STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF FISH AND GAME

HAZARD ASSESSMENT OF THE INSECTICIDE DIAZINON TO AQUATIC ORGANISMS IN THE SACRAMENTO-SAN JOAQUIN RIVER SYSTEM

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PREFACE

The California Department of Fish and Game (CDFG) is responsible for protection and management of fish and wildlife. The CDFG protects fish and wildlife from pesticide hazards through consultation with the California Environmental Protection Agency's Department of Pesticide Regulation (DPR) Pesticide Registration and Evaluation Committee and Pesticide Advisory Committee. The State Water Resources Control Board and the Regional Water Quality Control Boards also protect fish and wildlife by promulgating and enforcing water quality standards for pesticides and other toxic materials. In recognition of the need for applicable environmental standards for fish and wildlife, the DPR contracted with the CDFG to assess the effects of pesticides on fish and wildlife and to facilitate development of water quality criteria to protect aquatic organisms.

This document is the fifth in a series of pesticide hazard assessments. Hazard assessments have also been prepared for the herbicides molinate and thiobencarb, and for the insecticides methyl parathion, carbofuran, and chlorpyrifos.

Hazard Assessment of the Insecticide Diazinon to Aquatic Organisms in the Sacramento-San Joaquin River System

by

Mary Menconi and Cara Cox

Pesticide Investigations Unit
1701 Nimbus Road, Suite F
Rancho Cordova, California 95670

SUMMARY

A freshwater Water Quality Criterion (WQC) for protection of aquatic organisms from the insecticide diazinon was developed and a hazard assessment was performed for California's Sacramento-San Joaquin River system. Insufficient data were available to derive a saltwater WQC.

Sixty-nine tests on the acute and chronic effects of diazinon to aquatic animals were reviewed and evaluated. The most acutely sensitive freshwater species tested was the amphipod *Gammarus fasciatus* with a mean 96-h LC_{50} value of 0.20 μg/L. The lowest Maximum Acceptable Toxicant Concentration (MATC) value was 0.23 μg/L for the freshwater cladoceran *Daphnia magna*. The calculated Final Acute Value (FAV) for diazinon was 0.16 μg/L. The Final Acute-Chronic Ratio (FACR) was 4, and the Final Chronic Value (FCV) was 0.04 μg/L (FCV=FAV/FACR).

Freshwater aquatic organisms should not be affected unacceptably if the four-day average concentration of diazinon does not exceed 0.04 μg/L, and if the one-hour average concentration does not exceed 0.08 μg/L more than once every three years.

The U.S. Environmental Protection Agency (EPA) has not established a WQC for diazinon. However, the National Academy of Sciences recommended a guideline of 0.009 μg/L for the protection of aquatic life. The NAS guideline is lower than the CDFG WQC because the ACR value of 100 used by the NAS is much larger than current data indicate is appropriate. The California Department of Fish and Game WQC was derived using current toxicity data and hazard assessment procedures.

Although diazinon was detected in the Sacramento-San Joaquin River system at concentrations as high as 36.8 μg/L, more typical concentrations ranged from 0.01 to 1.0 μg/L (Table 1). A comparison of detected concentrations of diazinon with toxicity data and the WQC indicates that diazinon may present a hazard to aquatic invertebrates, especially mysids and cladocerans.

Acute toxicity data were available for seven of the eight freshwater families recommended by EPA for development of numerical criteria. Paired acute and chronic tests should be performed with invertebrates such as *Neomysis mercedis* and *Ceriodaphnia dubia*. *Neomysis mercedis* is a native estuarine mysid and cladocerans are widely distributed invertebrates. An acute test should be conducted on a freshwater mollusk to complete the eight families, however, this value is unlikely to lower the WQC. Paired acute and chronic toxicity tests should be performed with fish such as rainbow trout *Oncorhynchus mykiss* to better define effects on fish.

TABLE OF CONTENTS

LIST OF TABLES

ACKNOWLEDGEMENTS

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INTRODUCTION

The organophosphate insecticide and nematicide diazinon is used on alfalfa, nuts, stone fruits, vegetables, and other crops. In 1992 approximately 612,455 kg of diazinon were used in California (California Department of Pesticide Regulation n.d.).

The Central Valley Regional Water Quality Control Board (CVRWQCB), the DPR, and the U.S. Geological Survey (USGS) monitored diazinon in the Sacramento-San Joaquin River system (Table 1). Detected concentrations of diazinon ranged from 0.01 to 36.8 µg/L. Typical concentrations ranged from 0.01 to 1.0 µg/L. Samples collected by DPR were also analyzed for diazoxon, an oxygen analog of diazinon. Diazoxon was detected in only one sample. (L. Ross DPR pers. comm.)

The U.S. Environmental Protection Agency (EPA) has not established a Water Quality Criterion (WQC) for diazinon. However, the National Academy of Sciences (NAS) has recommended an aquatic life guideline of 0.009 µg/L (NAS 1973). The NAS guideline is lower than current data have shown to be necessary because the NAS application factor of 0.01 does not accurately represent the acute/chronic relationship for diazinon. Neither the U.S. Food and Drug Administration nor the State of California have established diazinon action levels for human consumption (B. Brodberg. California Office of Environmental Health Hazard Assessment. pers. comm.)

The effects of diazinon were assessed by evaluating toxicity tests for conformance with specific criteria adapted from the EPA and the American Society for Testing and Materials (ASTM). Although toxicity tests were not required to comply with all criteria, tests were rejected if they did not observe certain important procedures. The WQC was calculated using accepted data and methods adapted from EPA (1985a) guidelines (Appendix A).

Table 1. Concentrations of diazinon (μg/L) detected in the Sacramento-San Joaquin River system, March 1991 through February 1993.

Date	Location[a]	Concentration
4/13/92	Bishop Cut at Eight Mile Slough	0.01[b]
1/20/92	Central Road Drain	0.01[b]
2/10/92	Clark's Ditch at White Road	0.44[b]
2/17/92	Clark's Ditch at White Road	1.41[b]
3/04/91	Del Puerto Creek	0.10[b]
3/19/91	Del Puerto Creek	0.03[b]
4/23-26/91	Del Puerto Creek	0.05[b]
5/15/91	Del Puerto Creek	0.04[b]
5/28/91	Del Puerto Creek	0.42[b]
12/23/91	Del Puerto Creek	0.01[b]
1/05/92	Del Puerto Creek	0.12[b]
2/03/92	Del Puerto Creek	2.60[b]
2/10/92	Del Puerto Creek	1.30[b]
4/06/92	Del Puerto Creek	0.02[b]
4/27/92	Del Puerto Creek	0.02[b]
5/04/92	Del Puerto Creek	0.01[b]
5/11/92	Del Puerto Creek	0.22[b]
5/18/92	Del Puerto Creek	0.01[b]
5/25/92	Del Puerto Creek	0.20[b]
6/01/92	Del Puerto Creek	0.02[b]
6/15/92	Del Puerto Creek	0.01[b]
6/22/92	Del Puerto Creek	0.02[b]
2/15/93	Delta at Chipps Island	0.20[d]
2/18/93	Delta at Martinez	0.11[d]
2/20/93	Delta at Martinez	0.12[d]
2/17/92	Feather River at Lee Road	0.08[b]
1/27/92	French Camp Slough at Manthey	0.46[b]
2/03/92	French Camp Slough at Manthey	0.25[b]
2/10/92	French Camp Slough at Manthey	0.85[b]
2/10/92	French Camp Slough at Manthey	1.26[b]
2/10/92	French Camp Slough at Manthey	1.22[b]
1/27/92	Gilsizer Slough at G. Washington Road	0.83[b]
2/03/92	Gilsizer Slough at G. Washington Road	3.97[b]
2/10/92	Gilsizer Slough at G. Washington Road	3.39[b]
2/17/92	Gilsizer Slough at G. Washington Road	6.84[b]
2/24/92	Gilsizer Slough at G. Washington Road	0.51[b]
2/08/93	Highline Spillway	2.54[c]
3/04/91	Ingram\Hospital Creeks	0.02[b]
3/19/91	Ingram\Hospital Creeks	0.02[b]
4/23-26/91	Ingram\Hospital Creeks	0.04[b]
5/15/91	Ingram\Hospital Creeks	0.03[b]
5/28/91	Ingram\Hospital Creeks	0.03[b]
9/09/91	Ingram\Hospital Creeks	0.01[b]
10/24/91	Ingram\Hospital Creeks	0.19[b]
12/04/91	Ingram\Hospital Creeks	0.31[b]
12/23/91	Ingram\Hospital Creeks	0.01[b]
1/05/92	Ingram\Hospital Creeks	0.16[b]

Table 1. Continued -2-

Date	Location[a]	Concentration
1/28-30/92	Ingram\Hospital Creeks	0.09[b]
1/28-30/92	Ingram\Hospital Creeks	0.06[b]
1/30/92	Ingram Hospital Creeks	0.06[c]
2/10/92	Ingram\Hospital Creeks	0.24[b]
2/19/92	Ingram\Hospital Creeks	0.20[c]
3/09/92	Ingram\Hospital Creeks	0.06[b]
3/16/92	Ingram\Hospital Creeks	0.02[b]
4/27/92	Ingram\Hospital Creeks	0.02[b]
5/04/92	Ingram\Hospital Creeks	0.01[b]
5/11/92	Ingram\Hospital Creeks	0.06[b]
5/18/92	Ingram\Hospital Creeks	0.05[b]
5/25/92	Ingram\Hospital Creeks	1.80[b]
6/01/92	Ingram\Hospital Creeks	0.07[b]
6/15/92	Ingram\Hospital Creeks	0.01[b]
6/22/92	Ingram\Hospital Creeks	0.01[b]
1/17/93	Ingram\Hospital Creeks	0.16[c]
2/10/93	Ingram\Hospital Creeks	0.41[c]
2/10/92	Ledgewood Creek at Portsmouth	0.30[b]
2/08/93	Livingston Spillway	0.78[c]
1/20/92	Lone Tree Creek at Austin Road	0.12[b]
1/27/92	Lone Tree Creek at Austin Road	1.04[b]
2/03/92	Lone Tree Creek at Austin Road	0.98[b]
2/10/92	Lone Tree Creek at Austin Road	2.79[b]
2/17/92	Lone Tree Creek at Austin Road	0.32[b]
4/23-26/91	Los Banos Creek	0.01[b]
1/28-30/92	Los Banos Creek	0.02[b]
2/17/92	Los Banos Creek	0.06[c]
2/08/93	Los Banos Creek	0.11[c]
2/10/92	Marsh Creek at Cypress Road	0.28[b]
1/20/92	Merced River	0.08[b]
1/28/92	Merced River	0.10[c]
1/28-30/92	Merced River	0.10[b]
2/17/92	Merced River	0.32[b]
2/18/92	Merced River	0.07[c]
3/09/92	Merced River	0.04[b]
4/13/92	Merced River	0.01[b]
1/16/93	Merced River	0.08[c]
2/09/93	Merced River	0.40[c]
1/27/92	Mokelumne River at New Hope Road	0.23[b]
2/17/92	Mokelumne River at New Hope Road	0.02[b]
4/23-26/91	Mud Slough	0.02[b]
2/17/92	Mud Slough	0.06[c]
2/08/93	Mud Slough	0.17[c]

4/23-26/91	Newman Wasteway	0.01[b]

Table 1. Continued -3-

Date	Location[a]	Concentration
1/28-30/92	Newman Wasteway	0.03[b]
1/28-30/92	Newman Wasteway	0.09[b]
2/17/92	Newman Wasteway	2.14[c]
1/15/93	Newman Wasteway	0.05[c]
2/09/93	Newman Wasteway	36.8[c]
2/16/92	Old River at Tracy Road	0.07[b]
2/03/92	Old River at Cohen Road	0.10[b]
2/17/92	Old River at Cohen Road	0.25[b]
2/17/92	Old River at Cohen Road	0.35[b]
2/17/92	Old River at Cohen Road	0.47[b]
3/04/91	Orestimba Creek	0.02[b]
3/19/91	Orestimba Creek	0.30[b]
4/15/91	Orestimba Creek	0.44[c]
4/15/91	Orestimba Creek	0.52[c]
4/18/91	Orestimba Creek	0.02[b]
5/15/91	Orestimba Creek	0.01[b]
2/10/92	Orestimba Creek	0.26[b]
2/17/92	Orestimba Creek	0.38[b]
2/18/92	Orestimba Creek	0.60[c]
4/20/92	Orestimba Creek	0.01[b]
4/27/92	Orestimba Creek	0.01[b]
5/04/92	Orestimba Creek	0.01[b]
5/11/92	Orestimba Creek	0.18[b]
5/18/92	Orestimba Creek	0.07[b]
5/25/92	Orestimba Creek	0.88[b]
6/01/92	Orestimba Creek	0.02[b]
6/22/92	Orestimba Creek	0.03[b]
7/29/92	Orestimba Creek	0.08[c]
2/09/93	Orestimba Creek	0.07[c]
2/12/93	Sacramento River at Freeport	0.39[d]
2/21/93	Sacramento River at Freeport	0.19[d]
2/22/93	Sacramento River at Freeport	0.19[d]
2/13/93	Sacramento River at Rio Vista	0.28[d]
4/14/91	Salt Slough	0.06[c]
4/23/91	Salt Slough	0.07[c]
4/23-26/91	Salt Slough at HWY 165	0.02[b]
1/28-30/92	Salt Slough	0.01[b]
3/16/92	Salt Slough at HWY 165	0.33[b]
4/13/92	Salt Slough at HWY 165	0.01[b]
4/27/92	Salt Slough at HWY 165	0.17[b]
5/04/92	Salt Slough at HWY 165	0.06[b]
5/11/92	Salt Slough at HWY 165	0.02[b]
5/18/92	Salt Slough at HWY 165	0.03[b]
5/25/92	Salt Slough at HWY 165	0.04[b]
6/01/92	Salt Slough at HWY 165	0.02[b]
6/22/92	Salt Slough at HWY 165	0.01[b]
8/24/92	Salt Slough	0.17[c]
2/08/93	Salt Slough	0.13[c]

Table 1. Continued -4-

Date	Location[a]	Concentration
5/15/91	San Joaquin River at Airport Road	0.01[b]
6/12/91	San Joaquin River at Airport Road	0.02[b]
1/20/92	San Joaquin River at Airport Road	0.04[b]
1/28-30/92	San Joaquin River at Airport Road	0.05[b]
1/28-30/92	San Joaquin River at Airport Road	0.09[b]
2/17/92	San Joaquin River at Airport Road	0.28[b]
3/09/92	San Joaquin River at Airport Road	0.04[b]
5/11/92	San Joaquin River at Airport Road	0.01[b]
5/18/92	San Joaquin River at Airport Road	0.05[b]
5/25/92	San Joaquin River at Airport Road	0.06[b]
6/01/92	San Joaquin River at Airport Road	0.01[b]
2/03/92	San Joaquin River at Bowman Road	0.04[b]
2/17/92	San Joaquin River at Bowman Road	0.67[b]
2/17/92	San Joaquin River at Bowman Road	0.47[b]
2/24/92	San Joaquin River at Bowman Road	0.40[b]
4/23/91	San Joaquin River at Fremont Ford	0.08[c]
4/23-26/91	San Joaquin River at Fremont Ford	0.21[b]
2/17/92	San Joaquin River at Fremont Ford	0.05[c]
8/25/92	San Joaquin River at Fremont Ford	0.28[c]
2/09/93	San Joaquin River at Fremont Ford	0.17[c]
4/23-26/91	San Joaquin River at HWY 165	0.05[b]
1/28-30/92	San Joaquin River at HWY 165	0.03[b]
1/28-30/92	San Joaquin River at HWY 165	0.15[b]
4/23-26/91	San Joaquin River at Hills Ferry	0.09[b]
4/24/91	San Joaquin River at Hills Ferry	0.08[c]
6/12/91	San Joaquin River at Hills Ferry	0.01[b]
1/28/92	San Joaquin River at Hills Ferry	0.09[c]
1/28-30/92	San Joaquin River at Hills Ferry	0.03[b]
1/28-30/92	San Joaquin River at Hills Ferry	0.09[b]
2/18/92	San Joaquin River at Hills Ferry	0.13[c]
3/16/92	San Joaquin River at Hills Ferry	0.38[b]
4/27/92	San Joaquin River at Hills Ferry	0.07[b]
5/04/92	San Joaquin River at Hills Ferry	0.06[b]
5/11/92	San Joaquin River at Hills Ferry	0.02[b]
5/18/92	San Joaquin River at Hills Ferry	0.02[b]
5/25/92	San Joaquin River at Hills Ferry	0.03[b]
6/01/92	San Joaquin River at Hills Ferry	0.02[b]
6/22/92	San Joaquin River at Hills Ferry	0.01[b]
8/25/92	San Joaquin River at Hills Ferry	0.06[c]
2/09/93	San Joaquin River at Hills Ferry	1.69[c]
4/23-26/91	San Joaquin River at Laird Park	0.06[b]
5/15/91	San Joaquin River at Laird Park	0.01[b]
5/28/91	San Joaquin River at Laird Park	0.06[b]
9/09/91	San Joaquin River at Laird Park	0.01[b]
9/26/91	San Joaquin River at Laird Park	0.01[b]
10/24/91	San Joaquin River at Laird Park	0.01[b]
10/30/91	San Joaquin River at Laird Park	0.01[b]

11/13/91	San Joaquin River at Laird Park	0.01[b]

Table 1. Continued -5-

Date	Location[a]	Concentration
1/05/92	San Joaquin River at Laird Park	0.02[b]
1/20/92	San Joaquin River at Laird Park	0.07[c]
1/20/92	San Joaquin River at Laird Park	0.01[b]
1/23/92	San Joaquin River at Laird Park	0.10[c]
1/28-30/92	San Joaquin River at Laird Park	0.04[b]
1/28-30/92	San Joaquin River at Laird Park	0.09[b]
1/30/92	San Joaquin River at Laird Park	0.09[c]
2/03/92	San Joaquin River at Laird Park	0.08[c]
2/03/92	San Joaquin River at Laird Park	0.06[b]
2/06/92	San Joaquin River at Laird Park	0.09[c]
2/10/92	San Joaquin River at Laird Park	0.07[b]
2/10/92	San Joaquin River at Laird Park	0.12[c]
2/13/92	San Joaquin River at Laird Park	0.35[c]
2/19/92	San Joaquin River at Laird Park	0.14[c]
2/24/92	San Joaquin River at Laird Park	0.08[c]
2/27/92	San Joaquin River at Laird Park	0.06[c]
3/02/92	San Joaquin River at Laird Park	0.05[c]
3/09/92	San Joaquin River at Laird Park	0.04[b]
3/09/92	San Joaquin River at Laird Park	0.06[c]
3/12/92	San Joaquin River at Laird Park	0.10[c]
3/16/92	San Joaquin River at Laird Park	0.07[b]
3/16/92	San Joaquin River at Laird Park	0.09[c]
3/19/92	San Joaquin River at Laird Park	0.09[c]
3/23/92	San Joaquin River at Laird Park	0.05[c]
3/30/92	San Joaquin River at Laird Park	0.03[b]
3/30/92	San Joaquin River at Laird Park	0.06[c]
4/06/92	San Joaquin River at Laird Park	0.02[b]
4/13/92	San Joaquin River at Laird Park	0.02[b]
4/20/92	San Joaquin River at Laird Park	0.02[b]
4/27/92	San Joaquin River at Laird Park	0.03[b]
5/04/92	San Joaquin River at Laird Park	0.02[b]
5/18/92	San Joaquin River at Laird Park	0.04[b]
5/25/92	San Joaquin River at Laird Park	0.02[b]
6/01/92	San Joaquin River at Laird Park	0.02[b]
6/22/92	San Joaquin River at Laird Park	0.02[b]
8/05/92	San Joaquin River at Laird Park	0.21[c]
1/07/93	San Joaquin River at Laird Park	0.08[c]
1/11/93	San Joaquin River at Laird Park	0.27[c]
1/14/93	San Joaquin River at Laird Park	1.09[c]
1/17/93	San Joaquin River at Laird Park	0.17[c]
1/21/93	San Joaquin River at Laird Park	0.14[c]
1/21/93	San Joaquin River at Laird Park	0.13[c]
1/28/93	San Joaquin River at Laird Park	0.07[c]
2/01/93	San Joaquin River at Laird Park	0.09[c]
2/04/93	San Joaquin River at Laird Park	0.23[c]
2/10/93	San Joaquin River at Laird Park	0.77[c]
2/11/93	San Joaquin River at Laird Park	1.22[c]
2/15/93	San Joaquin River at Laird Park	0.25[c]
2/18/93	San Joaquin River at Laird Park	0.15[c]
2/22/93	San Joaquin River at Laird Park	0.11[c]
2/25/93	San Joaquin River at Laird Park	0.06[c]
4/23-26/91	San Joaquin River at Maze Blvd	0.02[b]
1/28-30/92	San Joaquin River at Maze Blvd	0.11[b]

1/28-30/92	San Joaquin River at Maze Blvd	0.07[b]
1/30/92	San Joaquin River at Maze Blvd	0.11[c]
2/19/92	San Joaquin River at Maze Blvd	0.17[c]

Table 1. Continued -6-

Date	Location[a]	Concentration
1/17/93	San Joaquin River at Maze Blvd	0.15[c]
2/10/93	San Joaquin River at Maze Blvd	0.37[c]
8/19/92	San Joaquin River just above Merced River	0.07[c]
1/28/92	San Joaquin River at Newman Wasteway	0.09[c]
1/29/92	San Joaquin River at Patterson	0.08[c]
2/19/92	San Joaquin River at Patterson	0.11[c]
8/05/92	San Joaquin River at Patterson	0.18[c]
8/26/92	San Joaquin River at Patterson	0.06[c]
2/10/93	San Joaquin River at Patterson	1.18[c]
1/27/92	San Joaquin River at Stevenson	0.15[c]
2/17/92	San Joaquin River at Stevenson	0.06[c]
2/08/93	San Joaquin River at Stevenson	0.26[c]
1/31/92	San Joaquin River at Vernalis	0.09[c]
2/19/92	San Joaquin River at Vernalis	0.15[c]
1/17/93	San Joaquin River at Vernalis	0.13[c]
2/08/93	San Joaquin River at Vernalis	0.77[d]
2/10/93	San Joaquin River at Vernalis	0.36[c]
2/11/93	San Joaquin River at Vernalis	1.07[d]
4/23-26/91	San Joaquin River at West Main	0.06[b]
1/28-30/92	San Joaquin River at West Main	0.08[b]
1/28-30/92	San Joaquin River at West Main	0.05[b]
3/04/91	Spanish Grant Combined Drain	0.02[b]
3/19/91	Spanish Grant Combined Drain	0.02[b]
4/18/91	Spanish Grant Combined Drain	0.01[b]
5/15/91	Spanish Grant Combined Drain	0.02[b]
5/28/91	Spanish Grant Combined Drain	0.05[b]
6/12/91	Spanish Grant Combined Drain	0.02[b]
1/05/92	Spanish Grant Combined Drain	0.08[b]
2/10/92	Spanish Grant Combined Drain	0.02[b]
2/17/92	Spanish Grant Combined Drain	0.06[b]
4/13/92	Spanish Grant Combined Drain	0.03[b]
4/27/92	Spanish Grant Combined Drain	0.02[b]
5/04/92	Spanish Grant Combined Drain	0.01[b]
5/11/92	Spanish Grant Combined Drain	1.20[b]
5/18/92	Spanish Grant Combined Drain	0.08[b]
5/25/92	Spanish Grant Combined Drain	0.07[b]
6/01/92	Spanish Grant Combined Drain	0.02[b]
6/15/92	Spanish Grant Combined Drain	0.01[b]
6/22/92	Spanish Grant Combined Drain	0.02[b]
1/16/93	Spanish Grant Combined Drain	0.15[c]
2/09/93	Spanish Grant Combined Drain	0.19[c]
4/23-26/91	Stanislaus River	0.01[b]

6/12/91	Stanislaus River	0.02[b]
1/20/92	Stanislaus River	0.02[b]
1/28-30/92	Stanislaus River	0.10[b]

Table 1. Continued -7-

Date	Location[a]	Concentration
1/28-30/92	Stanislaus River	0.04[b]
1/30/92	Stanislaus River	0.10[c]
2/17/92	Stanislaus River	0.06[b]
2/10/93	Stanislaus River	0.11[c]
2/09/93	Stevinson Spillway	1.32[c]
1/20/92	Tuolumne River	0.03[b]
1/28-30/92	Tuolumne River	0.09[b]
1/28-30/92	Tuolumne River	0.04[b]
1/30/92	Tuolumne River	0.09[c]
2/17/92	Tuolumne River	0.35[b]
2/19/92	Tuolumne River	0.22[c]
5/18/92	Tuolumne River	0.02[b]
5/25/92	Tuolumne River	0.03[b]
6/01/92	Tuolumne River	0.01[b]
6/22/92	Tuolumne River	0.01[b]
2/10/93	Tuolumne River	0.18[c]
3/04/91	Turlock Irrigation Drain #3	0.19[b]
3/19/91	Turlock Irrigation Drain #3	0.04[b]
4/04/91	Turlock Irrigation Drain #3	0.02[b]
1/05/92	Turlock Irrigation Drain #3	0.20[b]
2/10/92	Turlock Irrigation Drain #3	2.60[b]
2/17/92	Turlock Irrigation Drain #3	0.82[b]
3/02/92	Turlock Irrigation Drain #3	0.33[b]
3/09/92	Turlock Irrigation Drain #3	0.27[b]
3/16/92	Turlock Irrigation Drain #3	0.18[b]
5/04/92	Turlock Irrigation Drain #3	0.03[b]
5/11/92	Turlock Irrigation Drain #3	0.01[b]
3/19/91	Turlock Irrigation Drain #5	0.03[b]
4/04/91	Turlock Irrigation Drain #5	0.04[b]
4/23-26/91	Turlock Irrigation Drain #5	0.02[b]
12/18/91	Turlock Irrigation Drain #5	0.08[b]
1/05/92	Turlock Irrigation Drain #5	0.05[b]
1/13/92	Turlock Irrigation Drain #5	0.17[b]
1/20/92	Turlock Irrigation Drain #5	0.09[b]
1/28-30/92	Turlock Irrigation Drain #5	0.45[b]
1/28-30/92	Turlock Irrigation Drain #5	0.54[b]
1/29/92	Turlock Irrigation Drain #5	0.45[c]
2/03/92	Turlock Irrigation Drain #5	0.26[b]
2/10/92	Turlock Irrigation Drain #5	0.29[b]
2/17/92	Turlock Irrigation Drain #5	0.05[b]
3/09/92	Turlock Irrigation Drain #5	0.08[b]
4/27/92	Turlock Irrigation Drain #5	0.01[b]
5/04/92	Turlock Irrigation Drain #5	0.01[b]
5/11/92	Turlock Irrigation Drain #5	0.01[b]
1/16/93	Turlock Irrigation Drain #5	0.12[c]
2/09/93	Turlock Irrigation Drain #5	1.69[c]
1/20/92	Turlock Irrigation Drain #6	0.02[b]

1/20/92	Turlock Irrigation Drain #6	0.09[b]
2/03/92	Turlock Irrigation Drain #6	0.11[b]
2/10/92	Turlock Irrigation Drain #6	0.91[b]

Table 1. Continued -8-

Date	Location[a]	Concentration
2/17/92	Turlock Irrigation Drain #6	0.35[b]
4/06/92	Turlock Irrigation Drain #6	0.01[b]
4/06/92	Ulatis Creek at Salem Road	0.24[b]

[a] These and other locations were sampled in 1991, 1992, and 1993. Only the dates on which diazinon was detected are listed.

[b] Unpublished data from monitoring by the Central Valley Regional Water Quality Control Board

[c] Unpublished data from monitoring by the Department of Pesticide Regulation

[d] Unpublished data from monitoring by the U.S. Geological Survey

ENVIRONMENTAL FATE

Diazinon is an organophosphate insecticide. Photolysis half-life ($t_{1/2}$) values on sandy loam soil exposed to sunlight range from 2.5 to 10 days (Bunkhard 1978; Spare 1988). Hydrolysis $t_{1/2}$ values range from four to 12 days at pH 5, 78 to 138 days at pH 7, and 40 to 77 days at pH 9. Hydrolysis occurs more slowly at lower temperatures (Bunkhard 1979; Matt 1988). The water solubility of diazinon is 60 mg/L at pH 7 and 22^{o}C (Bunkhard 1988). Diazinon soil adsorption is relatively low, with a soil adsorption coefficient (K_{oc}) of 1200 cm^3/g (Johnson 1991). Under field conditions the $t_{1/2}$ of total diazinon residue and metabolite in soil was 15 days (Jacobson 1989).

The moderate water solubility and low K_{oc} of diazinon indicate a potential to be carried in field runoff water or to leach to groundwater. However, diazinon hydrolysis and soil half-life vary, and the tendency of diazinon to run off or leach would depend on field conditions.

To cause toxicity diazinon must be changed to its oxygen analogues, such as diazoxon, within organisms. Diazinon does not appear to bioconcentrate to a significant degree (Pait et al. 1992), and is rapidly excreted after exposure (Kanazawa 1978).

TOXICITY TO AQUATIC ORGANISMS

Acute Toxicity to Aquatic Animals

Fifty-nine tests on the acute toxicity of diazinon to aquatic animals were evaluated (Appendix B). Thirty-four of these tests were accepted (Table B-1) and 25 were not accepted (Table B-2). EPA (1985a) guidelines recommend eight families of freshwater organisms for which acceptable data should be available for deriving a freshwater Final Acute Value (FAV), and eight families of saltwater organisms for deriving a saltwater FAV (Table 2). Acceptable data were available for seven of the recommended eight freshwater families, and EPA (1985a) guidelines were used to calculate a freshwater FAV. Genus Mean Acute Values (GMAVs) were calculated using data from accepted acute toxicity tests and were ranked in ascending order (Table 3). The freshwater GMAVs ranged from 0.20 µg/L, the 96-h LC_{50} value for the amphipod *Gammarus fasciatus* to 29,220 µg/L, the 24-h LC_{50} value for the rotifer *Branchionus calyciflorus*.

The four lowest GMAVs are the most significant determinants of the FAV. For the freshwater FAV the lowest four GMAVs were for invertebrate species. The calculated freshwater FAV was 0.16 µg/L. No freshwater or saltwater GMAV was lower than the freshwater FAV. Although only seven of the eight families are represented, additional data for a family in the remaining category would likely be for a mollusk. As indicated by the LC_{50} value for the saltwater eastern oyster (880 µg/L), mollusks are not very sensitive to diazinon and therefore data for the remaining category would not be likely to lower the FAV.

Acceptable data were available for only two saltwater species, the eastern oyster *Crassostrea virginica*, and the mysid *Mysidopsis bahia*, so a saltwater FAV could not be calculated. The 96-h EC_{50} value for the eastern oyster was 880 µg/L; the mean 96-h LC_{50} value for *M. bahia* was 4.5 µg/L.

Table 2. Eight families of freshwater aquatic animals recommended by EPA (1985) for use in deriving the Final Acute Value (FAV) and representative species for which diazinon acute toxicity data were available.

Family	Animal
1. One Salmonid	Brook trout
2. Another family in Osteichthyes	Bluegill
3. Another family in Chordata	Fathead minnow
4. One family not in Arthropoda or Chordata	Not available
5. One insect family or any phylum not already represented	Rotifer
6. One planktonic crustacean	Cladoceran
7. One benthic crustacean	Amphipod
8. One insect	Stonefly

Table 3. Ranked Genus Mean Acute Values (GMAV) from accepted acute toxicity tests on freshwater species used to calculate the freshwater FAV.

Rank	GMAV (µg/L)	Species
1	0.20[a]	Amphipod *Gammarus fasciatus*
2	0.49[b]	Cladoceran *Ceriodaphnia dubia*
3	1.06[c]	Genus: *Daphnia* *D. pulex*[d] (0.78) *D. magna* (1.44)
4	1.59[b] Cladoceran	*Simocephales serrulatus*
5	4.15[b]	Mysid[d] *Neomysis mercedis*
6	25[a]	Stonefly *Pteronarcys californica*
7	272[b]	Bluegill[d] *Lepomis macrochirus*
8	441[c]	Genus: *Oncorhynchus* *O. clarki* (2166) *O. mykiss* (90)[c]
9	602[a]	Lake trout *Salvelinus namaycush*
10	723[b]	Brook trout[d] *Salvelinus fontinalis*
11	800[a]	Guppy *Poecilia reticulata*
12	1,643[b]	Flagfish *Jordanella floridae*
13	7,656[b]	Fathead minnow *Pimephales promelas*
14	8,000[a]	Zebrafish *Brachydanio rerio*
15	29,220[a]	Rotifer *Branchionus calyciflorus*
Freshwater FAV:	0.16	

[a] LC_{50} value from one toxicity test on this species

[b] Species Mean Acute Value: geometric mean of values from several toxicity tests on this species. Individual values are listed in Table B-1.

[c] Genus Mean Acute Value: geometric mean of values from toxicity tests on several species in this genus. Individual values are listed in Table B-1.

[d] Occurs in Sacramento-San Joaquin River system.

Chronic Toxicity to Aquatic Animals

Ten tests on the chronic toxicity of diazinon were evaluated for use in deriving the Final Chronic Value (FCV) (Appendix C). Three of these tests were accepted (Table C-1); seven were not accepted (Table C-2). The lowest Maximum Acceptable Toxicant Concentration value (MATC) was 0.23 µg/L for cladoceran *Daphnia magna* (Table C-1).

The EPA (1985a) guidelines specify calculating the Acute-Chronic Ratio (ACR) for a species using for the numerator the geometric mean of LC_{50} values and for the denominator the geometric mean of MATC values, and that these acute and chronic values should be from the same study. However, insufficient data were available to consistently use this method to derive the ACR values and Final Acute-Chronic Ratio (FACR) values. Therefore, the ACR value for each species for which acute and chronic toxicity data were available was obtained by dividing the geometric mean of all available LC_{50} values from accepted tests by the available MATC value from accepted chronic tests. If an LC_{50} and MATC value from the same study were available, these values were kept separate from LC_{50} values from other tests for that species and were used to derive the ACR value for that species (Table 4).

The EPA (1985a) guidelines specify that freshwater or saltwater FACR values be derived using ACR values of both freshwater and saltwater species, including at least a fish, an invertebrate, and an acutely sensitive species. The FACR value used to derive a freshwater FCV should include an acutely sensitive freshwater species. The other species used may be either freshwater or saltwater. For diazinon, two of the three chronic toxicity values available were for freshwater species, and one of these, *Daphnia magna*, was acutely sensitive.

However, the ACR values available for diazinon generally increase with increasing acute values (Table 4). EPA (1985a) procedures specify that if ACR values increase or decrease with acute toxicity values, then the FACR should be calculated as the geometric mean of the ACR values for only those species whose acute toxicity values are close (within a factor of 10) to the FAV. Therefore, the ACR values for *D. magna* and *M. bahia* were used to estimate a FACR value of 4.0 ($[6.3 \times 2.5]^{1/2}$). The FCV was derived by dividing the FAV by the FACR, resulting in a value of 0.04 μg/L (0.16/4).

Table 4. Acute-Chronic Ratios (ACR) for species for which acceptable acute and chronic toxicity data were available.

Species	LC_{50} or SMAV (μg/L)	NOEC LOEC (μg/L)	MATC $(NOEC \times LOEC)^{1/2}$ (μg/L)	ACR (LC_{50}/MATC)
Cladoceran *Daphnia magna*	1.44[a]	0.17 0.32	0.23	6.3
Mysid *Mysidopsis bahia*	4.82[b]	1.15 3.27	1.9	2.5
Fathead minnow *Pimephales promelas*	7656[a]	92 170	125	61
Final Acute-Chronic Ratio: 4				

[a] Species Mean Acute Value: geometric mean of values from several tests on this species. Individual values are listed in Table B-1.

[b] LC_{50} and MATC values from same test.

Toxicity to Aquatic Plants

Thirteen tests on the toxicity of diazinon to aquatic plants were evaluated (Appendix D) to derive a Final Plant Value (FPV). The FPV is the lowest concentration of pesticide that demonstrates a biologically important toxic endpoint (EPA 1985a).

In tests for which specific values were reported, the lowest concentration at which growth was inhibited was 1,000 µg/L for green algae *Chlamydomonas reinhardtii* and *Chlorella pyrenoidosa*, and the FPV for diazinon is 1,000 µg/L. None of the tests indicated that diazinon was more toxic to aquatic plants than to aquatic animals, therefore criteria that protect aquatic animals will also protect aquatic plants.

HAZARD ASSESSMENT

Water Quality Criterion

The EPA guidelines specify that a WQC consists of two concentrations, the Criterion Maximum Concentration (CMC), and the Criterion Continuous Concentration (CCC). The CMC is equal to one-half the FAV. The CCC is equal to the lowest of three values: the FCV, the FPV, or the Final Residue Value (FRV). The FRV is intended to prevent pesticide concentrations in commercially or recreationally important species from affecting marketability because of excedence of applicable action levels, and to protect wildlife that consume aquatic organisms. (EPA 1985a)

Diazinon does not appear to bioconcentrate to a significant degree (Pait et al. 1992), and is rapidly excreted after exposure (Kanazawa 1978). In addition, neither the U.S. Food and Drug Administration nor the State of California have established diazinon action levels (B. Brodberg California Office of Environmental Health Hazard Assessment pers. comm.)

Therefore, for diazinon, the CMC is 0.08 µg/L and the CCC is 0.04 µg/L, equivalent to the FCV. The WQC may be refined as more data become available.

The U.S. Environmental Protection Agency (EPA) has not established a WQC for diazinon. However, the National Academy of Sciences recommended a guideline of 0.009 μg/L for the protection of aquatic life (NAS 1973). The NAS guideline was derived by dividing the lowest acute toxicity value available at that time, 0.9 μg/L for *Daphnia pulex* (Sanders and Cope 1966) by an ACR value of 100. The NAS guideline is lower than the CDFG WQC because the ACR value of 100 used by the NAS is much larger than current data indicate is appropriate. The CDFG WQC also differs from the NAS criterion because a larger data set, more recent data, and different procedures were used to derive the CDFG value. The CDFG criterion is consistent with current toxicity data and hazard assessment procedures.

The freshwater WQC proposed in this assessment is based on the toxicity of diazinon alone. It appears that the toxicity of some insecticides commonly found together in the Sacramento-San Joaquin River system is additive (CDFG 1992a). The WQC may need to be revaluated to adequately protect aquatic organisms from the additive effects of pesticides likely to be present concurrently in the Sacramento-San Joaquin River system.

Hazard to Aquatic Animals

Freshwater aquatic organisms should not be affected unacceptably if the four-day average concentration of diazinon does not exceed 0.04 μg/L more than once every three years on the average, and if the one-hour average concentration does not exceed 0.08 μg/L more than once every three years on the average.

Although diazinon has been detected in the Sacramento-San Joaquin River system at concentrations as high as 36.8 μg/L, more typical concentrations ranged from 0.01 to 1.0 μg/L (Table 1). Concentrations of diazinon in the Sacramento-San Joaquin River system have periodically exceeded the WQC. Although the duration of these excedences is not known, it is likely that in at least some cases diazinon concentrations remained above the WQC for one hour or longer.

A comparison of detected concentrations of diazinon with toxicity data and the freshwater WQC indicates that diazinon may present a hazard to aquatic invertebrates in the Sacramento-San Joaquin River system. Generally, invertebrates are more sensitive to diazinon than are fish. The lowest 96-h LC_{50} and MATC values for invertebrates were 0.20 and 0.23 µg/L for amphipod and cladoceran, respectively. The lowest 96-h LC_{50} and MATC values for fish were 90 and 125 µg/L for rainbow trout and fathead minnow, respectively. The detection limit of 0.01 µg/L commonly used for diazinon is lower than the WQC and is sufficiently sensitive.

Data Requirements

Acute toxicity data were available for seven of the eight families recommended by the EPA (1985a) (Table 3). An acute test should be conducted on a freshwater mollusk to complete the eight families, however, this value is unlikely to lower the WQC. Although chronic toxicity data were available for a fish, an invertebrate, and an acutely sensitive species additional acute and chronic paired tests and chronic tests should be performed with other invertebrates such as *Neomysis mercedis* and *Ceriodaphnia dubia*. *Neomysis mercedis* is a native estuarine mysid and cladocerans are widely distributed invertebrates. Paired acute and chronic tests should be performed with fish such as rainbow trout *Oncorhynchus mykiss* to better define effects on fish.

Monitoring of the Sacramento-San Joaquin Estuary should be continued to help assess hazards posed by diazinon to aquatic species.

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APPENDIX A. Procedures used by the California Department of Fish and Game to prepare hazard assessments.

The California Department of Fish and Game (CDFG) Pesticide Investigations Unit assesses the hazard of pesticides to aquatic organisms. The hazard assessment procedure includes evaluation of toxicity studies, establishment of the Water Quality Criterion (WQC), and assessment of potential hazards.

Acute and chronic toxicity data are obtained from studies published in scientific literature and laboratory reports required by the U. S. Environmental Protection Agency for pesticide registration. The CDFG evaluates the quality of these data by evaluating the tests for compliance with standards adapted from the EPA and the American Society for Testing and Materials (ASTM). The tests are evaluated for compliance with standards for test type, method, design and species, and for water quality and toxicant monitoring and maintenance. Although a study need not comply with every standard, tests are rejected if they do not observe certain fundamental procedures or if several important standards are not met. Studies are also rejected if they do not contain sufficient information to be properly evaluated and the necessary information cannot be obtained from the original researcher.

Acute toxicity data from acceptable tests on freshwater and saltwater organisms are used to determine a Final Acute Value (FAV). The EPA (1985a) guidelines recommend eight categories of freshwater organisms for which data should be available for deriving a freshwater FAV, and eight categories of saltwater organisms for deriving a saltwater FAV.

The FAV is calculated as follows:

1. The Species Mean Acute Value (SMAV) is the geometric mean of EC_{50} values and LC_{50} values from all accepted toxicity tests performed on that species.

2. The Genus Mean Acute Value (GMAV) is the geometric mean of all SMAVs for each genus.

3. The GMAVs are ranked (R) from "1" for the lowest to "N" for the highest. Identical GMAVs are arbitrarily assigned successive ranks.

4. The cumulative probability (P) is calculated for each GMAV as R/(N+1).

5. The four GMAVs with cumulative probabilities closest to 0.05 are selected. If fewer than 59 GMAVs are available, these will always be the four lowest GMAVs.

6. The FAV is calculated using the selected GMAVs and Ps, as follows:

$$S^2 = \frac{3((\ln GMAV)^2)-((3(\ln GMAV))^2/4)}{3(P) - ((3(\%P))^2/4)}$$

$$L = (3(\ln GMAV) - S(3(\%P)))/4$$

$$A = S(\%0.05) + L$$

$$FAV = e^A$$

Chronic toxicity data from acceptable tests on freshwater and saltwater organisms are used to determine a Final Chronic Value (FCV). If data are available for the eight families, the FCV is calculated using the same procedure as described for the FAV. If sufficient data are not available, the following procedure is used:

1. Chronic values are obtained by calculating the geometric mean of the NOEC and the LOEC values from accepted chronic toxicity tests.

2. Acute-Chronic Ratios (ACR) are calculated for each chronic value for which at least one corresponding acute value is

available. Whenever possible, the acute test(s) should be part of the same study as the chronic test.

3. The Final ACR (FACR) is calculated as the geometric mean of all the species mean ACRs available for both freshwater and saltwater species.

4. FCV = FAV/FACR.

Plant toxicity data from algae or aquatic vascular plants are used to determine a Final Plant Value (FPV). The FPV is the lowest result from a test with a biologically important endpoint.

The EPA guidelines specify that a WQC consists of two concentrations, the Criterion Maximum Concentration (CMC), and the Criterion Continuous Concentration (CCC). The CMC is equal to one-half the FAV. The CCC is equal to the lowest of three values: the FCV, the FPV, or the Final Residue Value (FRV). The FRV is intended to prevent pesticide concentrations in commercially or recreationally important species from affecting marketability because of excedence of applicable action levels, and to protect wildlife that consume aquatic organisms. The WQC can be lowered to protect important resident species (EPA 1985a).

The WQC is stated as follows: (Freshwater/saltwater) aquatic organisms should not be affected unacceptably if the four-day average concentration of (pesticide) does not exceed (CCC value), and if the one-hour average concentration does not exceed (CMC value) more than once every three years on the average.

Hazard assessment is an iterative process by which new data are evaluated to refine the WQC. Hazard assessments frequently recommend additional toxicity tests with sensitive native species and commonly-used test organisms listed by ASTM.

APPENDIX B. Abstracts of accepted and unaccepted acute toxicity tests reviewed for hazard assessment.

Accepted acute toxicity tests - The following tests used accepted test methods.

<u>Allison and Hermanutz (1977), Hermanutz (pers. comm.)</u> - From 1971 to 1973, 96-h flow-through toxicity tests were performed by the EPA on technical grade diazinon (92.5%) with 13-, 15-, and 20-week old fathead minnow *Pimephales promelas* (three tests), 1-year old bluegill *Lepomis macrochirus* (two tests), 1-y old brook trout *Salvelinus fontinalis* (three tests), and 6 week old flagfish *Jordanella floridae* (two tests). American Public Health Association (APHA) (1971) test standards were used. Five concentrations were tested in replicate and a water control was included. Concentrations were measured three to six times during the test. Water quality parameters during the tests averaged: temperature 25 $\pm$1°C (fathead minnow), 25 $\pm$0.5°C (bluegill), 12 $\pm$0.5°C (brook trout), and 25 $\pm$0.5°C (flagfish); pH 7.3-7.5; dissolved oxygen 65-105% saturation; and hardness 44-45 mg/L as $CaCO_3$. Control survival was not mentioned. The 96-h LC_{50} values were: fathead minnow: 10,000 µg/L, 6,800 µg/L and 6,600 µg/L ; bluegill: 440 µg/L; brook trout: 800 µg/L, 450 µg/L , and 1,050 µg/L; flagfish: 1,500 µg/L and 1,800 µg/L. One test performed with bluegill was not included because an insufficient number of organisms was used (ASTM 1988a). Chronic tests were also conducted with fathead minnow and brook trout (Appendix C).

<u>Ankley et al. (1991), Ankley (pers. comm.)</u> - In 1991, 48-h static toxicity tests were performed by the EPA and AScI Corporation on technical grade diazinon (95-99%) with $\leq$48-h old cladocerans *Ceriodaphnia dubia*, *Daphnia magna* and *Daphnia pulex*. EPA (1990) test standards were used. Five concentrations were tested in replicate and water controls were used. Concentrations were not measured during the test. Water quality parameters during the

test averaged: temperature of 25EC; pH of 7.6-8.0; dissolved oxygen of ≥90% saturation; and hardness of 160-180 mg/L. Control survival was ≥90%. The 48-h LC_{50} values were: *Ceriodaphnia dubia*: 0.50 µg/L; *Daphnia magna*: 0.80 µg/L and *Daphnia pulex*: 0.65 µg/L.

CDFG (1992b) - In 1992, 96-h static renewal toxicity tests were performed by the CDFG Aquatic Toxicology Laboratory on technical grade diazinon (87%) with neonate cladoceran *Ceriodaphnia dubia*. EPA (1990), ASTM (1988a) test standards were used. Five concentrations were tested and water and solvent controls were used. Concentrations were measured during the test. Water quality parameters during the test averaged: temperature of 24.4EC; pH of 8.3; hardness of 123.5 mg/L; conductivity of 382.5 µs/cm; salinity not mentioned; alkalinity of 112.0 mg/L and dissolved oxygen of 8.0 mg/L. Water control survival was 90% and solvent control survival was 100%. The 96-h LC_{50} value was 0.47 µg/L, the No Observable Effect Concentration (NOEC) and the Lowest Observable Effects Concentration (LOEC) values based on immobilization were 0.354 µg/L and 0.625 µg/L, respectively.

CDFG (1992c) - In 1992, a 96-h static renewal toxicity test was performed by the CDFG Aquatic Toxicology Laboratory on technical grade diazinon (87%) with neonate mysids *Neomysis mercedis*. ASTM (1992) test standards were used. Five concentrations of diazinon were tested and solvent and water controls were used. Concentrations were measured during the test. Water quality parameters during the test averaged: temperature of 17EC; pH of 8.3; hardness of 457.0 mg/L; salinity of 1.8 $^{o}/_{oo}$; conductivity of 3002.78 µs/cm; alkalinity of 149.63 mg/L; and dissolved oxygen of 8.71 mg/L. Control survival was 100%. The 96-h LC_{50} value was 3.57 µg/L, the NOEC and LOEC values, based on immobilization, were 2.10 µg/L and 4.15 µg/L, respectively.

CDFG (1992d) - In 1992, a 96-h static renewal test was performed by the CDFG Aquatic Toxicology Laboratory on technical grade diazinon (87%) with neonate cladoceran *Ceriodaphnia dubia*. EPA (1990), ASTM (1988a) test standards were used. Five concentrations were tested and water and solvent controls were used. Concentrations were measured during the test. Water quality parameters during the test averaged: temperature of 24.4EC; pH of 8.5; hardness of 125.0 mg/L $CaCo_3$; conductivity of 388.7 µs/cm; alkalinity of 100.0 mg/L; dissolved oxygen of 7.81 mg/L. Control survival was 100%. The 96-h LC_{50} value was 0.507 µg/L, the NOEC and LOEC values based on immobilization were 0.345 µg/L and 0.605 µg/L, respectively.

CDFG (1992e) - In 1992, a 96-h static renewal toxicity test was performed by the CDFG Aquatic Toxicology Laboratory on technical diazinon (87%) with neonate mysid *Neomysis mercedis*. ASTM (1988a) standards were used. Five concentrations of diazinon were tested and solvent and water controls were used. Concentrations were measured during the test. Water quality parameters during the test averaged: temperature of 17.5 EC; pH of 8.36; hardness of 465.3 mg/L; salinity $1.73^{o}/_{oo}$; conductivity 2932 µs/cm; dissolved oxygen of 8.92 mg/L. Control survival was 100%. The 96-h LC_{50} value was 4.82 µg/L. The NOEC and LOEC values, based on immobilization, were 2.45 µg/L and 4.5 µg/L, respectively.

Fernandez-Casalderry et al. (1992a) - In 1989, a 24-h static toxicity test was performed by the University of Valencia, Spain on technical grade diazinon (92%) with rotifer *Branchionus calyciflorus*. No commonly recognized test standards were used. Five concentrations were tested with nine replicates and a solvent control was included. Concentrations were not measured during the test and nominal concentrations were not given. Water quality parameters during testing were: temperature of 25^{o}C, pH of 7.4-7.8, and hardness of 80-100 mg/L. Control survival was 100%. The 24-h LC_{50} value was 29,220 μg/L.

Keizer et al. (1991) - In 1991, 96-h static toxicity tests were performed by the Instituto Superiore di Sanita Biochemical Toxicology Unit in Rome, Italy on technical grade diazinon (98%) with adult guppy *Poecilia reticulata* and adult zebrafish *Brachydanio rerio*. European Economic Community (1979) test methods were used. Seven concentrations were tested with three replicates for guppy and two replicates for zebrafish, and solvent controls were used. Concentrations were measured daily but concentrations were not given. Water quality parameters during testing averaged: temperatures of 20-22 EC; pH of 7.6; dissolved oxygen of 6-9 mg/L. Control survival was 100%. The 96-h LC_{50} values were guppy: 800 μg/L and zebrafish: 8,000 μg/L.

Mayer and Ellersieck (1986), Dwyer and Sappington (pers. comm.) - From 1965 to 1985, 48-h and 96-h static toxicity tests were performed by the Columbia National Fisheries Laboratory of the U.S. Fish and Wildlife Service on technical grade diazinon (89-92%) with first instar cladoceran *Daphnia pulex*, mature amphipod *Gammarus fasciatus*, second year class stonefly *Pteronarcys californica*, bluegill *Lepomis macrochirus*, cutthroat trout *Oncorhynchus clarki* (two tests), lake trout *Salvelinus namaycush*, and rainbow trout *Oncorhynchus mykiss*. ASTM (1980) test standards were used. Four or more concentrations were tested in replicate and solvent (acetone) controls were used. Diazinon concentrations were not measured during the tests. Water quality parameters during the tests averaged: temperature of 21^{o}C (cladocerans), 21^{o}C (amphipod), 15^{o}C (stonefly), 18^{o}C (bluegill), 12^{o}C and 10^{o}C (cutthroat trout), 12^{o}C (lake trout) and 13^{o}C (rainbow trout); pH of 7.1-7.4; and hardness of 44-162 mg/L as $CaCO_3$. Control survival was acceptable in all tests. The 48-h EC_{50} value for cladoceran mortality and morbidity was 0.8 μg/L. The 96-h LC_{50} values were; bluegill: 168 μg/L, amphipod: 0.2

µg/L, stonefly: 25 µg/L, cutthroat trout: 2,760 µg/L and 1700 µg/L, lake trout: 602 µg/L, and rainbow trout: 90 µg/L. Although dissolved oxygen levels were not given, these tests were accepted because control survival was acceptable and ASTM standards were used.

Nimmo et al. (1980) - In 1980, a 96-h static toxicity test was performed by Environmental Research and Technology, Inc. and the EPA at Gulf Breeze, Florida on technical grade (percent active ingredient not given) diazinon on $\leq$48-h old mysids *Mysidopsis bahia*. EPA (1978) test standards were used. Five concentrations of diazinon were tested with four replicates and water and solvent controls. Concentrations were not measured during the test. Water quality parameters during the test averaged: temperature of 22-25 EC; pH of 8.0-8.2; and dissolved oxygen of 60% saturation. Control survival was 90%. The 96-h LC_{50} value was 4.82 µg/L.

Sanders and Cope (1966) - In 1966, 48-h static toxicity tests were performed by Fish-Pesticide Research Laboratory, Bureau of Sport Fisheries and Wildlife in Denver, Colorado on technical grade diazinon (percent active ingredient not given) with first instar larvae cladocerans *Daphnia pulex* and *Simocephalus serrulatus* (two tests). No commonly recognized test standard was mentioned. Four concentrations were used for *D. pulex* and five concentrations for *S. serrulatus*. Each test used a water control. Concentrations were not measured during the test. Water quality parameters during the tests averaged: temperatures of 60EC *Daphnia pulex*, 60EC and 70EC *Simocephalus serrulatus*; pH of 7.4-7.8; hardness and alkalinity not mentioned. Test water was aerated. Control survival was 100%. The 48-h EC_{50} values based on immobilization were: *Daphnia pulex*: 0.90 µg/L and *Simocephalus serrulatus:* 1.80 µg/L and 1.40 µg/L.

Surprenant (1988a) - In 1988, a 96-h flow-through toxicity test was performed by Springborn Life Sciences on technical grade diazinon (87.7%) with $\leq$24-h old mysids *Mysidopsis bahia*. Test methods used were similar to EPA (1985b) methods. Five concentrations of diazinon were tested in replicate and solvent and water controls were used. Concentrations were measured at the beginning and end of testing and measured concentrations averaged 78-100% of nominal concentrations. Water quality parameters during the test ranged: temperature of 25 $\pm 1^{o}$C; pH of 7.8-7.9; dissolved oxygen of 5.6-7.3 mg/L; and salinity of 30-32$^{o}/_{oo}$. Control survival was 100%. The 96-h LC_{50} value for mysids was 4.2 µg/L.

Surprenant (1988b) - In 1988, a 96-h flow-through toxicity test was performed by Springborn Life Sciences on technical grade diazinon (87.7%) with eastern oyster *Crassostrea virginica*. Test methods used were similar to EPA (1985b) methods. Five concentrations of diazinon were tested in replicate and solvent and water controls were used. Concentrations were measured at the beginning and end of testing and measured concentrations averaged 55-88% of nominal concentrations. Water quality parameters during the test were: temperature of 20 $\pm 2^{o}$C; pH of 7.4-8.1; dissolved oxygen of 5.8-7.7 mg/L; and salinity of 30-32$^{o}/_{oo}$. Control survival was 100%. The 96-h EC_{50} value (effect not given) for eastern oyster was 880 µg/L.

Vial (1990) - In 1990, 48-h static renewal toxicity tests were performed by Ciba-Geigy in Basel, Switzerland on technical diazinon (96%) with <24-h old cladoceran *Daphnia magna*. Organization for Economic Cooperation and Development (OECD) (1984) test standards were used. Six concentrations were tested with ten replicates and a water control. Concentrations were not measured during the test. Water quality parameters during the test were: temperature of 20 $\pm 1^{o}$C; pH ranged from 7.8 to 9.3; dissolved oxygen ranged from 96 to 130% saturation; and hardness of 240 mg/L $CaCO_3$. Control survival was 100% The 48-h EC_{50} value for cladoceran *Daphnia magna* based on immobilization was >2.6 µg/L.

Unaccepted acute toxicity tests - The following tests did not use accepted test methods and/or produce accepted results.

Ebere and Akintonwa (1992) - In 1992, 96-hr static toxicity tests were performed by University of Lagos, Nigeria on technical grade diazinon (percent active ingredient not given) with fingerling *Gobius sp*, and juvenile *Desmocaris tirspimosa* and *Palaemontes africanus*. No commonly recognized test standards were mentioned. At least four concentrations of diazinon were tested and a water control was used. No mention of replicates was made. Concentrations were not measured during the test. Water quality parameters for the *Gobius sp*. and *Desmocaris tirspimosa* freshwater tests were: temperature of 25-27EC; dissolved oxygen of 8.1 ppm; conductivity of 90 µmho/cm; alkalinity of 20.4 mg/L. Water quality parameters for the brackish water averaged: dissolved oxygen of 4.3 ppm; salinity of 17 $^{o}/_{oo}$; conductivity of 38,000 µmhocm^{-1}; alkalinity of 60 mg/L. Control survival was >90%. The 96-h LC_{50} values were: *Gobius* sp.: 0.04 µl/L; *Palaemontes africanus*: 17.9 µl/L and *Desmocaris trispimosa*: 20.8 µl/L. These values were not accepted because concentrations were given in µl/L and it was not possible to convert to µg/L because percent active ingredient was not given. Attempts to obtain the necessary information from the researcher were not successful.

Federle and Collins (1975) - In 1975, a 96-h toxicity test was performed by Ohio State University on diazinon (percent active ingredient not given) with late instar damselfly *Lestes congener* nymphs. No commonly recognized test standards were mentioned and test dynamics were not given. Four concentrations were tested and solvent controls were used. Concentrations were not measured during the test. Water quality parameters during the tests were:

temperature of 25 ±0.2EC; pH of 7.4. Dissolved oxygen levels, water hardness, and control survival were not given. The 96-h LC_{50} value was estimated to be 50 µg/L. This test was not accepted because the LC_{50} value was not calculated and essential information such as dissolved oxygen levels, water hardness, and control survival were not given.

Fernandez-Casalderrey et al. (1992b) - In 1992, a static toxicity test was performed on diazinon (92%) with 0-2 hr old rotifers *Brachionus calyciflorus pallas*. No commonly recognized test standards were mentioned and test duration was not given. Four concentrations were tested with four replicates per concentration. A solvent control was used. Concentrations were not measured during the test. Water quality parameters during the test were: temperature of 25EC; pH of 7.4-7.8; hardness of 80-100 mg/L; alkalinity of 60-70 mg/L as $CaCO_3$. Dissolved oxygen levels and control survival were not given. No LC_{50} values, NOEC values, or LOEC values were given. This test was not accepted because essential information such as test duration and dissolved oxygen levels were not given and no toxicity values were determined.

Ferrando et al. (1991) - In 1991, a 96-h flow-through toxicity test was performed by the University of Valencia, Spain on technical grade diazinon (92%) with European eel *Anguilla anguilla*. Life stage was not given. EPA (1975) standards were used. Four concentrations were tested and solvent controls were used. Concentrations were not measured during the test. Water quality parameters during the test were: temperature of 20EC; pH of 7.9±0.2; hardness of 250 mg/L; alkalinity of 4.1 mmol/L; dissolved oxygen not given. Control survival was 100%. The 96-h LC_{50} value was 80 µg/L. This test was not accepted because essential information such as dissolved oxygen levels, concentration scale, and mortality at each concentration was lacking. Efforts to obtain the missing information from the author were not successful.

Goodman et al. (1979) - In 1979, a 96-h flow-through toxicity test was performed by the EPA Environmental Research Laboratory in Gulf Breeze, Florida on diazinon (92.6%) with juvenile sheepshead minnow *Cyprinodon variegatus*. No commonly recognized test standards were mentioned. Five concentrations were tested and a solvent control was included. Concentrations were measured during the test. Water quality parameters during the test averaged: temperature of 30 $\pm$2EC; pH not given; salinity of 22.7$^{o}/_{oo}$. The test solutions were aerated and control survival was 100%. The 96-h LC_{50} value was 1470 µg/L. This was not used the concentrations tested did not produce an adequate mortality range.

Hashimoto et al. (1982) - In 1982, 24-h static toxicity tests were performed by Tokai Regional Fisheries Research Laboratory in Japan on diazinon (percent active ingredient not given) with eight life stages of carp *Cyprinus carpio*. No commonly recognized test standards were mentioned. Number of concentrations tested and use of controls were not mentioned. Concentrations were not measured during the test. Water quality parameters during the test were: temperature of 25 $\pm$2EC; pH of 6.9-7.2. Dissolved oxygen, water hardness, and control survival were not given. The 24-h LC_{50} values were: eyed egg: 7.2 µg/L; sac fry: 6.1 µg/L; floating fry: 2.5 µg/L; one week old: 2.7 µg/L; two weeks old: 2.8 µg/L; four weeks old: 2.3 µg/L; eight weeks old; 1.9 µg/L and eleven weeks old: 2.4 µg/L. These tests were not accepted because essential information such as concentrations tested and use of controls was not given, and test duration was too short.

Khattat and Farley (1976) - In 1976, a 96-h static toxicity test was performed by the EPA Environmental Research Laboratory at

Narragansett, Rhode Island on technical grade diazinon (97.6%) with adult marine copepod *Acartia tonsa*. No commonly recognized test standards were mentioned. Seven concentrations were tested with four replicates and solvent and water controls were used. Concentrations were measured at 24-h intervals. Water quality parameters during the test averaged: dissolved oxygen of 80% saturation; temperature of 17 $\pm$1EC; salinity of 20$^{o}/_{oo}$. Water and solvent control survival were 86.2% and 85.0%, respectively. The 96-h LC_{50} value was 2.57 µg/L. This test was unacceptable because control survival for both water and solvent was less than 90%.

Morgan 1976 - In 1975, a 168-h static toxicity test was performed by the University of Guelph on diazinon (50%) with midges *Chironomus tentans*. No test standards were mentioned. Three replicates were tested. Concentrations were measured. The temperature averaged 16^{o}C. Other water quality parameters were not measured. Control survival was not given. The 168-h LC_{50} for the midge was 0.027 µg/L. This value was not used because the pesticide formulation was too low in active ingredient and essential information, such as control survival and mortality range in the treatments, was not given.

Robertson and Mazella (1989) - In 1987, a 96-h static renewal toxicity test was performed by East Carolina University at Greenville, North Carolina on technical grade diazinon (88.6%) with freshwater snail *Gillia altilis*. Life stage was not given, and no commonly recognized test standards were mentioned. Four concentrations of diazinon were tested in triplicate and a solvent control was used. Concentrations were not measured during the test. Water quality parameters during the test were: temperature of 22 $\pm$1.5^{E}C, pH of 6.7-6.9; dissolved oxygen of 8-11 mg/L; and hardness of 22-35 mg/L. Control survival was not given. The 96-h LC_{50} value was 11,000 µg/L.

This test was not accepted because dechlorinated water was used and essential information such as control survival was not given.

<u>Surprenant (1987a)</u> - In 1987, a 96-h static toxicity test was performed on diazinon (48%) using bluegill *Lepomis macrochirus*. Life stage was not given. Test methods similar to ASTM (1980) methods were used. Five concentrations were tested in replicate with solvent controls. Concentrations were measured during the test. Water quality parameters during the test were: temperature of 22 $\pm$1 ^{o}C; pH of 7.6; dissolved oxygen of 62-103% saturation; hardness of 50 mg/L; conductivity of 90-140 umhos/cm; and alkalinity of 35 mg/L. Control survival was 100%. The 96-h LC_{50} value was 200 µg/L. This value was not used because the diazinon formulation was too low in active ingredient.

<u>Surprenant (1987b)</u> - In 1987, a 48-h static toxicity test was performed on diazinon (48%) with $\leq$24-hr old cladoceran *Daphnia magna*. Test methods similar to ASTM (1980) methods were used. Seven concentrations were tested with two replicates and solvent controls were used. Concentrations were measured twice during the test and averaged 82-100% of nominal concentrations. Water quality parameters during the test were: temperature of 21 $\pm$1^{o}C; pH of 7.5-8.5; dissolved oxygen of 82-104% saturation; hardness of 180 mg/L; and alkalinity of 124 mg/L. Control survival was 100%. The 48-h LC_{50} value was 1.1 µg/L. This value was not used because the diazinon formulation was too low in active ingredient.

<u>Surprenant (1987c)</u> - In 1987, a 96-hr static toxicity test was performed on diazinon (48%) using rainbow trout *Oncorhynchus mykiss*. Life stage was not given. Test methods similar to ASTM (1980) methods were used. Seven concentrations were tested in replicate and solvent controls were used. Measured concentrations averaged 74-102% of nominal concentrations. Concentrations decreased 41% during the test. Water quality

parameters during the test were: temperature of 13EC; pH of 7.1-8.1; dissolved oxygen of 66-98% saturation; and water hardness of 50 mg/L. Control survival was 100%. The 96-h LC_{50} value was 1,800 µg/L. This value was not used because the diazinon formulation was too low in active ingredient and the concentrations tested did not produce an adequate range of mortality.

Union Carbide (1978a) - In 1978, a 96-h static toxicity test was performed on diazinon (23%) using four month old bluegill *Lepomis macrochirus*. EPA (1975) test standards were used. Five concentrations were tested and a water control was included. Concentrations were not measured during the test. Water quality parameters during the test were: temperature of 21.8 $\pm$0.3^{o}C; pH of 7.46; dissolved oxygen of 4.4-9.0 mg/L; hardness of 44 mg/L; and conductivity of 32 mg/L. Control survival was not given. The 96-h LC_{50} value was 28,600 µg/L. The 96-h NOEC value (effects not given) was <18,000 µg/L. These values were not used because the formulation was too low in active ingredient, dissolved oxygen levels were too low, and control survival was not given.

Union Carbide (1978b) - In 1978, a 48-h static toxicity test was performed on diazinon (23%) using first instar cladoceran *Daphnia magna*. EPA (1975) test standards were used. Five concentrations were tested with four replicates per treatment. A water control was included. Concentrations were not measured; nominal concentrations ranged from 1.0-10 µg/L. Water quality parameters during the test were: temperature of 20^{o}C; pH of 8.39; dissolved oxygen of 8.4-8.8 mg/L; and hardness of 252 mg/L. Control survival was 95%. The 48-h LC_{50} value was 5.03 µg/L. The NOEC value at 48-h was 3.2 µg/L. These values were not used because the diazinon formulation was too low in active ingredient.

Union Carbide (1978c) - In 1978, 96-h static toxicity test was performed on diazinon (23%) using four-month old rainbow trout *Oncorhynchus mykiss*. EPA (1975) test standards were used. Five concentrations were tested and a water control was included. Concentrations were not measured during the test. Water quality parameters during the test were: temperature of 11.8 $\pm$0.3^{o}C; pH of 7.47; dissolved oxygen of 4.1-9.0 mg/L; hardness of 44 mg/L; and alkalinity of 32 mg/L. Control survival was 100%. The 96-h LC_{50} value was 60,300 µg/L. The NOEC value at 96-h was <32,000 µg/L. These values were not used because the formulation was too low in active ingredient.

Vilkas (1976) - In 1986, a 48-h static toxicity test was performed on technical grade diazinon (percent active ingredient not given) with <20-h old cladocerans *Daphnia magna*. EPA (1975) and APHA (1971) test standards were used. Five concentrations were tested with four replicates and solvent controls were used. Concentrations were not measured during the test. Water quality parameters during the test were: temperature of 17^{o}C; pH of 7.9; dissolved oxygen of 8.6-9.2 ppm; hardness of 50 mg/L; conductivity of 140 umhos/cm; and alkalinity of 25 mg/L. Control survival was 100%. The 48-h LC_{50} value was 0.98 µg/L. This test was not accepted because the concentrations tested did not produce an adequate mortality range.

B-1. Values (μg/L) from accepted tests on the acute toxicity of diazinon to aquatic animals.

Species	Life Stage	Method[b]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (95% C.L.[c])	Reference
Amphipod *Gammarus fasciatus*	Mature	S,U	Technical (89%)	44 mg/L as $CaCO_3$	96-h	LC_{50}	0.20 (0.15-0.28)	Mayer and Ellersieck 1986
Bluegill *Lepomis macrochirus*	N/A[a]	S,U	Technical (92%)	44 mg/L as $CaCO_3$	96-h	LC_{50}	168 (120-220)	Mayer and Ellersieck 1986
Bluegill *Lepomis macrochirus*	1-yr	F,M	Technical (92.5%)	44-45 mg/L as $CaCO_3$	96-h	LC_{50}	440 (310-620)	Allison and Hermanutz 1977
Brook trout *Salvelinus fontinalis*	1-yr Hermanutz 1977	F,M	Technical	44-45 mg/L (92.5%)	96-h as $CaCO_3$	LC_{50}	800	Allison and (440-1,140)
Brook trout *Salvelinus fontinalis*	1-yr Hermanutz 1977	F,M	Technical	44-45 mg/L (92.5%)	96-h as $CaCO_3$	LC_{50}	450	Allison and (320-630)
Brook trout *Salvelinus fontinalis*	1-yr Hermanutz 1977	F,M	Technical	44-45 mg/L (92.5%)	96-h as $CaCO_3$	LC_{50}	1,050	Allison and (720-1,520)
Cladoceran *Ceriodaphnia dubia*	≤48-h	S,M	Technical (95%-99%)	160-180 mg/L as $CaCO_3$	48-h	LC_{50}	0.50 (0.43-0.61)	Ankley et al. 1991
Cladoceran *Ceriodaphnia dubia*	Neonate	S,M	Technical (87%)	123.5 mg/L as $CaCO_3$	96-h	LC_{50}	0.47 (N/A)	CDFG 1992b
Cladoceran *Ceriodaphnia dubia*	Neonate	S,M	Technical (87%)	125.0 mg/L as $CaCO_3$	96-h	LC_{50}	0.51 (N/A)	CDFG 1992d
Cladoceran *Daphnia magna*	≤48-h	S,U	Technical (95%-99%)	160-180 mg/L as $CaCO_3$	48-h	LC_{50}	0.80 (0.65-1.00)	Ankley et al. 1991

Cladoceran *Daphnia magna*	≤24-h	S,U	Technical (96%)	240 mg/L as $CaCO_3$	48-h	EC_{50}	>2.6 (N/A)	Vial 1990
Cladoceran *Daphnia pulex*	≤48-h	S,U	Technical (95%-99%)	160-180 mg/L as $CaCO_3$	48-h	LC_{50}	0.65 (0.53-0.80)	Ankley et al. 1991
Cladoceran *Daphnia pulex*	1st instar	S,U	Technical (89%)	44 mg/L as $CaCO_3$	48-h	EC_{50}	0.80 (0.6-1.1)	Mayer and Ellersieck 1986
Cladoceran *Daphnia pulex*	1st instar	S,U	Technical (N/A)	N/A	48-h	EC_{50}	0.90 (0.67-1.2)	Sanders and Cope 1966

Table B-1. Continued -2-

Species	Life Stage	Method[b]	Formulation	Salinity/ Hardness	Test length	Effect	Values (95% C.L.[c])	Reference
Cladoceran *Simocephalus serrulatus*	1st instar	S,U	Technical (N/A)	N/A	48-h	EC_{50}	1.8 (1.4-2.2)	Sanders and Cope 1966
Cladoceran *Simocephalus serrulatus*	1st instar	S,U	Technical (N/A)	N/A	48-h	EC_{50}	1.4 (1.2-1.6)	Sanders and Cope 1966
Cutthroat trout *Oncorhynchus clarki*	N/A	S,U	Technical (92%)	44 mg/L as $CaCO_3$	96-h	LC_{50}	2,760 (2,280-3,330)	Mayer and Ellersieck 1986
Cutthroat trout *Oncorhynchus clarkii*	N/A	S,M	Technical (92%)	162 mg/L as $CaCO_3$	96-h	LC_{50}	1,700 (1,390-2,090)	Mayer and Ellersieck 1986
Eastern oyster *Crassostrea virginica*	N/A	F,M	Technical	30-32 $^{o}/_{oo}$ (87.7%)	96-h	EC_{50}	880	Surprenant 1988b (630-1,100)
Fathead minnow *Pimephales promelas*	13-w	F,M	Technical (92.5%)	44-45 mg/L as $CaCO_3$	96-h	LC_{50}	10,000 (6,700-15,000)	Allison and Hermanutz 1977
Fathead minnow *Pimephales promelas*	15-w	F,M	Technical (92.5%)	44-45 mg/L as $CaCO_3$	96-h	LC_{50}	6,800 (5,400-8,55)	Allison and Hermanutz 1977
Fathead minnow *Pimephales promelas*	20-w	F,M	Technical (92.5%)	44-45 mg/L as $CaCO_3$	96-h	LC_{50}	6,600 (5,100-8,600)	Allison and Hermanutz 1977
Flagfish *Jordanella floridae*	6-w	F,M	Technical (92.5%)	44-45 mg/L as $CaCO_3$	96-h	LC_{50}	1,500 (1,200-1,900)	Allison and Hermanutz 1977
Flagfish *Jordanella floridae*	7-w	F,M	Technical (92.5%)	44-45 mg/L as $CaCO_3$	96-h	LC_{50}	1,800 (1,600-2,000)	Allison and Hermanutz 1977
Guppy *Poecilia reticulata*	adult	S,M	Technical (98%)	N/A	96-h	LC_{50}	800 (N/A)	Keizer et al. 1991

Lake trout *Salvelinus namaycush*	N/A	S,M	Technical (92%)	162 mg/L as $CaCO_3$	96-h	LC_{50}	602 (400-906)	Mayer and Ellersieck 1986
Mysid *Mysidopsis bahia*	≤24-h	F,M	Technical (87.7%)	30-32$^{o}/_{oo}$	96-h	LC_{50}	4.2 (3.7-4.8)	Surprenant 1988a
Mysid *Mysidopsis bahia*	≤48-h	S,U	Technical N/A	N/A	96-h	LC_{50}	4.82 (4.11-5.87)	Nimmo et al. 1980

Table B-1. Continued -3-

Species	Life Stage	Method[b]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (95% C.L.[c])	Reference
Mysid *Neomysis mercedis*	neonate	S,M	Technical (87%)	457.0 mg/L as $CaCO_3$	96-h	LC_{50}	3.57 (N/A)	CDFG 1992c
Mysid *Neomysis mercedis*	neonate	S,M	Technical (87%)	465.3 mg/L as $CaCO_3$	96-h	LC_{50}	4.82 (N/A)	CDFG 1992e
Rainbow trout *Oncorhynchus mykiss*	N/A	S,U	Technical (89%)	44 mg/L as $CaCO_3$	96-h	LC_{50}	90 (N/A)	Mayer and Ellersieck 1986
Rotifer *Branchionus calyciflorus*	cysts	S,U	Technical (92%)	80-100 mg/L as $CaCO_3$	24-h	LC_{50}	29,220 (28,470-29,960)	Fernandez-Casalderry et al. 1992a
Stonefly *Pteronarcys californica*	2nd-yr	S,U	Technical (89%)	44 mg/L as $CaCO_3$	96-h	LC_{50}	25 (20-30)	Mayer and Ellersieck 1986
Zebrafish *Brachydanio rerio*	adult	S,M	Technical (98%)	N/A	96-h	LC_{50}	8,000 (N/A)	Keizer et al. 1991

[a] N/A = Not available

[b] S = Static F = Flow through M = Measured concentrations U = Unmeasured concentrations

[c] Confidence limits

Table B-2. Values (ug/L) from unaccepted tests on the acute toxicity of diazinon to aquatic animals.

Species	Life Stage	Method[b]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (95% C.L.[c])	Reference	Test Deficiencies[d]
Bluegill *Lepomis macrochirus*	N/A	S,M	Technical (48%)	50 mg/L as $CaCO_3$	96-h	LC_{50}	200 (160-290)	Surprenant 1987a	2
Bluegill *Lepomis macrochirus*	4-mo	S,U	Formulation (23%)	44 mg/L as $CaCO_3$	96-h	LC_{50}	28,600 (21,800-37,400)	Union Carbide 1978a	2,5,6
Carp *Cyprinus carpio*	eyed egg	S,U	N/A	N/A	24-h	LC_{50}	7.2 (N/A)	Hashimoto et al. 1982	6,8
Carp *Cyprinus carpio*	sac fry	S,U	N/A	N/A	24-h	LC_{50}	6.1 (N/A)	Hashimoto et al. 1982	6,8
Carp *Cyprinus carpio*	floating fry	S,U	N/A	N/A	24-h	LC_{50}	2.5 (N/A)	Hashimoto et al. 1982	6,8
Carp *Cyprinus carpio*	1-week	S,U	N/A	N/A	24-h	LC_{50}	2.7 (N/A)	Hashimoto et al. 1982	6,8
Carp *Cyprinus carpio*	2-week	S,U	N/A	N/A	24-h	LC_{50}	2.8 (N/A)	Hashimoto et al. 1982	6,8
Carp *Cyprinus carpio*	4-week	S,U	N/A	N/A	24-h	LC_{50}	2.3 (N/A)	Hashimoto et al. 1982	6,8
Carp *Cyprinus carpio*	8-week	S,U	N/A	N/A	24-h	LC_{50}	1.9 (N/A)	Hashimoto et al. 1982	6,8
Carp *Cyprinus carpio*	11-week	S,U	N/A	N/A	24-h	LC_{50}	2.4 (N/A)	Hashimoto et al. 1982	6,8

Cladoceran *Daphnia magna*	1st instar	S,U	Formulation (23%)	252 mg/L as $CaCO_3$	48-h	LC_{50}	5.03 (4.45-5.67)	Union Carbide 1978b	2
Cladoceran *Daphnia magna*	$\leq$24-h	S,M	Formulation (48%)	180 mg/L as $CaCO_3$	48-h	LC_{50}	1.1 (1.1-1.3)	Surprenant 1987b	2
Cladoceran *Daphnia magna*	<20-h	S,U	Technical (N/A)	50 mg/L as $CaCO_3$	48-h	LC_{50}	0.98 (0.83-1.10)	Vilkas 1976	3
Damselfly *Lestes congener*	nymph	N/A,U	N/A	N/A	N/A	LC_{50}	50 (N/A)	Federle and Collins 1975	6,9

Table B-2. Continued -2-

Species	Life Stage	Method[b]	Formulation	Salinity/ Hardness	Test Length	Effect	Values (95% C.L.[c])	Reference	Test Deficiencies[d]
N/A *Desmocaris tirspimosa*	juv.	S,U	Technical (N/A)	N/A	96-h	LC_{50}	20.75μl/L (N/A)	Ebere and Akintonwa 1992	6,9
European eel *Anguilla anguilla*	N/A	F,U	Technical (92%)	250 mg/L as $CaCO_3$	96-h	LC_{50}	80 (60-100)	Ferrando et al. 1991	3,6
Freshwater snail *Gillia altilis*	N/A	S,U	Technical (88.6%)	22-35 mg/L as $CaCO_3$	96-h	LC_{50}	11,000 (N/A)	Robertson and Mazella 1989	4
N/A *Gobius* sp.	fngling	S,U	Technical (N/A)	N/A	96-h	LC_{50}	0.04μl/L (N/A)	Ebere and Akintonwa 1992	6,9
Marine copepod *Acartia tonsa*	adult	S,M	Technical (97.6%)	20$^{o}/_{oo}$	96-h	LC_{50}	2.57 (1.73-3.83)	Khattat and Farley 1976	4
Midge *Chironomus tentans*	N/A	S,M	Formulation	N/A (50%)	168-h	LC_{50}	0.027	Morgan 1976 N/A	2,3,5,6
N/A *Palaemontes africanus*	juv.	S,U	Technical (N/A)	17$^{o}/_{oo}$	96-h	LC_{50}	17.9 μl/L (N/A)	Ebere and Akintonwa 1992	6,9
Rainbow trout *Oncorhynchus mykiss*	4-mo	S,U	Formulation (23%)	44 mg/L as $CaCo_3$	96-h	LC_{50}	60,300 (43,800-83,200)	Union Carbide 1978c	2,5
Rainbow trout *Oncorhynchus mykiss*	N/A	S,M	Formulation (48%)	50 mg/L as $CaCO_3$	96-h	LC_{50}	1,800 (1,400-2,900)	Surprenant 1987c	2,3
Rotifer *Brachionus*	≤2-h	S,U	Technical (92%)	80-100 mg/L as $CaCO_3$	N/A	LC_{50}	N/A	Fernandez-Casalderrey	6,8,9

calyciflorus pallas								et al.	
Sheepshead minnow *Cyprinodon variegatus*	juv.	F,M	Technical (92.6%)	$22.7^{o}/_{oo}$	96-h	LC_{50}	1,470 (1,070-3,310)	Goodman et al. 1979	3,6

[a] N/A = Not available

[b] S = Static F = Flow through
M = Measured U = Unmeasured

[c] 95% Confidence limits

[d] 1 = Insufficient number of organisms tested per concentration
2 = Formulation too low in active ingredient
3 = Unacceptable mortality range or mortality range not given
4 = Unacceptable control survival
5 = Unacceptable or unmeasured dissolved oxygen level
6 = Essential information lacking
7 = Measured concnetration varied too much from nominal
8 = Test duration too short or not given
9 = Values estimated or no pertinent values given
10 = Inadequate number of concentrations tested

APPENDIX C. Abstracts of accepted and unaccepted chronic toxicity tests reviewed for hazard assessment.

Accepted chronic toxicity tests - The following tests used accepted test methods.

Nimmo et al. (1980), Nimmo (pers. comm.) - In 1980, a 28-d static toxicity test was performed by Environmental Research and Technology Inc. and the EPA in Gulf Breeze, Florida on technical grade diazinon (percent active ingredient not given) with $\leq$48-h old neonate mysid *Mysidopsis bahia*. EPA (1978) test standards were used. Five concentrations were tested with four replicates per treatment, and solvent and dilution water controls. Concentrations were measured weekly during the test. Water quality parameters during the tests were: temperature of 22-25EC; pH of 8.0-8.2; dissolved oxygen of 60% saturation. Control survival was >80%. The 28-d NOEC, LOEC, and MATC values based on reduced growth and fecundity were 1.15 µg/L, 3.27 µg/L, and 1.94 µg/L, respectively.

Surprenant (1988c) - In 1988, a 21-d flow-through toxicity test was performed by Springborn Life Sciences, Inc. on technical grade diazinon (87.7%) with $\leq$24-h old cladoceran *Daphnia magna*. ASTM (1980) and APHA (1985) test standards were used. Five concentrations were tested with four replicates per treatment and solvent and water controls were used. Concentrations were measured weekly during the test and measured concentrations averaged 64% of nominal concentrations. Water quality parameters during the test were: temperature of 20 $\pm$1EC; pH of 7.9-8.3; dissolved oxygen of >60% saturation; hardness of 160-180 mg/L; and conductivity of 400-600 µmhos/cm. Control survival was >95% The 21-d NOEC, LOEC, and MATC values based on immobilization were 0.17 µg/L, 0.32 µg/L, and 0.23 µg/L, respectively.

Surprenant (1988d) - In 1988, a 34-d flow-through toxicity test was performed by Springborn Life Sciences Inc. on technical grade diazinon (87.7%) with embryo and larval fathead minnow *Pimephales promelas*. APHA (1985) and EPA (1981) test standards were used. Five concentrations were tested in replicate and water and solvent controls were used. Concentrations were measured and were 98-135% of nominal concentrations. Water quality parameters during the test were: temperature of 25 $\pm$1EC; pH of 7.0-7.6; dissolved oxygen of 7.9-8.6 mg/L; hardness of 27-34 mg/L. Control survival was >90%. The 34-d NOEC, LOEC, and MATC values based on growth were 92 µg/L, 170 µg/L, and 125 µg/L, respectively.

Unaccepted chronic toxicity tests - The following tests did not use accepted test methods and/or produce acceptable results

Allison and Hermanutz (1977) - In 1977, a 274-d flow-through adult survival and reproduction test and a 60-d progeny (from tested adults) growth test were performed by the EPA Environmental Research Laboratory at Duluth, Minnesota on technical grade diazinon (92.5%) with fathead minnow *Pimephales promelas.* The EPA also performed a 173-d adult survival and reproduction test and a 122-d progeny test (from tested adults) on brook trout *Salvelinus fontinalis*. APHA (1971) test standards were used. Five concentrations were tested in replicate and a solvent control was used. Concentrations were measured weekly and averaged 73 to 110% of nominal concentrations. Water quality parameters during the tests were: temperature of 25 $\pm$1°C (minnows) and 12 $\pm$1°C (trout); pH of 7.3-7.5; dissolved oxygen of 85-86% saturation; and hardness of 44-45 mg/L. Control survival was 67% and 93% for progeny and adult fathead minnow, respectively. Control survival was 89% and 100% for progeny and adult brook trout, respectively. The lowest concentration tested on fathead minnow, 3.2 µg/L, had a significant detrimental effect on hatching success and caused scoliosis in progeny. The lowest concentration tested on brook trout, 0.8 μg/L, had a significant detrimental effect on progeny growth. These values were not used because no NOEC value was determined. One fathead minnow test was terminated at 91-d because the concentrations were too high. Acute tests were also conducted with fathead minnow, bluegill, brook trout, and flagfish (Appendix B).

Bresch (1991), Bresch (pers.comm.) - In 1991, 28-d and 42-d flow-through toxicity tests were performed by the Institute for Hygiene and Toxicology, Germany on analytical grade diazinon (percent active ingredient not given) with adult zebrafish *Brachydanio rerio* and fingerling rainbow trout *Oncorhynchus mykiss*. EPA (1982), ASTM (1988b), and OECD (1983) test standards were used. Three concentrations of diazinon were tested in replicate and a water control was used. Concentrations were measured weekly and measured concentrations averaged 20% of nominal concentrations. Water quality parameters during the tests were: temperatures of 24-26EC (zebrafish) and 15-17EC (rainbow trout); pH of 7.4; dissolved oxygen of >60% saturation (zebrafish); >70% saturation (rainbow trout); and hardness of 360 mg/L. Control survival was 86.5% (zebrafish); 100% (rainbow trout). The zebrafish NOEC and LOEC values, based on growth (length) reduction, were 750 μg/L and 1,500 μg/L, respectively. No rainbow trout died during the test, however abnormal fish were present in all groups. The zebrafish test was not accepted because the test did not have a sufficient number of concentrations. The rainbow trout test was not accepted because it did not have a sufficient number of concentrations, no pertinent values were obtained, and an insufficient number of trout were tested.

Goodman et al. (1979) - In 1979, a 108-d flow-through toxicity test was performed by the EPA Environmental Research Laboratory in Gulf Breeze, Florida on diazinon (92.6%) using juvenile sheepshead minnow *Cyprinodon variegatus*. No commonly recognized testing standards were mentioned. Five concentrations and a solvent control were tested. Measured concentrations were 65-78% of nominal concentrations. Water quality parameters during the test were: temperature of 30 $\pm 2^{o}$C; pH not given; salinity averaged 16.5$^{o}/_{oo}$; test solutions were aerated; water hardness not given. Control survival was not given. Fecundity decreased at the lowest concentration tested (0.47 µg/L) and darkened flesh appeared at concentrations between 3.5 µg/L and 6.5 µg/L. These values were not used because no NOEC value was determined.

Morgan 1976 - In 1975, a 113-d static toxicity test was performed by the University of Guelph on diazinon (50 %) with midges *Chironomus tentans*. No test standards were mentioned. Six replicates were tested. Concentrations were measured. The temperature ranged from 22 to 25^{o}C. Other water quality parameters were not measured. Control survival was not given. The effects were not given. This test was not accepted because the pesticide formulation was too low in active ingredient; essential information, such as control survival and mortality range, was not given, and effects were not determined.

Vial (1990) - In 1990, 22-d static renewal toxicity tests were performed by Ciba-Geigy in Basel, Switzerland on technical diazinon with <24-h old cladoceran *Daphnia magna*. OECD test standards were used. Six concentrations were tested with ten replicates and a water control. Concentrations were measured weekly during the test and measured concentrations ranged from 75 to 4215% of nominal concentrations. Water quality parameters during the test were: temperature of 20 $\pm 1^{o}$ C; pH ranged from 7.8 to 9.3; dissolved oxygen ranged from 96 to 130% saturation; and hardness of 240 mg/L $CaCO_3$. Control survival was 100%. The EC_{50} value for cladoceran *Daphnia magna*, based on immobilization, was >2.6 µg/L. The LOEC value, based on number of young produced, was 0.0026 µg/L. The NOEC value was reported as <0.0026 µg/L, and no MATC could be calculated. The chronic toxicity data produced by this study could not be used because no definite NOEC or MATC values were determined. The LOEC value was 100-fold lower than that obtained by Surprenant (1988c). In addition, the nominal and measured concentrations differed too much to be accepted for a chronic study. However, the acute toxicity data were accepted (see Appendix B).

Table C-1. Values (µg/L) from accepted tests on the chronic toxicity of diazinon to aquatic animals.

Species	Life Stage	Method[a]	Formulation	Salinity/ Hardness	Test Length	Effect	Values	MATC $(NOECXLOEC)^{1/2}$	Reference
Cladoceran *Daphnia magna*	≤24-h	F,M	Technical (87.7%)	160-180 mg/L as $CaCO_3$	21-d	NOEC LOEC	0.17 0.32	0.23	Surprenant 1988c
Fathead minnow *Pimephales promelas*	embryo-larvae	F,M	Technical (87.7%)	27-34 mg/L as $CaCO_3$	34-d	NOEC LOEC	92 170	125	Surprenant 1988d
Mysid *Mysidopsis bahia*	≤48-h	S,M	Technical (N/A)[b]	N/A	28-d	NOEC LOEC	1.15 3.27	1.94	Nimmo et al. 1980

[a] S = Static F = Flow through M = Measured concentrations U = Unmeasured concentrations

[b] N/A = Not available

[c] 1 = Values estimated or no pertinent values determined
2 = Inadequate number of concentrations tested
3 = Insufficient number of organisms tested per concentration, or number not given

Table C-2. Values (µg/L) from unaccepted tests on the chronic toxicity of diazinon to aquatic animals.

Species	Life Stage	Method[a]	Formulation[b]	Salinity/ Hardness[b]	Test Length	Effect	Values	Reference	Deficiencies
Brook trout *Salvelinus fontinalis*	adult	F,M	Technical (92.5%)	44-45 mg/L as $CaCO_3$	173-d	LOEC	0.8	Allison and Hermanutz 1977	1
Cladoceran *Daphnia magna*	<24-h	F,M	Technical (96%)	240 mg/L as $CaCO_3$	22-d	LOEC NOEC	0.0026 <0.0026	Vial 1990	1
Fathead minnow *Pimpehales promelas*	adult	F,M	Technical (92.5%)	44-45 mg/L as $CaCO_3$	274-d	LOEC	3.2	Allison and Hermanutz 1977	1
Midge *Chironomus tentans*	larvae	S,M	Formulation (50%)	N/A	113-d	N/A		Morgan, 1976	1,2
Rainbow trout *Oncorhynchus mykiss*	fngling	F,M	Analytical (N/A)	360 mg/L as $CaCO_3$	42-d	NOEC LOEC	N/A	Bresh 1991	1,2,3
Sheepshead minnow *Cyprinodon variegatus*	juv.	F,M	Technical (92.6%)	$16.5^{o}/_{oo}$	108-d	LOEC	0.47	Goodman et. al 1979	1
Zebrafish *Brachydanio rerio*	adult	F,M (N/A)	Analytical (N/A)	360 mg/L as $CaCO_3$	28-d	NOEC LOEC	750 1,500	Bresch 1991	2

[a] S = Static F = Flow through M = Measured concentrations U = Unmeasured concentrations

[b] N/A = Not available

[c] 1 = Values estimated or no pertinent values determined
2 = Inadequate number of concentrations tested
3 = Insufficient number of organisms tested per concentration, or number not given

APPENDIX D. Abstracts of aquatic plant toxicity tests reviewed for hazard assessment.

Clegg and Koevenig (1974) - In 1974, 3-d static toxicity tests were performed by the University of Kansas on diazinon (formulation not given) with fresh water algae *Chlorella ellipsoidea*, *Chlamydomonas sp*., and *Euglena elastica*. No test standards were mentioned. One concentration (100 mg/L) was tested with no replicates and a control was used. Concentrations were not measured during the tests. Water temperature ranged from 23 to 25EC; no other water quality parameters were given. Growth of green algae was not affected, however ATP levels were significantly reduced. Effects on controls were not mentioned.

Doggett and Rhodes (1991) - In 1991, 9-d static toxicity tests were performed by Southwest Missouri State University on diazinon (47.5%) with phytoplankton *Chlorella pyrenoidosa* (normal and high temperature strains), *Selenastrum capricornutum*, and *Synechococcus leopolienis*. No commonly recognized test standards were mentioned. Five concentrations were tested in triplicate and three controls were used. Concentrations were not measured but nominal concentrations were given. Test water pH was 7.1; no other water quality parameters were given. *C. pyrenoidosa* (normal temperature strain) growth was stimulated at 1,000 µg/L and was inhibited at 40,000 µg/L. *C. pyrenoidosa* (high temperature strain) was inhibited at 1,000 µg/L and was not stimulated. *S. capricornutum* growth was stimulated at 1,000 µg/L and inhibited at 10,000 µg/L. *S. leopolienis* growth was inhibited at 1,000 µg/L and simulated between 1,000 µg/L and 20,000 µg/L. Effects on controls were not given. No pertinent values were determined.

Murray and Guthrie (1980) - In 1980, 14-d flow-through toxicity tests were performed by University of Texas on diazinon (percent active ingredient not given) using bacteria and the phytoplankton crysophyta, chlorophyta (green algae), and chrysophyta (gold algae). Scientific names were not given. APHA (1975) test standards were used. One concentration was tested with three replicates. Controls were used, but effects on controls were not given. Concentrations were not measured. Test water temperature was 21 ±2EC; no other water quality parameters were given. At 5,000 µg/L, chrysophyta and chlorophyta exhibited a population increase, but cyanophyta exhibited a population decrease. Bacteria response was inconsistent at 5,000 µg/L.

Stadnyk and Campbell (1971) - In 1971, a 10-d static toxicity test was performed by University of Missouri on diazinon (percent active ingredient not given) with green algae *Scenedesmus quadricaudata*. No commonly recognized test standards were mentioned. Two concentrations of diazinon (100 and 1000 µg/L) were tested with four replicates each, and a solvent control was used. Concentrations were measured at two day intervals but only nominal concentration were given. Test water temperature was 21 ±1EC; no other water quality parameters were given. Effect on controls was not given. No effects were observed on cell growth, photosynthesis or biomass.

Wong and Chang (1988) - In 1988, 8-d toxicity tests were performed by Chinese University of Hong Kong on technical grade diazinon (60%) using green algae *Chlamydomonas reinhardtii*. No commonly recognized test standards were used. Five concentrations were tested in replicate and a control was used. Concentrations were not measured. Water quality parameters during the test were: temperature of 25 ±2EC; pH of 6.8. All concentrations of diazinon tested were found to inhibit chlorophyll *a* synthesis and growth rate. At low levels diazinon stimulated photosynthesis; at higher levels it inhibited photosynthesis. Pertinent values and effect on controls were not given.

Table D-1. Values (µg/L) from tests on the toxicity of diazinon to aquatic plants.

Species[a]	Formulation[a]	Test Length	Effect	Concentration (µg/L)	Reference
Bacteria N/A	N/A	14-d	Inconsistent	5,000	Murray and Guthrie 1980
Chlorophyta N/A	N/A	14-d	Population stimulated	5,000	Murray and Guthrie 1980
Chrysophyta N/A	N/A	14-d	Population stimulated	5,000	Murray and Guthrie 1980
Cyanophyta N/A	N/A	14-d	Population inhibited	5,000	Murray and Guthrie 1980
Freshwater alga *Chlorella ellipsoidea*	N/A	3-d	ATP levels inhibited	100,000	Clegg and Koevenig 1974
Freshwater alga *Chlamydomonas* sp.	N/A	3-d	ATP levels inhibited	100,000	Clegg and Koevenig 1974
Freshwater alga *Euglena elastica*	N/A	3-d	ATP levels inhibited	100,000	Clegg and Koevenig 1974
Green alga *Scenedeomus quadricaudata*	N/A	10-d	No effect on photosynthesis biomass growth	100-1,000	Stadnyk and Campbell 1971
Green alga *Chlamydomonas reinhardtii*	60%	8-d	Photosynthesis stimulated Photosynthesis inhibited Growth inhibited Chlorophyll *a* inhibited	1,000 10,000 1,000 1,000	Wong and Chang 1988

Green alga *Chlorella pyrenoidosa* (normal strain)	47.5%	9-d	Growth stimulated	1,000	Doggett and Rhodes 1991
			Growth inhibited	40,000	

Table D-1. Continued. -2-

Species[a]	Formulation	Test Length	Effect	Concentration (µg/L)	Reference
Green alga *Chlorella pyrenoidosa* (high temp. strain)	47.5%	9-d	Growth inhibited	1,000	Doggett and Rhodes 1991
Phytoplankton *Selenastrum capricornutum*	47.5%	9-d	Growth stimulated	1,000	Doggett and Rhodes 1991
			Growth inhibited	10,000	
Phytoplankton *Synechococcus leopolienis*	47.5%	9-d	Growth stimulated	1,000-20,000	Doggett and Rhodes 1991
			Growth inhibited	1,000	

[a] N/A = Not available