A	0.50	26	130	1	6.49	1.00
	16-02 F	G			102	1	5.12	1.00
	15-12 PP	SI	2.05	2	40.19	1	2.01	1.04
	15-12 PP	A			76.48	1	3.82	1.00
	15-12 PP	G			70.76	1	3.54	1.00
	16-02 F	A	0.51	4b	66.1	1	3.30	1.00
	16-02 F	G			54.9	1	2.75	1.00
Garlic and Leek	15-10 PP	G	4.03	1	38.0	1	1.90	1.05
Melons	01-08 F	G	0.77	26	147	1	7.37	1.00
	01-05 PP	G	4.10	1	15.5	1	0.78	3.87
	01-08 F	G			18.0	1	0.90	2.55
	01-05 PP	SI			11.4	1	0.57	14.1
	01-08 F	G	4.10	26	790	1	39.5	1.00
	01-08 F	G	0.77	1	3.37	1	0.17	5.34×10^5
Onion	02-01 PP	G	4.10	1	20.1	1	1.01	1.96
	02-01 PP	SI			14.5	1	0.73	1.00
Rutabega	02-02 PP	G	4.03	1	103	1	5.13	1.00
Nursery Stock and Ornamentals	15-10 (NS)	G	1.0	26	409	1	20.5	1.00
	15-09 (Plant Present)	G	3.984	3	90.5	1	4.53	1.00
	01-11 (NS)	G	1.02	1	16.6	1	0.83	3.19
Strawberry	01-01 F	G	1.02	26	581	1	29.0	1.00
	01-01 F	G	1.02	1	43.0	1	2.15	1.02
	15-12 PP	SI	1.02	1	29.8	1	1.49	1.18
	01-01 F	G	0.5	26	306.2	1	15.3	1.00

Uses Group[3]	Date of First Application (DD-MM)	App Type	Max app rate /app in lbs a.i./A	#of app/ year	Freshwater		Estuarine/Marine	
					Acute RQ	Likelihood of Individual Effect (1 in…)[1]	Acute RQ	Likelihood of Individual Effect (1 in…)[2]
	01-01 F	G	0.5	2b	46.5	1	2.32	1.01
Tomato	15-02 PP	G	4.0	1	69.7	1	3.49	1.00
	15-02 PP	SI			42.0	1	2.10	1.03
	15-06 F	G	0.77	5/cc	14.1	1	0.70	5.68

Abbreviations: A=air; AB=airblast; G=ground; SI=soil incorporation; cc=crop cycle; App=applications; F=foliar; PP=preplant; D=dormant; AP=at plant; M=ant mound treatment

1 based on slope of 6.34 estimated based on data for aquatic invertebrates (**Appendix O**) for the 48-hr EC_{50} if 0.21 µg/L for the water flea (*C. dubia*)

2 based on slope of 6.01 for the 48-hr EC_{50} of 4.2 µg/L for the mysid shrimp

3 Crops in each use group are listed in **Table 3-2**

Based on acute and chronic LOC exceedances, likelihood of individual mortality analysis and genus sensitivity distribution information for aquatic invertebrates, there is a potential for indirect effects to the DS and TG from loss of prey items for all uses of diazinon.

Non-vascular aquatic plants

Based on RQs for algae (**Table 5-3)**, applications of diazinon are not expected to affect this food source for any of the assessed uses. Therefore, indirect effects of diazinon to DS and TG by reductions in phytoplankton are not expected based on the animal's diet during this life stage.

ii. Potential Modification of Habitat

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. Emergent plants help reduce sediment loading and provide stability to near-shore areas and lower stream banks. In addition, vascular aquatic plants are important as attachment sites for egg masses of DS.[17]

Based on RQs for non-vascular plants inhabiting aquatic habitats (**Table 5-3**), applications of diazinon are not expected to affect these aquatic nonvascular plants. Aquatic vascular plants provide important habitat for DS and TG and their prey. Data are not available to assess the risk to vascular aquatic plants; however, based on the results for nonvascular plants, lack of effects on plants in mesocosm studies, and lack of predicted effects for terrestrial plants (except at very high application rates); the likelihood of risk to vascular aquatic plants is considered low.

Terrestrial plants serve several important habitat-related functions for the listed assessed species. 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. Based on RQ values for terrestrial plants (**Table 5-4** and **Table 5-5**), which are all less than 0.1 for all uses except for use on cole

[17] TG lay eggs in burrows (Attachment III)

crops on a per plant basis, the likelihood of adverse effects to TG and DS due to effects on riparian vegetation is considered low. For the cole crop use scenario with an application rate of 116 lbs a.i./A based on a per plant application rate on the label for transplant use on cole crops, the RQs are less than 4.41 in semiaquatic areas for monocots and 2.57 for dicots. Therefore, for this specific high rate on cole crops there is a potential for direct effects to terrestrial plants in semi-aquatic areas and as a result indirect effects to TG and DS. For this one use scenario, the application rate on the label is on a per plant basis and application rate on a lbs a.i./A was estimated based on the maximum number of plants that may be planted in an acre resulting in a very high application rate of 116 lbs a.i./A. This high application rate may not commonly occur. The application rate would need to be reduced to an equivalent of 26 lbs a.i./A to reduce RQs to below LOCs for terrestrial plants.

5.2.2. Modification of Designated Critical Habitat

Based on the weight-of-evidence there is a potential for the modification of designated critical habitat based on the potential effects on prey base for all uses and possibly based on the potential affects to terrestrial plants for the highest use scenario of 116 lbs a.i./A for cole crops.

5.2.3. Spatial Extent of Potential Effects

Since LOCs are exceeded, analysis of the spatial extent of potential LAA effects 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 DS and TG habitat or areas of occurrence and/or critical habitat, a likely to adversely affect determination is made. If the Potential Area of LAA Effects and the DS and TG habitat and areas of occurrence and/or critical habitat do not overlap, a no effect determination is made.

To determine this area, the footprint of diazinon's use pattern is identified, using corresponding land cover data, see Section 2.8. Diazinon has uses on agricultural crops that are represented by the cultivated crop land cover class and on orchards/vineyards that are represented by the orchard/vineyard land cover class. Diazinon also has uses on ornamental nursery stock and other miscellaneous nursery stock. It was uncertain what land cover class should be used to represent use of diazinon in nurseries. Therefore, it is assumed that diazinon may be used anywhere in California and thus there will be overlap with critical habitat for both the TG and DS. Maps depicting the cultivated crop land cover class and the orchard/vineyard land cover class along with critical habitats for the DS are provided in **Figure 5-1**. Multiple maps for the TG are available in **Appendix N** as its habitat areas are all along the coast of California, an example map is provided in **Figure 5-2**. The maps do not have a land cover representing the uses on nursery stock and ornamental nursery stock. Except for the nursery uses, actual usage is expected to occur in a smaller area than shown on the map 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). Because of the spatial extent of the use patterns of diazinon, essentially all DS and TG habitat could be affected by the pesticide. Because of the wide usage assumption for diazinon, the spray drift distance and downstream dilution distance were not determined.

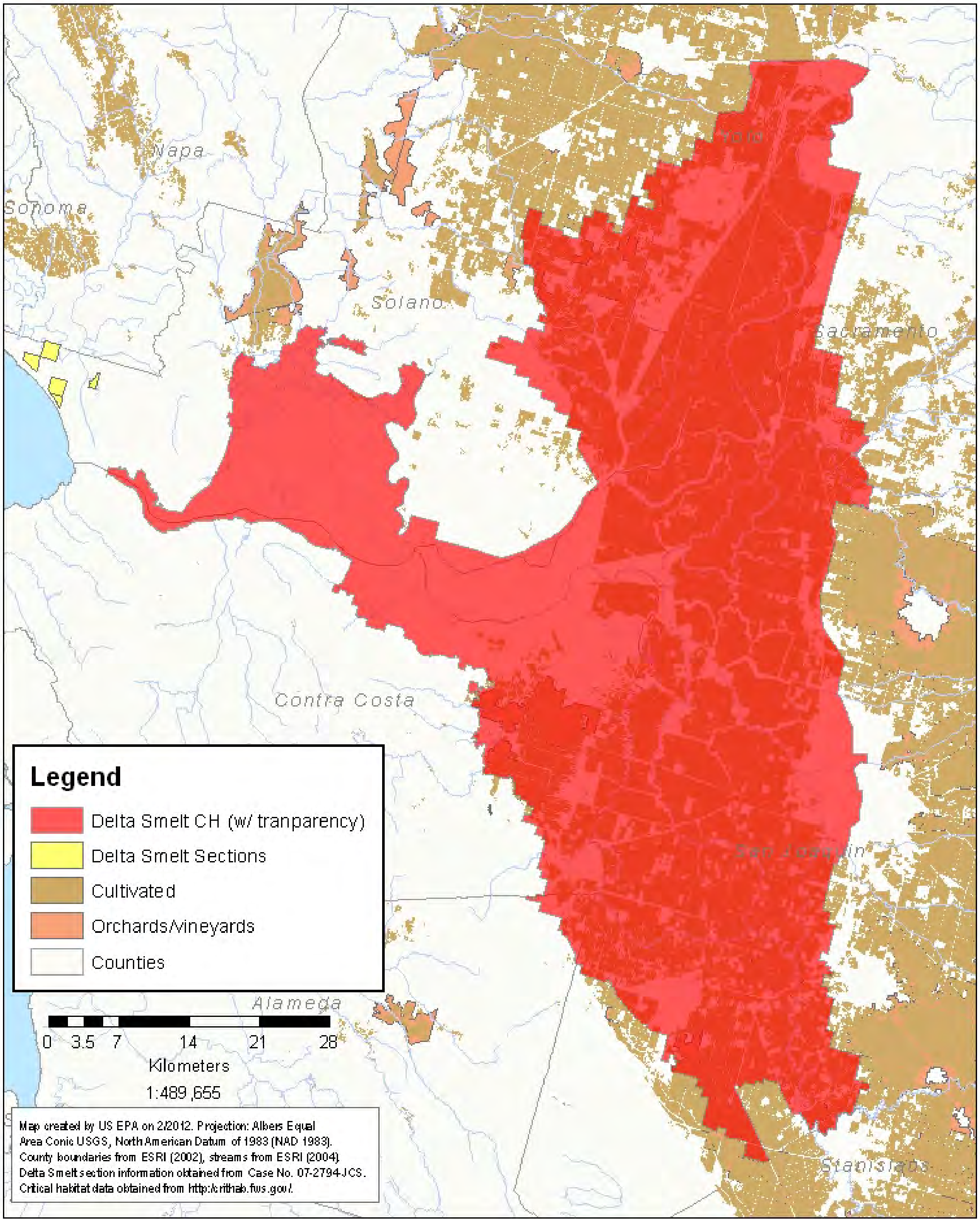

Figure 5-1. Map Showing the Overlap of DS Critical Habitat and Occurrence Sections Identified by Case No. 07-2794-JCS with the NLCD Cultivated Crop Land Cover Class and Orchards/vineyards land cover class. Use areas representing use on nurseries are not shown.

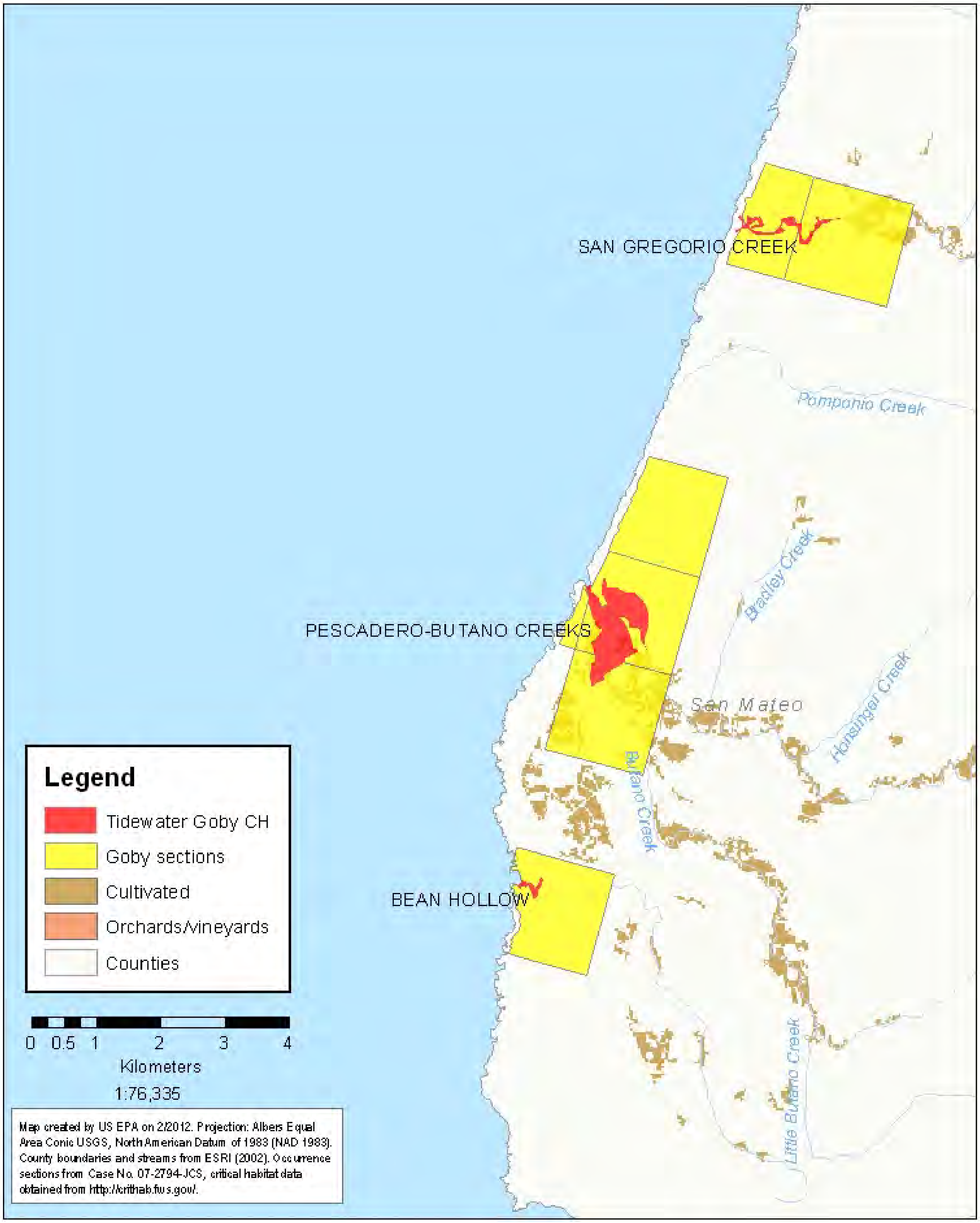

Figure 5-2. Map Showing the Overlap of TG Critical Habitat and Occurrence Sections Identified by Case No. 07-2794-JCS with the NLCD Cultivated Crop Land Cover Class and Orchards/Vineyards Land Cover. A Landcover Representing Uses in Nurseries is not Available and Possible Use in Nurseries is Not Depicted.

5.3. Effects Determinations for Delta Smelt and Tidewater Goby

In summary, based on the above information, the determinations for effects to the DS and TG are "LAA" for all diazinon uses. For effects through habitat modification through effects on terrestrial plants, there is a potential for indirect effects when diazinon is applied at 116 lbs a.i/A to cole crops only.

Therefore, the Agency makes a "**may affect, and likely to adversely affect**" determination for the DS and TG and a "**habitat modification determination"** for their designated critical habitat based on the potential for direct and indirect effects and effects to the PCEs of critical habitat.

5.3.1. Addressing the Risk Hypotheses

In order to conclude this risk assessment, it is necessary to address the risk hypotheses defined in Section 2.10.1. Based on the conclusions of this assessment, the following hypothesis can be rejected.

- The labeled use of diazinon may indirectly affect the DS and TG and/or affect 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.

The following hypotheses can not be rejected meaning that the stated hypotheses represent concerns in terms of direct and indirect effects of diazinon on the DS and TG and its designated critical habitat.

The labeled use of diazinon may:

- …directly affect DS and TG by causing acute mortality or by adversely affecting chronic growth or fecundity;
- … indirectly affect the DS and TG and/or affect their designated critical habitat by reducing or changing the composition of the food supply;
- … indirectly affect the DS and TG and affect their designated critical habitat by reducing or changing the composition of the terrestrial plant community in the species' current range;
- … indirectly affect the DS and TG and affect 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).

6. Uncertainties

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

6.1. Exposure Assessment Uncertainties

There are a few uses where a maximum number of applications and a maximum yearly application rate were not available (melons, strawberries, lettuce, and nursery stock). Finally, the use rates on ant mounds (0.0007 to 0.0008 lbs a.i./inch diameter of ant mound in blueberries) and cole crop transplant rates (0.003 lbs a.i./plant) are not available in typically used units. Reported diameter ranges of ant mounds ranged from 8 to 18 inches (Pest Control Solutions, 2012) in diameter with 20 to 1000 plus mounds per acre (Texas Imported Fire Ant Research and Management Project, 2012). Assuming an average 18 inch diameter for ant mounds and 1000 mounds per acre results in an estimated maximum application rate of 14.4 lbs a.i./A. Assuming an average 8 inch diameter ant mound and 1000 mounds per acre results in an estimated maximum application rate of 2.8 lbs a.i./A. The low end of an application rate was calculated assuming an average 8 inch diameter ant mound and 20 mounds per acre resulting in an application rate of 0.128 lbs a.i./A. In this assessment, high and low application rates for use on ant mounds of 14.4 lbs a.i./A and 2.8 lbs a.i./A, respectively, were assumed. For the transplant use on cole crops on a per plant basis, the application rate was estimated from a reported application rate for transplants of 0.003 lbs a.i./plant multiplied by 38,720 plants/acre, resulting in an application rate of 116 lbs a.i./A (Kahn *et al.*). These estimated application rates likely overestimate use on cole crops and could overestimate use to control ants in orchards. The actual use rate is an uncertainty in this assessment. The risk conclusions for these uses may be overestimated.

6.1.1. Aquatic Exposure Modeling of Diazinon

6.1.1.a. Additional Exposure Due to Rainfall

Diazinon has been detected in precipitation samples in California (See Section 3.4.2) (**Table 6-1**). Based on these data, it is possible that diazinon can be deposited on land in precipitation. Estimates of exposure of the diazinon, its prey and its habitat to diazinon included in this assessment are based only on transport of diazinon through runoff and spray drift from application sites. Current estimates of exposures of DS and TG and its prey to diazinon through runoff and spray drift, which are already sufficient to exceed the LOC, would be expected to be greater due to deposition in precipitation.

Table 6-1. Diazinon detections in air and precipitation samples taken in California.

Location	Year	Sample type	Maximum Concentration (µg/L)	Detection frequency (number samples)	Source
San Joaquin Valley, CA	2002-2004	Rain	0.756	68% (n = 137)	Majewski *et al.* 2006
Monterey, CA	1987	Fog	4.0	100% (n = 5)	Schomburg *et al.* 1991

In an attempt to estimate the amount of diazinon deposited into aquatic and terrestrial habitats, diazinon concentrations measured in rain samples taken in California (Majewski *et al.*, 2006) were considered in combination with California specific precipitation data and runoff estimates from PRZM. Precipitation and runoff data associated with the PRZM scenarios used to model aquatic EECs were used to determine relevant 1-in-10 year peak runoff and rain events. The scenarios included were: CA almond, CA lettuce, CA wine grape, CA row crop, CA fruit, CA nursery, and CA onion. The corresponding meteorological data were from the following locations: Sacramento, Santa Maria, San Francisco, Monterey County, Fresno, San Diego, and Bakersfield, respectively.

To estimate concentrations of diazinon in the aquatic habitat resulting from deposition in rain, the daily PRZM-simulated volume of runoff from a 10-ha field is combined with an estimate of daily precipitation volumes over the 1-ha farm pond relevant to the EXAMS environment. This volume is multiplied by the maximum concentration of diazinon in precipitation reported in monitoring data, which is 0.756 $\mu g \cdot L^{-1}$. The result is a daily mass load of diazinon into the farm pond. This mass is then divided by the volume of water in the farm pond (2.0×10^7 L) to achieve a daily estimate of diazinon concentration in the farm pond, which represents the aquatic habitat. From the daily values, the 1-in-10 year peak estimate of the concentration of diazinon in the aquatic habitat is determined for each PRZM scenario (**Table 6-2**). These concentrations are higher than some concentrations where effects after chronic exposure were observed for freshwater and estuarine/marine fish and invertebrates. There are several assumptions associated with this approach, including: 1) the concentration of diazinon in the rain event is spatially and temporally homogeneous (*e.g.*, constant over the 10 ha field and 1 ha pond for the entire rain event); 2) the entire mass of diazinon contained in the precipitation runs off of the pond or is deposited directly into the pond; 3) there is no degradation of diazinon between the time it leaves the air and the time it reaches the pond.

Table 6-2. 1-in-10 year peak estimates of diazinon concentrations in aquatic habitats resulting from deposition of diazinon at 0.756 $\mu g \cdot L^{-1}$ diazinon in rain.

Met Station	Scenario	Concentration in aquatic habitat (µg/L)
Sacramento	CA almond	0.141
Santa Maria	CA lettuce	0.152
San Francisco	CA wine grape	0.133
Monterey Co.	CA row crop	0.122
Fresno	CA fruit	0.055
San Diego	CA nursery	0.102
Bakersfield	CA onion	0.041

6.1.2. Chemistry Input Parameters for Models

There are many environmental fate data gaps for diazinon. Each data gap was discussed in the data gaps Section 1.1.1.

6.1.3. Modeled and Monitoring Concentrations

Modeling and monitoring data are not expected to be similar as monitoring data are generally not collected at sites that have a conceptual model that matches the modeling. Modeling can generate estimates every day and simulate locations that are likely to be vulnerable from the use of a pesticide. Simulations for pesticide in the Agency are generally run for 30 years whereas the duration of monitoring data at any one site seldom exceeds two or three years. Currently modeling is used to characterize a few vulnerable sites well in time whereas monitoring data tends to provide a better spatial representation of how the pesticide concentration varies in the environment, but is less well defined in time. Monitoring data typically is collected at sites with variable usage and that may not be vulnerable sites. The frequency of monitoring is typically not frequent enough to capture peak concentrations. While monitoring data and modeling data are expected to be different it is useful to compare the results of monitoring and modeling to better understand whether the modeled data are conservative and whether monitoring results indicate concentrations may be high enough to result in LOC exceedances. Monitoring data and modeling provide complementary approaches to assessing exposure.

In order to account for this uncertainty, available monitoring data were compared to PRZM/EXAMS estimates of peak EECs for the different uses. As discussed above, several data values were available from NAWQA for diazinon concentrations measured in surface waters receiving runoff from agricultural areas. The specific use patterns (*e.g.*, application rates and timing, crops) associated with the agricultural areas are unknown; however, they are assumed to be representative of potential diazinon use areas. One-in-ten-year peak EECs estimate using tier 2 modeling resulting from different diazinon uses ranged 0.50 to 496.30 µg/L. The maximum concentration of diazinon reported by NAWQA (1999-2012) for California surface waters with agricultural watersheds (3.8 µg/L) is within the range of EECs calculated using the Tier 2 models. The maximum concentration of diazinon reported by the California Department of Pesticide Regulation surface water database (1992-2012) (46.63 µg/L) is also within the range of predicted peak EECs. The maximum measured diazinon concentration in California after 2004 was 2.4 µg/L detected in 2005 in Imperial County. This concentration is also within the range of peak estimated EECs. Monitoring concentrations were commonly high enough to result in an LOC exceedance for aquatic invertebrates, even after several uses were cancelled in 2004.

6.1. Effects Assessment Uncertainties

Effects data gaps are discussed in the data gaps Section 1.1.1.

6.1.1. Use of Surrogate Species Effects Data

Guideline toxicity tests and open literature data on diazinon are not available for DS or TG; therefore, other fish are used as surrogate species for assessing risks to the target species. 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.

6.1.2. Sublethal Effects

When assessing acute risk, the screening risk assessment relies on the acute mortality endpoint as well as a suite of sub-lethal responses to the pesticide as well as effects determined by the testing of species response to chronic exposure conditions and subsequent chronic risk assessment. Consideration of additional sub-lethal data in the effects determination is exercised on a case-by-case basis and only after careful consideration of the nature of the sub-lethal effect measured and the extent and quality of available data to support establishing a plausible relationship between the measure of effect (sub-lethal endpoint) and the assessment endpoints. OPP acknowledges that a number of sub-lethal effects have been associated with diazinon exposure; however, at this point there are insufficient data to definitively link the measurement endpoints to the EPA's assessment endpoints of survival, growth and reproduction.

6.1.3. Chronic Toxicity

In assessing chronic toxicity, data were not available for several taxa and the assessment relied on the use of ACRs. There is uncertainty regarding the extent to which these ACRs result in conservative estimates of NOAEC values. Additionally, for freshwater fish, definitive toxicity data were not available for brook trout and RQ values were estimated using an ACR which was based on a non-definitive NOAEC. However, this uncertainty was qualitatively assessed by applying the ACR for estuarine/marine fish (ACR=3846) to rainbow trout to yield a NOAEC of 0.023 µg/L. When using this estimated NOAEC, fish RQ values increased by a factor of 2.7X; the resulting RQ values ranged from 6.09 to 9239.

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 diazinon to DS and TG and their designated critical habitat.

Based on the best available information, the Agency makes a 'Likely to Adversely Affect' determination for the DS and TG. Additionally, the Agency has determined that there is the potential for modification of the designated critical habitat for the DS and TG from the use of the chemical on a per plant basis for the cole crops use. Given the LAA determination for DS and TG and potential modification of designated critical habitat for this species, a description of the baseline status and cumulative effects is provided in Attachment III.

A summary of the risk conclusions and effects determinations for DS and TG and their critical habitat, given the uncertainties discussed in Section 6 and Attachment I, are presented in **Tables 7-1** and **7-2**. A use-specific summary of effect determinations is presented in **Table 7-3**.

Table 7-1. Effects Determination Summary for Effects of Diazinon on the Delta Smelt and Tidewater Goby

Species	Effects Determination	Basis for Determination
Delta smelt (*Hypomesus transpacificus*) and Tidewater Goby (*Eucyclogobius newberryi*)	May Affect, Likely to Adversely Affect (LAA)	**Potential for Direct Effects** Using fish toxicity data for rainbow trout, brook trout, sheepshead minnow, and striped mullet and model-derived EECs, risk could not be precluded for any of the assessed uses due to the potential for chronic effects. Additionally, the likelihood of acute effects (mortality) could not be precluded for uses on almonds, tree fruit, beans, row crops, dormant use on berries, cole crops,

Species	Effects Determination	Basis for Determination
		leafy vegetables, lettuce, garlic and leek, melons with 26 applications, onions, strawberry, and tomato.
		Potential for Indirect Effects
		Aquatic prey items, aquatic habitat, cover and/or primary productivity Using toxicity data representing freshwater (*C. dubia*) and estuarine invertebrates (mysid shrimp) and modeled exposures, risks could not be precluded based on acute and chronic effects to prey items for all use patterns. This includes risk to benthic invertebrates. Available data on one species of non-vascular plants (*P. subcapitata*) suggests that risk to dietary items for young DS and TG and to non-vascular plants important for maintaining aquatic habitat is not likely because risk quotients did not exceed LOCs. Based on the mode of action of diazinon not being particularly toxic to plants, results from mesocosm studies, and the lack of incidents reported for aquatic plants; the likelihood of risk to aquatic plants is assumed to be low.
		Terrestrial prey items, riparian habitat RQs for terrestrial plants for transplant applications to cole crops exceeded the LOC for dicots and could exceed the LOC for monocots whose available endpoint is a greater than value, indicating there is a potential for risk to terrestrial plants for the transplant per plant rate for cole crops. RQs for all other uses were less than 1.0 and risk to terrestrial plants is not expected for any other use.[1]

[1] The risk to terrestrial plants was identified for a transplant use on cole crops. The application rate on the label is on a per plant basis and application rate on a lbs a.i./A was estimated based on the maximum number of plants that may be planted in an acre resulting in a very high application rate of 116 lbs a.i./A. This high application rate may not commonly occur. The application rate would need to be reduced to an equivalent of 26 lbs a.i./A to reduce RQs to below LOCs for terrestrial plants.

Table 7-2. Effects Determination Summary for the Critical Habitat Impact Analysis for the Delta Smelt and Tidewater Goby

Designated Critical Habitat for:	Effects Determination	Basis for Determination
Delta smelt (*Hypomesus transpacificus*) and Tidewater Goby (*Eucyclogobius newberryi*)	Habitat Modification	***Aquatic prey items, aquatic habitat, cover and/or primary productivity*** Using toxicity data representing freshwater (*C. dubia*) and estuarine invertebrates (mysid shrimp) and modeled exposures, risks could not be precluded based on acute and chronic effects to prey items for all use patterns. This includes risk to benthic invertebrates. Available data on one species of non-vascular aquatic plants (*P. subcapitata*) suggests that risk to dietary items for young DS and TG and to non-vascular plants important for maintaining aquatic habitat is not likely because risk quotients did not exceed LOCs. Based on the mode of action of diazinon not being particularly toxic to plants, results from mesocosm studies, and the lack of incidents reported for aquatic plants; the likelihood of risk to aquatic plants is assumed to be low.
		Terrestrial prey items, riparian habitat RQs for terrestrial plants for transplant applications to cole crops exceeded the LOC for dicots and could exceed the LOC for monocots whose available endpoint is a greater than value, indicating there is a potential for risk to terrestrial plants for the transplant per plant rate for cole crops. RQs for all other uses were less than 1.0 and risk to terrestrial plants is not expected for any other

		use.[1]

[1] The risk to terrestrial plants was identified for a transplant use on cole crops. The application rate on the label is on a per plant basis and application rate on a lbs a.i./A was estimated based on the maximum number of plants that may be planted in an acre resulting in a very high application rate of 116 lbs a.i./A. This high application rate may not commonly occur. The application rate would need to be reduced to an equivalent of 26 lbs a.i./A to reduce RQs to below LOCs for terrestrial plants.

Table 7-3. Use Specific Summary of the Potential for Adverse Effects to Delta Smelt and Tidewater Goby

Uses	Potential for Effects to Identified Taxa Found in the Aquatic Environment:									
	Delta smelt, Tidewater Goby and Estuarine/Marine Vertebrates[1]		Delta smelt, Tidewater Goby and Freshwater Vertebrates[2]		Freshwater Invertebrates[3]		Estuarine/Marine Invertebrates[4]		Aquatic Vascular Plants[5]	Aquatic Non-vascular Plant[6]
	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic		
Almonds	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Tree Fruit	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Fig	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No
Beans	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Row Crop	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Berries except blueberry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Blueberry	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No
Cole Crops	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Leafy Vegetables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Lettuce	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Garlic and Leek	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Melons	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Onion	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Rutabega	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Outdoor ornamentals	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Strawberry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Tomato	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Cattle Ear Tags	No	No	No	No	No	No	No	No	No	No

1 A yes in this column indicates a potential for direct effects to DS and TG.
2 A yes in this column indicates a potential for direct effects to DS and TG.
3 A yes in this column indicates a potential for indirect effects to DS and TG.
4 A yes in this column indicates a potential for indirect effects to DS and TG.
5 Available data on one species of nonvascular plants suggests that risk to dietary items for young and nonvascular plants important for maintaining aquatic habitat is not likely because risk quotients did not exceed LOCs. Based on the mode of action of diazinon not being particularly toxic to plants, results from mesocosm studies, and the lack of incidents reported for aquatic plants; the likelihood of risk to aquatic plants is assumed to be low.
6 Data are only available on one nonvascular plant species. Available data indicate risk to that species is unlikely; however, data are typically available on four species and it is possible that the species tested does not reflect the toxicity to the most sensitive species of the standard species tested.

Based on the conclusions of this assessment, a formal consultation with the USFWS 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 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 DS and TG 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 bi bliography of E COTOX r eferences that were re jected is l ocated i n **Appendix J** ; a bibliography of ECOTOX references that were accepted is located in **Appendix K**.

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8.2. MRID List

Documents submitted for pesticide registration

8.2.1. Submitted Fate Studies

MRID	Citation Reference
Hydrolysis	
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118027	Burkhard, N. (1979) Hydrolysis of Diazinon (Basudin) under Laboratory Conditions: Project Report 02/79. (Unpublished study received Nov 5, 1982 under 4581-351; prepared by Ciba-Geigy, Ltd., Switz., submitted by Agchem Div., Pennwalt Corp., Philadelphia, PA; CDL:2348818-H)
120419	Burkhard, N. (1979) Hydrolysis of Diazinon (Basudin) under Laboratory Conditions: Project Report 02/79. (Unpublished study received Dec 15, 1982 under 4581-335; prepared by Ciba-Geigy, Ltd., Switz., submitted by Agchem Div., Pennwalt Corp., Philadelphia, PA; CDL:249074-A)
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Photodegradation-water

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8.3. Submitted Relevant Ecotoxicity Studies

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