Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
TX-97/1933-3F, Volume 3		

4. Title and Subtitle	5. Report Date
FINAL ENVIRONMENTAL IMPACT STATEMENT: ROADSIDE PEST MANAGEMENT PROGRAM, VOLUME 3	August 1996
	6. Performing Organization Code
7. Author(s) Danise S. Hauser and Wayne G. McCully	8. Performing Organization Report No. Research Report 1933-3F, Volume 3
9. Performing Organization Name and Address Texas Transportation Institute The Texas A&M University System College Station, Texas 77843-3135	10. Work Unit No. (TRAIS) 11. Contract or Grant No. Study No. 7-1933
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Transfer Office P. O. Box 5080 Austin, Texas 78763-5080	13. Type of Report and Period Covered Final: April 1991- August 1996 14. Sponsoring Agency Code

15. Supplementary Notes
Research performed in cooperation with Texas Department of Transportation.
Research Study Title: Environmental Concerns in Maintenance: A Proactive Initiative

16. Abstract
The environmental risks associated with the use of seven herbicides and three insecticides comprising a portion of the Texas Department of Transportation's roadside pest management program were assessed. The materials were classified as EPA Category 3 or 4, signifying minimal toxicity. Although the chemicals used may pose a threat to environmental components in some situations, the manner in which they are used combined with the small roadside area treated mitigates the effects and treatment such that the risk is insignificant. This document contains recommendations including guidelines and mitigation measures for mechanical, chemical, cultural, and biological methods for TxDOT's use in developing an integrated pest management program.

17. Key Words	18. Distribution Statement
Roadside Pest Management, Roadside Vegetation, Roadside Maintenance, Risk Assessment, Integrated Pest Management	No restrictions. This document is available to the public through NTIS: National Technical Information Service 5285 Port Royal Road Springfield, Virginia 22161

19. Security Classif.(of this report)	20. Security Classif.(of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	604	

Form DOT F 1700.7 (8-72)

FINAL
ENVIRONMENTAL IMPACT STATEMENT:
ROADSIDE PEST MANAGEMENT PROGRAM,
VOLUME 3

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Research Report 1933-3F, Volume 3
Research Study Number 7-1933
Research Study Title: Environmental Concerns in Maintenance: A Proactive Initiative

Sponsored by the
Texas Department of Transportation

August 1996

TEXAS TRANSPORTATION INSTITUTE
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IMPLEMENTATION STATEMENT

This report is an assessment of the Roadside Pest Management Program for the Texas Department of Transportation (TxDOT) and its impacts on the environment in the vicinity of the highway corridor. The findings are used to evaluate five program alternatives formulated for the purpose of this study. The results from this study are expected to enhance TxDOT policies and procedures for systematically incorporating environmental concerns into the planning and operational phases of roadside maintenance.

DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the Texas Department of Transportation (TxDOT). This report does not constitute a standard, specification, or regulation, nor is it intended for construction, bidding, or permit purposes.

ACKNOWLEDGMENTS

This report and the attendant public hearings continue the scoping effort toward the development of a final Environmental Impact Statement concerning the Roadside Pest Management Program for the Texas Department of Transportation. The authors gratefully acknowledge the interest shown by and participation of individuals, citizens' groups, and government agencies who offered their appraisal of the impacts of roadside pest management on the environment. The input received to date has been invaluable in establishing research study parameters.

The Design Division of TxDOT furnished a list of individuals, groups, and agencies concerned with the impacts of highways on the environment.

The authors gratefully acknowledge the assistance and support provided by Natilie Johnson, Robert E. Meyer, Ernest S. Motteram, and Jason Grier of the Texas Transportation Institute in the preparation of this report.

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List of Abbreviations

BMP - best management practice
Caltrans - California Department of Transportation
DEIS - draft environmental impact statement
EIS - environmental impact statement
EPA - Environmental Protection Agency
FEIS - final environmental impact statement
IMS - TxDOT's Insect Management System
IVM - integrated vegetation management
IPM - integrated pest management
MTO - mower-thrown object
MOU - memorandum of understanding
MSA - metropolition statistical area
NPDES - National Pollutant Discharge Elimination System
PMP - TxDOT's pest management program
RMP - Roadside Management Plan
ROW - right-of-way
TDA - Texas Department of Agriculture
TPWD - Texas Parks and Wildlife Department
TWC - Texas Water Commission
TNRCC - Texas Natural Resource Conservation Commission
TTI - Texas Transportation Institute
TxDOT - Texas Department of Transportation
USFS - United States Forest Service
USFWS - United States Fish and Wildlife Service
VMS - TxDOT's Vegetation Management System
WSDOT - Washington State Department of Transportation

Appendix B - Chapter 1

Appendix B - Chapter One — Fate, Transport, and Metabolism of Herbicides and Insecticides

1.0 Introduction

1.1 Objectives

This chapter is presented as a technical review of the environmental fate of the herbicide active ingredients. This review is necessary in order to understand how each of these compounds behaves once introduced into the environment. These data could help assess regional differences in environmental fate as they relate to soil types, precipitation, and use patterns.

1.2 Techniques

The data on the active ingredients was collected from the manufacturers, from other previously published EISs, and from technical journals.

1.3 Data Sets

Most of the herbicide information was taken from the Washington DOT report (1993). Some information on clopyralid and hexazinone was taken from the Herbicide Handbook of the Weed Science Society of America (Anonymous, 1989). Much information on hexazinone and triclopyr was taken from a review by Bovey (1993). Insecticide information was taken largely from the Farm Chemicals Handbook (1994).

There is a considerable volume of information for the active ingredients of pesticide formulations because the United States Environmental Protection Agency (US EPA) requires tests on the technical grade product for registration of the end use products. This information is generated by the manufacturer and by independent scientists conducting research.

2.0 Herbicides

2.1 Clopyralid

2.1.1 Environmental Fate

2.1.1.1
Soil - Clopyralid degrades at a medium to fast rate with an average halflife of 12 to 70 days in a wide range of soils. Bioassays following applications up to 0.5 lb/A show no residual injury to susceptible crops the next year. It is degraded by microbes.

2.1.1.2
Water - No data were available for the degradation of clopyralid in water.

2.1.2 Transport

Soil - Clopyralid is subject to leaching in basic soils because it occurs primarily as a salt.

2.1.3 Metabolism

2.1.3.1
Mode of Action - Clopyralid is a selective, auxin type herbicide which controls many broadleaf annual and perennial herbaceous and woody species. It is most effective against members of the Composite (Asteraceae), Leguminosae (Fabaceae), and Polygonaceae facilities. It is readily absorbed by both the foliage and roots and is translocated both upward and downward in plants. The exact mode of action is not known, but appears to be similar to that of phenoxy herbicides.

2.1.3.2
Plant Metabolism - Clopyralid remains unchanged in plants.

2.1.3.3
Animal Metabolism - Clopyralid has a low order of toxicity to birds, fish, and mammals. A single prolonged exposure is not likely to result in material being absorbed through the skin in harmful amounts.

2.1.4 Potential Regional Impacts

The persistence and mobility would be expected to influence the soil half-life in the drier areas of Texas.

2.1.5. Formulation

The monoethanolamine salt formulation of clopyralid, Transline®, is under test for controlling mesquite and certain other noxious plants.

2.2 Glyphosate

2.2.1 Environmental Fate

2.2.1.1
Soil - Glyphosate typically has a half-life of less than 60 days (Wilkerson and Kim, 1986). However, it is relatively persistent in sandy loam soils (USDI, 1989). Microbial degradation is the major decomposition path. The primary metabolite is aminomethylphosphonic acid, and three other phosphoric acids usually are produced. Further microbial activity breaks down the phosphoric acids to carbon dioxide (Menzie, 1980).

2.2.1.2
Water - Aquatic half-lives have been reported ranging from seven weeks in aquatic sediment to ten weeks in pond water. If glyphosate comes into contact with sediment in the water, it could be degraded rapidly; otherwise, no significant chemical degradation or hydrolysis occurs.

2.2.2 Transport

2.2.2.1
Soil - Leaching and Mobility - Glyphosate has very little potential for mobility. It is rapidly and strongly adsorbed to soil, especially to clay particles at lower pH values. Glyphosate is considered to have a low potential to move through the soil column (Jones and Stokes, 1991).

2.2.3 Metabolism

2.2.2.2
Mode of Action - Glyphosate is a wide spectrum, systemic herbicide that is absorbed by the foliage and rapidly translocated throughout the plant. It inhibits various enzyme systems, interfering with amino acid and other biosynthesis reactions (Merck Index, 1989).

2.2.2.3.
Plant Metabolism - Glyphosate is not metabolized by plants (Menzie, 1980).

2.2.2.4
Animal Metabolism - Glyphosate is poorly absorbed across the gastro-intestinal tract.

That which is absorbed is largely eliminated in feces and some in urine (Monsanto, 1990(c)).

2.2.4 Potential Regional Impacts

The data available do not indicate that there should be any specific regional concerns for the compound.

2.2.5 Formulations

Roundup® is an isopropyl amine salt formulation of glyphosate used for controlling broadleaf and grassy weeds *not* growing in water.

Rodeo® is an isopropal amine salt formulation of glyphosate labeled for aquatic application.

2.3 Hexazinone

2.3.1 Environmental Fate

2.3.1.1
Soil - Bovey (1993) has reviewed the fate of hexazinone in soil, water, and plants.

Hexazinone has a halflife of one to six months in silt loam soil under field conditions, but the halflife was four to five months in greenhouse tests on both silt loam and sandy loam soils. Hexazinone readily moves downslope in runoff water and leaches into soil where it may injure nontarget vegetation away from the point of application (Allender, 1991; Bouchard et al., 1985; Feng, 1987; Feng et al., 1989; Lavy et al., 1989; and Zandvoort, 1989). However, Prasad and Feng (1990) found that after one year, hexazinone residues were reduced to 1% at the treated spot, and they did not move laterally beyond 0.5 m on a sandy loam in Canada.

Hexazinone is microbially degraded by breaking of the triazine ring with liberation of CO_2. On thin soil surfaces, 60% of the herbicide applied was degraded during a six-week exposure to UV light. Volatile losses may be negligible.

2.3.1.2

Water - Hexazinone is highly water soluble (33,000 ppm) (Thomson, 1989). It degrades about 20% in eight weeks in distilled water under "artificial sunlight." The rate increases about three times faster when small amounts of inorganic salts are present and about seven times faster when a photoinhibitor is present. The compound is stable in the dark with less than 1% degradation occurring for at least five weeks at pH levels of 5, 7, and 9 and at temperatures of 15, 25, and 37 C. Lavy et al. (1989) found relatively small amounts of hexazinone in runoff water from a spot-gun application to a forest floor in Arkansas; apparently, the forest litter was highly effective in absorbing surface applications of hexazinone. Bouchard et al. (1985) found the maximum concentration of hexazinone was 14 ppm in a stream that drained a 11.5-ha watershed treated with 2 kg/ha. The amount of hexazinone transported from the watershed in stream discharge was only 2 to 3% of the amount initially applied. Neary et al. (1986) found only 0.53% loss of hexazinone in streamflow of the applied herbicide in Georgia. Residues in streamflow peaked at 442 ppb in the first storm but declined rapidly and disappeared within seven months. Leitch and Flinn (1983) aerially applied hexazinone at 2 kg/ha to a 46.4-ha catchment; subsequently, only 6 of 69 samples contained hexazinone.

2.3.2 Transport

2.3.2.1

Soil - No data were found regarding the transport of hexazinone in soil.

2.3.3 Metabolism

2.3.3.1

Mode of Action - Hexazinone controls most annual, biennial, and perennial herbaceous and woody plants. However, some herbaceous and woody crop species show resistance to the herbicide. Hexazinone mode of action is not clear but appears to be a photosynthetic inhibitor.

2.3.3.2

Plant Metabolism - Hexazinone is readily absorbed both through foliage and roots. It usually exhibits a high degree of contact activity which can be enhanced by addition of a nonionic surfactant. Hexazinone is primarily transported upward through the xylem. No information was found on the fate of hexazinone in plants.

2.3.3.3

Animal Metabolism - It has a low order of toxicity to birds, fish, and mammals. Hexazinone showed no evidence of cumulative toxicity to male rats at a repeated dose of 300 mg/kg per day to a total of ten doses within a two-week period. However, it may irritate eyes, nose, throat, and skin.

2.3.4 Potential Regional Impacts

Hexazinone is a persistent, but mobile, herbicide that readily moves down slopes after abundant rain and may cause injury or death to many nontarget herbaceous and woody species.

2.3.5 Formulation

Velpar® L is a water dispersible liquid form of hexazinone which has been used for pavement edge treatment during the dormant season. As soon as existing warehouse stocks have been exhausted, use of this material will be discontinued.

2.4 Imazapyr

2.4.1 Environmental Fate

2.4.1.1

Soil - Imazapyr has a half-life of 27 days in sandy loam soils (USFS, 1989). High temperatures and high soil moisture may increase this degradation rate (Little, 1991). The main route of degradation in moist soils is by photodegradation. However, imazapyr is stable in light with the absence of water and, thus, degrades very slowly in dry soils. Microbes play a minor role in soil metabolism of imazapyr (Little, 1991).

2.4.1.2

Water - Imazapyr will degrade very rapidly if exposed to light in an aqueous solution but is very stable in dark conditions (Little, 1991).

2.4.2 Transport

2.4.2.1

Soil - Leaching and Mobility - The adsorption coefficients for imazapyr were 0, 0.07, 0.17, and 0.19 for clay, clay loam, loamy sand, and sandy clay loam, respectively. As a result, imazapyr is considered to be fairly mobile (Little, 1991). Although it has relatively low adsorption coefficients, imazapyr is not considered to be a potential contaminant of groundwater because of its rapid degradation following irrigation or rain.

2.4.3 Metabolism

2.4.3.1

Mode of Action - Imazapyr is a broad-spectrum systemic herbicide that is absorbed by roots and foliage and is rapidly translocated to the meristematic regions where it accumulates. It then interferes with cell growth by inhibiting the synthesis of the amino acids isoleucine, leucine, and valine (Willis, 1991; Little, 1991).

2.4.3.2
Plant Metabolism - Very few plant species metabolize imazapyr. Most of the absorbed imazapyr is excreted through the roots as the unmetabolized acid. The plant half-life is approximately 12 to 40 days (Little, 1991).

2.4.3.3
Animal Metabolism - Approximately 87% of the imazapyr, when dosed to rats, is excreted in the urine and feces within 24 hours as the unmetabolized acid (American Cyanamid, 1986).

2.4.4 Potential Regional Impacts - The persistence, mobility, and relatively slow degradation rate of imazapyr in dry soils would be expected to influence soil half-life in the drier areas of Texas.

2.4.5 Formulation

Arsenal® is an isopropylamine salt of imazapyr being tested as a foliage spray to control undesirable grasses and weeds.

2.5 Metsulfuron Methyl

2.5.1 Environmental Fate

2.5.1.1
Soil - Metsulfuron methyl has a half-life of one week-three months, with an average of 30 days (Mike Link, October 1994). The most important degradation pathways in soil are chemical hydrolysis and microbial action; photolysis and volatilization are relatively minor processes. The rate of chemical hydrolytic degradation is influenced by soil temperature, pH, and levels of oxygen and moisture; degradation is faster at lower pH. The resulting compounds are considered non-toxic and non-herbicidal (Weed Science Society of America, 1989).

2.5.1.2
Water - No data were found for aquatic half-lives nor for degradation of metsulfuron methyl in aquatic environments.

2.5.2 Transport

2.5.2.1
Soil - Leaching and Mobility - Metsulfuron methyl is poorly adsorbed on neutral sandy loam and slightly alkaline loam soils with adsorption coefficients (K_d) of 0.05 and 0.15,

respectively. It is weakly adsorbed on slightly alkaline sandy clay loam and clay loam soils with K_d values of 0.3 and 0.6, respectively. It also is weakly adsorbed on acidic clay loam and sandy loam soils with K_d values of 0.3 and 4.9, respectively (Yang, 1987). Given the above information and its slow degradation rate, metsulfuron methyl does have the potential to move through the soil column.

2.5.3 Metabolism

2.5.3.1
Mode of Action - Metsulfuron methyl is a systemic, pre- or post-emergence herbicide that is absorbed by the roots and foliage. It is translocated to the meristematic regions where it inhibits cellular division (Hartley and Kidd, 1987).

2.5.3.2
Plant Metabolism - A study performed in cereal grain crops indicated that metsulfuron methyl was hydrolyzed rapidly to non-toxic metabolites. The specific metabolites were not identified (Hartley and Kidd, 1987).

2.5.3.3
Animal Metabolism - Metsulfuron methyl is rapidly eliminated once ingested by animals. One study indicated that 91% of the compound was eliminated within 96 hours of ingestion (USEPA, 1986).

2.5.4 Potential Regional Impacts

Since metsulfuron methyl is either poorly or weakly adsorbed to soils of varying organic content and has a fairly long half-life in soil, this compound has the potential to move downward readily through the soil column.

2.5.5 Formulation

Escort® is a 60% formulation of dry flowable metsulfuron methyl used to control field bindweed, African rue, and huisache.

2.6 Sulfometuron Methyl

2.6.1 Environmental Fate

2.6.1.1
Soil - The soil half-life of sulfometuron methyl ranges from 10 days in sandy loam soil (USFS, 1989) to 34 days in other soils (Ryan and Atkins, 1986). It is primarily degraded by hydrolysis and microbial action (Anderson and Dulka, 1985). In addition to carbon dioxide and saccharin, at least three other major aromatic sulfonyl breakdown

products have been identified (Harvey et al., 1985).

2.6.1.2
Water - There were no data available for aquatic half-lives and metabolism of sulfometuron methyl in aquatic environments. Photolysis, however, has been determined to play a minor role in the degradation of this product in water (Ryan and Atkins, 1986). In addition, hydrolysis does occur at pH 5 converting sulfometuron methyl to methyl-2-(aminosulfonyl)-benzoate and saccharin (Harvey et al., 1985).

2.6.2 Transport

Soil - Leaching and Mobility - Very few data were available which described the leaching or mobility of sulfometuron methyl. Sulfometuron methyl is included among those chemicals that are unlikely to move through the soil column (Jones and Stokes, 1991).

2.6.3 Metabolism

2.6.3.1
Mode of Action - Sulfometuron methyl is a broad-spectrum, systemic herbicide that is absorbed by the roots and foliage and translocated throughout the plant. It inhibits mitotic cell division in the growing tips of roots and plants (Hartley and Kidd, 1987).

2.6.3.2
Plant Metabolism - There were no data available on the metabolism of sulfometuron methyl by plants.

2.6.3.3
Animal Metabolism - No data were available.

2.6.4 Potential Regional Impacts - There should be no impacts of regional concern.

2.6.5 Formulation

Oust® is a 75% formulation of dispersible granules tank-mixed with Roundup® to control a wider range of plants and prolong the treatment life.

2.7 Triclopyr

2.7.1 Environmental Fate

2.7.1.1

Soil - The average soil half-life is approximately 30 days. This varies considerably with differences in soil moisture and temperature. Triclopyr may undergo rapid microbial breakdown in the soil (Dow Elanco, Undated(d)). Triclopyr persistence in soil has been reviewed by Bovey (1993). Moseman and Merkle (1977) determined that triclopyr, when applied in the fall, persisted about six months in a Miller clay soil but dissipated within three months after summer application. Schubert et al. (1980) reported that triclopyr residues in soil decreased from a maximum of 18 to 0.1 ppm in 166 days in a West Virginia watershed. At two sites in Oregon, Norris et al. (1987) found that triclopyr and its metabolites persisted for one year or more in small quantities, probably because of dry weather. Triclopyr residues were confined to the top 30 cm of soil. Newton et al. (1990) found that the residues decreased rapidly after application, leveled off 79 days after treatment, and then began a period of slow loss that continued until the following summer. Triclopyr dissipates from soil by leaching, photodegradation, and microbial breakdown (Anonymous, 1989).

2.7.1.2

Water - There was very little information collected concerning the half-lives and metabolism of triclopyr in aquatic environments. However, the rapid photodegradation of triclopyr along with the relatively rapid hydrolysis of triclopyr in aqueous solutions indicate a relatively short half-life in water (Dow Elanco, Undated(d)).
In surface runoff, Schubert et al. (1980) applied triclopyr at 11.2 kg/ha to a West Virginia watershed in May. They found only small quantities of triclopyr residues downslope in soil and water. The maximum concentration in stream water was 95 ppb the first 20 hours after application. In September, after the first significant rains, maximum triclopyr residues of 12 ppb were present in a small pond. No triclopyr was detected after November.

In a groundwater study, Bush et al. (1988) applied the ester and amine formulations of triclopyr to Florida Coastal Plain flatwood watersheds in October. Triclopyr residues of 1 to 2 ppb were detected during the first storm runoff event after application. However, no triclopyr residues were detected either in subsequent runoff events or in groundwater wells for six months after application.

Green et al. (1989) indicated that the triethylamine salt of triclopyr concentration in a lake varied from 3 to 21 days after spraying with the residue half-life being less than 4 days. Residue accumulation in sediment, plants, and fish was negligible.

2.7.2 Transport

2.7.2.1
Soil - Leaching and Mobility - The triclopyr acid has a very low leaching potential (Dow Elanco, Undated(d)). Triclopyr is listed (Jones and Stokes, 1991) as one of those chemicals that is unlikely to move through the soil column.

2.7.3 Metabolism

2.7.3.1
Mode of Action - Triclopyr is a selective, systemic herbicide that is absorbed by the foliage and roots and translocated throughout the plant. Residues eventually were concentrated in the meristematic tissue. Triclopyr kills plants by inducing an auxin-like response (Dow Elanco, Undated(d)).

2.7.3.2
Plant Metabolism - No data were found for the metabolism of triclopyr by plants.

2.7.3.3
Animal Metabolism - Triclopyr is rapidly excreted through the urine as unchanged triclopyr (Dow/Elanco, Undated(d)).

2.7.4 Potential Regional Impacts

There should be no impacts of regional concern.

2.7.5 Triclopyr

Originally, Garlon 4®, a oxyethyl ester formulation of triclopyr, was diluted in diesel for testing as a trunk base spray for controlling mesquite. Lately, DowElanco has reformulated triclopyr as the same formulation in Pathfinder II® to be applied directly from the container using a vegetable oil as a diluent. This procedure eliminates mixing of the spray solution and provides a less hazardous material for use.

3.0. Insecticides

3.1 Diazinon

Chemical and physical aspects of diazinon have been summarized and reviewed in a Ciba Technical Bulletin and by Gallo and Lawryk (1991), Meister (1994), and Montgomery (1993).

3.1.1 Environmental Fate

3.1.1.1

Soil - Montgomery (1993) cited studies where diazinon half-life in soil was about 32 days and in a sterile soil at pH 4.7 at 43.8 days. In another study, half-life in soil following incubation in sterile sand loam, sterile organic soil, nonsterile sandy loam, and nonsterile organic soil was 12.5, 6.5, >1, and 2 weeks, respectively. Getzin (1967) studied four different soil types and found that half of the original diazinon was lost in 2 to 4 weeks, and less than 8% remained after 20 weeks.

Getzin (1967) also studied the persistence of diazinon in autoclaved and non-autoclaved silt loam at three temperatures, four moisture levels, and four pH levels. Diazinon half-life was about six weeks in autoclaved soil and five weeks in non-autoclaved soil. Diazinon degraded faster with increasing temperature, moisture, and acidity levels in both autoclaved and non-autoclaved soils.

Knutson et al. (1971) studied the long range residue potential of diazinon when used in a normal soil and foliar insect control program for irrigated corn. During a 4-year study, no detectable diazinon residues were found after repeated applications when the silty clay loam soil was sampled 1.5 to 2.5 months after annual soil treatments.

Various hydrolysis products from diazinon have been reported. They include: 2-isopropyl-6-methyl-4-hydroxypyrimidine (Ciba Bulletin) and 2-isopropyl-4-methyl-2-hydroxypyrimidine, diethylphosphorothioic acid, carbon dioxide, and tetraethylpyrophosphate (Montgomery, 1993).

3.1.1.2

Water - Diazinon is stable in alkaline formulations but is hydrolyzed slowly by water and dilute acids. The solubility of diazinon in water at 20°C is 40 ppm, and it readily dissolves in aliphatic and aromatic solvents, alcohols, and ketones.

In a review, Montgomery (1993) cited information that the half-life of diazinon is about two to three weeks in a neutral solution at room temperature. In a 1% ethanol/buffered water solution at 25°C, diazinon half-life was 14, 54.6, 70, and 54 days at pH of 5.0, 6.0, 7.0, and 8.0, respectively. Diazinon is hydrolyzed in water to 2-isopropyl-4-methyl-6-hydroxypyrimidine and diethyl thiophosphoric acid or diethyl phosphoric in the pH range of 3.1 to 10.4.

Knutson et al. (1971) studied the long range residue potential of diazinon when used in a normal soil and foliar insect control program for irrigated corn. They found that water samples from capped wells and surface water in an irrigation district contained no residues at the 0.1 ppb level, indicating no vertical or lateral contamination of ground or surface water from repeated applications of diazinon.

In a national monitoring network of water in major US rivers in 1975-1980, Gilliom et al. (1985) reported that diazinon was detected in 1.2% of 2859 samples.

3.1.1.3
Air - Wright et al. (1981) sprayed diazinon in cracks of a vacant dormitory building for cockroach control. They found airborne diazinon concentrations of about 1.6 ug/m^3 on the day of application and 0.4 ug/m^3 by the third day after application.

3.1.2 Transport

3.1.2.1
Soil - Diazinon does not seem to move much in soil.

3.1.3 Metabolism

3.1.3.1
Mode of Action -Diazinon is an insecticide and nematocide labeled for use on more than 75 food crops and 50 ornamental plants. It controls a wide spectrum of insects in soil and on fruit, vegetables, tobacco, forage, field crops, range, pasture, grasslands, and ornamentals; for cockroaches and other household insects; in soil for grubs; for nematodes in turf; for seed treatment; and for fly control. It is an organophosphate cholinesterase-inhibiting insecticide that has a low to moderate toxicity. However, excessive doses may cause headaches, dizziness, blurred vision, weakening, nausea, cramps, diarrhea, discomfort in the chest, nervousness, sweating, miosis (pinpoint pupils), tearing, salivation, pulmonary edema, uncontrolled muscle twitches, convulsions, coma, loss of reflexes, and loss of sphincter control. In rats, it is not oncogenic, carcinogenic, or mutagenic. It did not affect reproduction capabilities in rats over two generations and was not teratogenic in rats or rabbits.

3.1.3.2
Plant Metabolism - The decrease of insecticidal activity of diazinon on plants appears to occur by two methods, namely, evaporation and hydrolysis of the ester. The resulting isopropyl-6-methyl-4-hydroxy-pyrimidine may be degraded to more polar metabolites. The formation of biologically active metabolites during the degradation process on plants is minimal, if present. The half-life of residues on plants is about one to two weeks. Eberle and Novak (1969) and Ralls et al. (1966) indicated that the only cholinesterase-inhibiting metabolite detectable at any time after diazinon application to plants was diazoxon at a maximum level of 0.004 to 0.007 ppm. At harvest, the fruits and vegetables tested all contained less than 0.002 ppm. Eberle and Novak (1969) concluded that the appearance and subsequent disappearance of traces of diazoxon give

evidence that diazinon is oxidized in plants to diazoxon which in turn is rapidly changed into non-cholinesterase inhibiting products because of its low hydrolytic stability.

3.1.3.3

Animal Metabolism - Mucke et al. (1970) found that a practically complete elimination of diazinon and its metabolites occurred rapidly. Half of the applied dose was excreted in 12 hours, and the radiolabeled material could not be detected in rats two days after application. Of the material excreted, 69 to 80% was recovered in the urine, and 18 to 25% was in the feces. Four metabolites were found in the urine, and three were identified in the feces. Neither diazinon nor its metabolites accumulated in the essential organs of the rat.

3.1.4 Potential Regional Impacts - Diazinon does not appear to have regional impacts under approved uses.

3.1.5 Formulation

Diazinon is purchased as Diazinon 4E® and is diluted in water for application.

3.2 Fenoxycarb

3.2.1 Environmental Fate

3.2.1.1

Soil - Fenoxycarb is subject to soil metabolism under aerobic conditions. Parent half-lives of about 50 to 100 days were calculated from soil metabolism studies using data from the first three to six months of the studies. Field dissipation studies show shorter half-lives, ranging from 5 to 18 days. Fenoxycarb is less subject to soil metabolism under anerobic conditions, with half-lives of 83 to 230 days. It is not subject to hydrolysis at pH levels of 3 to 9 that occur commonly in the environment. Fenoxycarb is photolytically stable on dry soil surfaces; however, it may be subject to aqueous photolysis.

3.2.1.2

Water - Fenoxycarb solubility in water at 25 C is about 5.66 ppm and is very soluble in most organic solvents, including acetone, diethylether, ethyl acetate, methanol, and toluene. The product is stable under normal conditions. No hydrolysis was observed in aqueous solution at pH levels of 3, 7, and 9 at 35 and 50 C.

3.2.2 Transport

3.2.2.1

Soil -Preliminary results from a laboratory adsorption/desorption study show that fenoxycarb is tightly bound to soil. Laboratory leaching studies indicate fenoxycarb is immobile, but its degradation products may be slightly mobile.

3.2.3 Metabolism

3.2.3.1

Mode of Action - Fenoxycarb is a growth regulator with action specific to insects; therefore, it has minimal influence on non-target organisms. It can be used as a bait to control fire ants in home lawns, commercial sod, nurseries, parks, and other turf and ornamental areas. It could be used around barns, outbuildings, fencerows, set aside acres, and other areas not used as cropland. Fenoxycarb cannot be used on areas grazed by cattle, sheep, or other domesticated animals, except on horse farms. The insecticide is slow acting. It may take 4 to 12 weeks before noticeable colony decline occurs, depending on the temperature. The compound controls a wide range of lepidoptera, psillids, and scale insects on cotton, fruits, and ornamentals. Non-bearing crops including apples, avocados, blueberries, carambola, citrus, guava, lychee, mangoes, mamey sapote, nectarines, peaches, pecans, plums, and West Indian cherry may be treated. However, the crops should be non-bearing for at least 1 year following application.

3.2.3.2

Plant Metabolism - Fenoxycarb is not translocated in the vascular system of plants, and its metabolism is not known.

3.2.3.3

Animal Metabolism - Fenoxycarb is a carbamate insecticide without cholinesterase inhibiting activity. It acts by contact and ingestion. It attacks stages in the life cycle when the insect normally would be changing form: egg to larva, larva to pupa, crawler to settled scale, or from one larval form to another as with lepidopterous leafminers. Fenoxycarb has been shown to be very selective in its effectiveness against various arthropods. Fenoxycarb apparently has no acute effect on foraging honeybees, but may temporarily reduce the colony if contaminated pollen is fed to the larvae. Certain predatory mites, internal hymenopterous parasites, and predatory bugs are not affected and subsequently build up and control undesirable insect species. Fenoxycarb demonstrates very low acute toxicity towards mammals and birds. It is not oncogenic or carcinogenic in rats and neither teratogenic nor mutagenic in rats or mice. At high dose levels, liver effects may occur in rats but not in mice. In rats, the acute oral LD50 is 16,800 mg/kg and inhalation LC50 is 480 mg/m^3. Dermal effect on rabbits is >2000 mg/kg.

3.2.4 Potential Regional Impacts - Fenoxycarb does not appear to have regional impacts at approved rates.

3.2.5 Formulation

Fenoxycarb is purchased as Logic® or Award®, a bait in granular form ready to apply.

3.3 Chlorpyrifos

3.3.1 Environmental Fate

3.3.1.1
Soil - The half-life and standard error of chlorpyrifos in ten soils at 25 C was 68 $\pm$ 13 days. Montgomery (1993) cited a study where the half-lives in Sultan silt loam at 5, 15, 25, 35, and 45 C were >20, >20, 8, 3, and 1 days, respectively. The major hydrolysis breakdown product is 3,5,6-trichloro-2- pyridinol. The compound is strongly sorbed to soils, especially those containing organic matter, so there is only slight volatilization from soil and strong resistance to leaching.

3.3.1.2
Water - Chorpyrifos should not be used in any type of irrigation system. Montgomery (1993) reviewed the fate of chlorpyrifos in water. The solubility of chlorpyrifos in water at 10, 20, and 30 C is 450, 730, and 1300 ug/L. In an estuary, the half-life of chlopyrifos was 24 days . DowElanco found chlorpyrifos hydrolyzes readily in water. The hydrolysis rate increased about three-fold for every 10 C rise in temperature. In a phosphate buffer at pH7, its half-lives at 15, 25, and 35 C were 100, 35, and 12 days, respectively. Chlorpyrifos is more stable in an acidic than an alkaline medium. At 25 C in phosphate buffers, the half-lives at pH 5, 7, and 8, were 63, 35, and 23 days, respectively. In aquatic environments, chlorphyrifos has a longer residual because of strong sorption to organic material. The chemical is also somewhat protected from hydrolysis when applied in formulations emulsified in water. Photolysis rates are dependent upon water depth and clarity and solar intensity as a function of time of year and location. Mid-summer half-lives would be about 30 days. The major hydrolysis product and microbial degradation metabolite of chlorpyrifos is 3,5,6-trichloro-2-pyridinol which photodecomposes rapidly in water.

3.3.2 Transport

3.3.2.1
Soil - Chlorpyrifos moves very little in soil because it is highly sorbed to soil, especially in the prescence of organic matter.

3.3.3 Metabolism

3.3.3.1
Mode of Action - Clorpyrifos controls insects primarily by contact action, but it also may kill them through ingestion and vapor action. It controls a wide range of insects on animals, in animal areas, in forests, in general indoor and outdoor areas, on shrubs and trees, in stored products, in turf, and in wood materials. Chlorpyrifos can be used within residential buildings, including homes and apartment buildings. Applications may also be made within nonfood areas of industrial, institutional, and commercial buildings, including hospitals, stores, manufacturing plants, and warehouses. Applications may be made within food handling establishments including restaurants, grocery stores, bakeries, bottling plants, canneries, and grain mills. Chlorpyrifos is highly toxic to fish, birds, and bees (Meister 1994). In humans, chlorpyrifos has caused eye pain, moderate irritation, and slight corneal injury; prolonged exposure may cause skin irritation. Chlorpyrifos causes organophosphate-type cholinesterase inhibition at excessive exposure levels. Signs and symptoms of excessive exposure may be headache, dizziness, incoordination, muscle twitching, tremors, nausea, abdominal cramps, diarrhea, sweating, pinpoint pupils, blurred vision, salivation, tearing, tightness in chest, excessive urination, or convulsions. On rats, chlorpyrifos is not carcinogenic, teratogenic, or mutagenic, and does not cause reproductive effects.

3.3.3.2
Plant Metabolism - Not known.

3.3.3.3
Animal Metabolism - In human urine, chlorpyrifos was degraded to diethylphosphate, diethyl thiophosphate, and a phenolic derivative. A single dose of chlorpyrifos to rats led to rapid absorption and excretion in urine (90%) and feces (10%). The products excreted were 3,5,6-trichloro-2-pyridylphosphate (75-80%), 3,5,6-trichloro-2-pyridinol, and a trace of unmetabolized material. Technical chlorpyrifos has an oral LD50 for male and female rats of 205-270 and 96-174 mg/kg, respectively, and for rabbit an LD50 of >1000 mg/kg body weight. Formulated Dursban 4E has an acute oral LD50 for male and female rats of 940 and 530 mg/kg and dermal rabbit LD50 of 1185 mg/kg body weight.

3.3.4 Potential Regional Impacts - Chlorpyrifos does not appear to have regional impacts at approved uses.

3.3.5 Formulation

Chlorpyrifos is purchased as Dursban 4E®, and it is diluted in water for application.

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Appendix B - Chapter 2

The purpose of this report is to assess the risk to human health of 10 pesticides used by the Texas Department of Transportation. The 10 pesticides considered in this risk assessment together with their product names, physical and chemical properties, and application rates used by the Texas Department of Transportation are outlined in Tables B2-1 through B2-4.

1.0 The Process of Chemical Risk Assessment

Risk means the probability that an adverse effect (injury, disease, or death) could occur under specified conditions of exposure or use. Risk depends on the inherent toxicity as well as the quantity of a chemical which may come into contact with an individual. The process by which one determines human health risks due to chemical exposure is known as a chemical risk assessment. The elements necessary to characterize the potential adverse health effects have been described by the National Research Council (1983). These elements can be briefly described as follows:

1.1 Hazard Assessment

The goal of this step is to identify the kind of adverse health effects which have been observed in humans or in laboratory animals and at what level of chemical exposure. Dose response relationships can be identified (*i.e.,* median lethal dose, LD_{50}) from acute laboratory animal studies. No observable effects levels (NOELs) can be identified from chronic toxicity studies as well as from reproductive and teratology studies. Reference doses (RFDs) can be obtained by dividing the NOEL by a safety factor. Safety factors make allowances for uncertainties or knowledge gaps in the data and may be used to reduce the NOEL dose to a level which would have a very low probability of producing adverse effects in man. A safety factor of 100 is often used, with the justification of a factor of 10 for interspecies variation, and an additional factor of 10 used for interindividiual differences in the human population. In the absence of an experimentally-derived NOEL, the lowest observable effect level (LOEL) may be used, and an additional safety factor of 10 applied. In addition, a modifying factor ranging from 1 to 10 may also be applied. These modifiers are used to reflect the degree of confidence in the data upon which the reference dose (RFD) is based (see Table 1-5). *In vitro* and *in vivo* short-term assays are used to determine whether the chemical in question is a mutagen, while chronic studies are used to ascertain whether the chemical produces cancer. Cancer potency factors for chemicals have been determined by the EPA's Carcinogen Assessment Group based on a review of all pertinent data. The cancer potency factor is based on the most sensitive tumor response in the most sensitive species and is defined as the increased probability of developing cancer from a unit increase in the dose of a chemical. The EPA assigns a weight of evidence classification to each chemical as to its potential to produce cancer in man. Chemicals can be grouped from A (human carcinogen) to E (evidence of noncarcinogenicity in humans). All of the pesticides considered in this assessment should be considered to be in Group E.

1.2 Exposure Assessment

The goal of this step is to determine the type and magnitude of potential human exposure to chemicals. Exposure analysis includes identifying those individuals who may be exposed to the chemical and the magnitude, frequency, duration, and route of exposure. Exposure doses can then be calculated to give estimates of daily and lifetime exposures.

1.3 Risk Assessment

This step utilizes all the assumptions and information acquired in the previous steps and provides qualitative conclusions regarding the likelihood that a chemical may pose a human health hazard. It also provides a quantitative risk value for exposure to the chemical under consideration. If the chemical in question is considered a carcinogen, a cancer risk value is determined. That is, the number of cancer cases that would be expected to occur beyond the background incidence in the unexposed population. If the chemical causes noncancer effects, a hazard index is calculated which allows a determination as to whether exposure to a particular chemical may result in significant adverse health effects.

This risk assessment examines the potential health effects on two human populations who may be directly or indirectly exposed to any of the 10 pesticides used by the Texas Department of Transportation. One population includes workers such as mixer/loaders and spray truck drivers who may come into contact with the pesticide during the performance of their duties. The second group, the general public, may be exposed inadvertently through contact with sprayed vegetation, or by consuming food items or drinking water contaminated with pesticide residues.

2.0 Sources of Toxicity Information

Information on the pesticides considered in this risk analysis was obtained from the Environmental Protection Agency (EPA) through the Freedom of Information Office. EPA maintains both science chapters and summary tables called "tox-one liners" which are available upon request. Additional information was obtained from the open literature through searches involving the National Library of Medicine's Registry of Toxic Effects of Chemical Substances (RTECS) and Hazardous Substances Data Bank (HSDB) databases, as well as Medline, Chem Abstracts Embase (Excerpta Medica), and International Pharmaceutical Abstract databases. The time period included in the searches was from 1988 to November, 1991 to locate current literature pertaining to the pesticides of interest.

3.0 Toxicity Testing

Information on the adverse health effects of pesticides in man is often limited to either case reports on accidental or intentional exposure to a chemical or to descriptive or analytical epidemiology studies on populations believed to have been exposed to a particular chemical. Often there is inadequate information available on the adverse effects of a chemical in man to make a risk analysis.

In many cases, information on the toxic effects of a chemical may be available only from animal studies. Ideally, a laboratory animal would both metabolize a chemical at the same rate and by the same metabolic pathway as man and show the same susceptibility to the adverse effects as man. Unfortunately, this seldom occurs. However, by using different laboratory animals, information may be obtained that when properly qualified may be applicable to predicting adverse effects in man.

3.1 Conduct and Design of Toxicity Tests

3.1.1 Animal Species

In general, rats and mice are the most commonly used laboratory animals for toxicity testing. Other animals used include rabbits, dogs, guinea pigs, and nonhuman primates. Rats and mice are often used in chronic studies due to their relatively short lifespans, size, ease of handling, and cost. Guinea pigs are often used in cutaneous sensitization studies because of their ability to form antibodies to applied chemicals, while rabbits are often used in dermal toxicity testing because of their highly sensitive skin.

3.1.2 Dose

Very high doses of a chemical often are needed to determine the median lethal dose. After this has been accomplished, additional studies often use progressively lower doses over longer periods of time. These studies would be used to determine both a range of doses over which adverse effects occur and also to identify the dose at which no adverse effects are seen. Chemicals usually are administered orally on a milligram of chemical per kilogram body weight basis (mg/kg) or in the animal's food or water on a part per million (ppm) basis (mg of chemical per kilogram of food or liter of water). Occasionally, chemicals would be administered on a body surface area basis (mg/cm^2) to reduce the dramatic differences between body weights of laboratory animals and man. Often, several dosing levels could be used in addition to a control group which receives the vehicle only. In order for a toxicity study to have any significance, at least one of the dosing levels must produce some adverse effect.

3.1.3 Route of Exposure

The most common routes by which chemicals are administered to laboratory animals in toxicity studies would be those frequently encountered by man. These routes include oral administration (often by stomach tube, or gavage, if the chemical is too unpalatable to be placed in the animal's diet), dermal application (application to the skin), and inhalation (through exposure to vapors or aerosol particles).

3.1.4 Threshold and Nonthreshold Effects

For many chemicals, there exists a threshold or level below which signs of toxicity are not observed. The dose at which adverse effects are first noted is referred to as the threshold dose. The NOEL is considered to be a conservative estimate of the threshold dose and is used in determining exposure levels which would have a very low probability of producing adverse effects in man.

There could be adverse effects, however, that are thought to not have thresholds. The induction of cancer or mutations is believed to be independent of dose. No matter how small the dose of chemical, there is always some finite probability of inducing a neoplasm or mutation, because all that is theoretically required is one molecule of chemical to interact with one molecule of DNA.

4.0 Animal Toxicity Studies

4.1 Acute Toxicity Studies

One of the first studies to be performed in assessing the toxicity of a chemical is a lethality study. Usually, a single dose or several doses of a chemical are administered to an animal within a 24 hour period. The end point in this type of study is death. The dose that kills 50 percent of the animals is referred to as the median lethal dose or LD_{50}. EPA has adapted the LD_{50} classification of Maxwell (1982), in which chemicals are classified according to their LD_{50}s . The lower the median lethal dose of a chemical, the more toxic the chemical. A comparison of the chemicals considered in this risk assessment with other well known chemicals is presented in Table B5-3. Acute lethality studies provide useful information when it is necessary to assess risk in acute exposure situations. In addition, lethality studies serve as a guide in determining dosage levels which would not be lethal in subchronic or chronic studies.

Other acute studies which provide useful information in assessing the toxicity of a chemical are the primary skin and eye irritation studies. Most often these studies involve single or multiple applications of the chemical under study to the skin or eyes of albino rabbits. These studies are used to detect the irritant properties of chemicals. If significant quantities of a chemical are absorbed, a dermal LD_{50} may be determined. Guinea pigs are used to differentiate between skin irritation and skin sensitization properties of a chemical.

4.2 Subchronic Studies

Subchronic studies are usually less than 90 days in duration. These studies often involve a range of doses administered orally or in the diet. The lowest dose group should not show any adverse effects while the highest dose group should show some adverse effect(s) which may include: changes in food consumption, body weight, respiratory and/or cardiovascular distress, behavior, fur coat texture, clinical blood chemistries, hematology (red and white cell counts), urine analysis, gross and microscopic pathology. These subchronic studies further define the dose-response relationship and also could be useful in determining appropriate dosage levels to be used in chronic toxicity studies.

4.3 Chronic Toxicity Studies

Chronic toxicity studies usually are 6 to 24 months in duration and involve repeated exposure to low levels of a chemical in order to assess its cumulative toxicity. Doses would be chosen such that there is no premature mortality in the exposed animals. Often, chronic studies seek to determine whether or not a chemical produces significantly more tumors in animals in the treatment groups than in control animals, whether these tumors are similar, and the length of time to tumor onset. It is important that a maximum tolerated dose (MTD) be used in cancer studies since many chemicals administered above the MTD may appear to be initiators of cancer, but really would be only promoters. All animals undergo both gross and microscopic pathologic examination.

4.4 Reproductive and Developmental Toxicity Studies

These studies seek to determine whether a chemical adversely affects the male and/or female reproductive systems and the developmental processes of their offspring. These studies are conducted over three generations, often in conjunction with chronic feeding studies.

Teratology studies involve the administration of the test chemical to pregnant dams through the critical periods of fetal development (days 7 to 15 in rats and mice). The dams are killed (mice on day 20 and rats on day 21) and the fetuses examined for evidence of malformations.

4.5 Mutagenicity Testing

Mutagenesis is the process by which sudden heritable changes in genetic material (DNA) occur in either somatic or germ cells. Because many carcinogens have also been shown to be mutagens, mutagenicity tests (both *in vivo* and *in vitro*) have been employed to screen for potential carcinogens. Mutations may occur either spontaneously or be induced by chemicals. Spontaneous mutations occur because each step in genetic replication has a finite probability for error. In order to quickly identify potential mutagens or carcinogens, a number of short term bioassays have been proposed. Since no one test is presently available which is capable of detecting all mutagens, a battery of tests is often carried out. *In vitro* microbial assays (*Salmonella typhimurium*, *Escherichia coli*) as well as indirect *in vivo* tests for gene mutations (host mediated assay) would be used to detect point mutations. *In vitro* cell culture or whole animal studies are used to assess chromosomal damage.

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Table B2-1. Pesticides Considered in this Analysis

<u>HERBICIDES</u>
Clopyralid
Glyphosate
Hexazinone
Imazapyr
Metsulfuron methyl
Sulfometuron methyl
Triclopyr
<u>INSECTICIDES</u>
Chlorpyrifos
Diazinon
Fenoxycarb

Table B2-2. Active Ingredients in Pesticides Formulations

Product Name	Active Ingredient
Arsenal	Imazapyr
Escort	Metsulfuron methyl
Diazinon 4E	Diazinon
Logic	Fenoxycarb
Dursban	Chlorpyrifos
Oust	Sulfometuron methyl
Pathfinder	Triclopyr
Transline	Clopyralid
Rodeo	Glyphosate
Roundup	Glyphosate
Velpar L	Hexazinone

Table B2-3. Application Rate of Chemicals Used by the Texas Department of Transportation

Pesticide	Application Rate (lbs A.I./acre)	
	Average	Maximum
HERBICIDES		
Clopyralid	0.125	0.500
Glyphosate	3.000	5.000
Hexazinone	2.000	6.000
Imazapyr	1.000	2.000
Metsulfuron methyl	0.063	0.187
Sulfometuron methyl	0.125	0.250
Triclopyr	1.000	4.000
INSECTICIDES		
Chlorpyrifos	0.500	3.000
Diazinon	1.000	3.000
Fenoxycarb	1.000	1.500

Table B2-4. Physical and Chemical Properties for Pesticides Considered in this Analysis

Pesticide	Mol. Wt. (g/mol)	Water Sol. (mg/l)	K_{oc} (ml/gm)	Vapor Pressure* (mm Hg)
HERBICIDES				
Clopyralid	192.0	1,000	4.6	1.3×10^{-5}
Glyphosate	169.1	11,600	25.0	N
Hexazinone	252.3	33,000	14.3	2×10^{-7}
Imazapyr	320.4	15,000	22	$< 2 \times 10^{-7}$**
Metsulfuron methyl	367.3	9,500	28	5.8×10^{-5}
Sulfometuron methyl	364.4	42,500	89	5.5×10^{-16}
Triclopyr	256.5	440	154	1.3×10^{-6}
INSECTICIDES				
Chlorpyrifos	350.6	2	13,600	1.9×10^{-5}**
Diazinon	304.4	40	440	4.1×10^{-4}***
Fenoxycarb	301.3	6	85.5	1.7×10^{-3}

N = Negligible
* at 25°C
** at 45°C
*** at 20°C

Table B2-5. Safety Factors Used in Chemical Risk Assessment to Establish Acceptable Levels of Exposure (Reference Doses) to Chemicals

Safety Factor	Criteria for Application
10	Extrapolating from animals to man
10	Variation in human responses
10	Absence of chronic animal studies
1 - 10	Additional safety factor to account for uncertainties not previously addressed

Table B2-6. Acute Toxicity Classification of Selected Chemicals

Herbicide or Other Chemical Substance	Oral LD_{50} for Rats (mg/kg)	Toxicity Category* (label signal words)	Equivalent Human Dose
	0 - 50 (range)	I Severe (Danger - Poison)	1 teaspoon or less
Nicotine	50		
Strychnine	30		
TCDD (a dioxin)	0.1		
Botulinus Toxin	0.00001		
	50 - 500 (range)	II Moderate (Danger)	1 teaspoon to 1 ounce
Caffeine	200		
Diazinon	96		
Chlorpyrifos	82		
	500 - 5,000 (range)	III Slight (Warning)	1 ounce to 1 pint
Glyphosate	4,320		
Clopyralid	4,300		
Triclopyr	4183-4464		
Table Salt	3,750		
Hexazinone	1,690		
	5,000 - 50,000 (range)	IV Very slight (Caution)	More than 1 pint
Sugar	30,000		
Fenoxycarb	16,800		
Ethyl Alcohol	13,700		
Imazapyr	> 5,000		
Sulfometuron Methyl	> 5,000		
Metsulfuron Methyl	> 5,000		

* Categories, signal words, and LD_{50} ranges are based on a classification system used by EPA for labeling pesticides. Adapted from Maxwell (1982).

5.0 Chemical Profiles

Toxicity profiles were developed for each of the 10 pesticides used by the Texas Department of Transportation. These profiles contain pesticide-specific information obtained from authoritative reviews, EPA Pesticide Fact Sheets, and Pesticide Registration and Re-registration documents. Additional information was obtained from the open literature through electronic databases such as the National Library of Medicine's Registry of Toxic Effects of Chemical Substances (RTECS) and Hazardous Substances Data Bank (HSDB), as well as Medline, Chem Abstracts Embase (Excerpta Medica), and International Pharmaceutical Abstract databases. These profiles contain summaries of human and animal toxicity data associated with exposure to each pesticide of concern. The health effects discussed in the toxicity profiles are divided into noncancer systemic effects, reproductive/developmental effects, genotoxic effects, and carcinogenic effects. Toxicity values such as reference doses (RFDs) or acceptable daily intakes (ADIs) developed by the EPA or other federal agencies and used in the quantitative risk assessment in this document are discussed in the toxicity profiles.

This risk assessment examines the potential health effects on two human populations which may be directly or indirectly exposed to any of the 10 pesticides used by the Texas Department of Transportation. One population includes workers such as mixers/loaders and spray truck drivers who may come into contact with the pesticide during the performance of their duties. The second group consists of members of the general public who may be inadvertently exposed to pesticide residues through contact with sprayed vegetation or ingestion of contaminated food or water. It is highly unlikely that the members of the general public or workers in any given area will be exposed to all of the pesticides examined in this assessment. For each exposure pathway identified, an average exposure case using reasonable exposure assumptions and a maximum plausible case using conservative exposure assumptions was used when estimating daily intakes. Although the maximum case may only have a remote probability of occurring, it is intended to place a plausible upper boundary on potential exposure estimates. The exposure estimates and, subsequently, the estimates of risk based on these exposures are not intended to show what will happen, but rather what potentially could occur if all the parameters and assumptions were met.

5.1 Chlorpyrifos (Dursban)

Chlorpyrifos (*O,O*-diethyl *O*-(3,4,5-trichloro-2-pyridyl) phosphorothioate) is a nonsystemic organophosphate insecticide used to control household and agricultural insects, including foliage and soil insects (Hayes and Laws, 1991). Chlorpyrifos is marketed by DowElanco under the trade name of Dursban for household products and Lorsban for agricultural products.

5.1.1 Acute Toxicological Effects

5.1.1.1 Man

The estimated oral lethal dose for an adult ranges from 73 to 410 mg/kg. A NOEL of 0.03 mg/kg/day for plasma cholinesterase inhibition was established in human adult volunteers ingesting chlorpyrifos (FAO/WHO, 1973). This corresponds with a recommended maximum occupational intake of 0.028 mg/kg. Red blood cell cholinesterase activity was not affected at any of the dosage levels tested (0.014 to 0.1 mg/kg/day). No red blood cell cholinesterase inhibition or overt toxicity was observed in six human volunteers who ingested single oral doses of chlorpyrifos (0.5 mg/kg) followed in two weeks by a dermal dose of 0.5 or 5.0 mg/kg. Plasma cholinesterase was reduced by 15% following the oral dose, but no significant changes were observed following the larger dermal dose (Nolan et al., 1984).

5.1.1.2 Animal Studies

Acute Oral Toxicity

The acute oral LD_{50} for chlorpyrifos in rats ranges from 82 mg/kg in female rats to 245 mg/kg in male rats (Hayes and Laws, 1991). Chlorpyrifos would, therefore, be classified as a moderately toxic chemical. The oral LD_{50} in other species ranges from 152 mg/kg in the mouse to 504 mg/kg in the guinea pig to over 1000 mg/kg in the rabbit (Hayes and Laws, 1991).

Acute Dermal Toxicity

The acute dermal LD_{50} of chlorpyrifos in male rats has been reported to be 202 mg/kg (Hayes and Laws, 1991). Chlorpyrifos has also been shown to be absorbed through both rabbit and human skin and may cause systemic poisoning. The acute dermal LD_{50} in rabbits has ranged from 1,000 to 2,000 mg/kg. Commercial formulations of chlorpyrifos have been reported to be nonirritating to rabbit skin. No signs of skin sensitization have been reported (EPA, 1984).

Acute Ocular Toxicity

Chlorpyrifos has been reported to produce conjunctival irritation in the Draize eye irritation assay at 24 hours, but this resolved at 48 hours (EPA, 1984).

Acute Inhalation Toxicity

The inhalation LC_{50} of chlorpyrifos in mice and rats has been reported to be 94 and 78 mg/kg, respectively (Berteau and Deen, 1978). Rats exposed to nose-only vapor inhalation (0.287 mg/m^3) for 13 weeks did not result in adverse effects (Calhoun et al., 1989). Dogs exposed for four-hour periods to 4 or 8 mg/ft^3 showed only mild suppression of plasma cholinesterase activity (HSDB,1991).

5.1.2 Subchronic and Chronic Toxicity Effects

Chlorpyrifos administered in the diet at a concentration of 65 ppm for 10 months failed to result in any gross toxic symptoms in mice. Rats administered chlorpyrifos for two years resulted in a red blood cell cholinesterase NOEL of 0.10 mg/kg/day. No overt signs of toxicity were noted even at the highest dose (3 mg/kg/day) tested (EPA, 1984). Dogs administered chlorpyrifos over two years resulted in plasma and red blood cell cholinesterase NOELs of 0.01 and 0.10 mg/kg/day, respectively (EPA,1985).

Monkeys administered chlorpyrifos for six months showed inhibition of both plasma and red cell cholinesterase activity at 2.0 and 4.0 mg/kg/day, but only plasma cholinesterase was inhibited at a dose of 0.8 mg/kg/day. Brain cholinesterase activity was not affected at any of these concentrations, and no overt signs of toxicity were noted (Hayes and Laws, 1991).

Chlorpyrifos has not been shown to produce delayed neurotoxicity in any experimental animal (Hayes and Laws, 1991).

5.1.2.1 Reproductive Effects

Rats were fed chlorpyrifos in the diet at levels of up to 0.3 mg/kg/day for one generation and up to 1.0 mg/kg/day for two generations. No adverse effects were noted, although neonatal mortality was somewhat higher at 1.0 mg/kg/day (Hayes and Laws, 1991). In two other studies in which chlorpyrifos was fed at dose levels up to 1.2 and 1.0 mg/kg/day, no adverse effects were observed (EPA, 1988).

5.1.2.2 Teratogenicity

No teratogenic effects were observed in the offspring of rats fed 1.0 mg/kg/day chlorpyrifos in a three-generation reproduction and fertility study (EPA, 1988). Chlorpyrifos has not been reported to be teratogenic in mice at doses of up to 25 mg/kg/day (EPA, 1985).

5.1.2.3 Carcinogenicity

A two-year chronic feeding study did not result in any oncogenic effects in rats. Mice also failed to show any oncogenic effect. However, both of these studies were determined to be inadequate and repeat studies have been requested by the EPA. The EPA does not consider chlorpyrifos to be oncogenic (EPA, 1984).

5.1.2.4 Mutagenicity

Chlorpyrifos has been reported to be negative for mutagenic activity in the *Salmonella*/microsome, *Escherichia coli* and *Bacillus subtilis* bacterial assays, mouse micronucleus assay, as well as in the sister chromatid exchange assay in Chinese hamster ovary and chick embryo assays. Chlorpyrifos has been reported to be mutagenic in *Drosophila melanogaster* (fruit flies) administered 50 ppb chlorpyrifos over three days. Chlorpyrifos has also been reported to be positive for unscheduled DNA synthesis and DNA repair in two bacterial assays (EPA, 1985). The EPA does not consider chlorpyrifos to be a mutagen.

5.1.2.5 Disposition

Chlorpyrifos is well-absorbed from the gastrointestinal tract of both rats and man. Over 88% of the parent compound and its major metabolite 3,5,6-trichloro-2-pyridinol is excreted by rats within 50 hours, primarily in the urine. Chlorpyrifos tends to accumulate in fatty tissues to some extent, but is slowly released once exposure ceases. The half-life of chlorpyrifos in fat, liver, kidney, and muscle has been reported to be 62, 10, 10 and 16, hours, respectively (Smith, 1966; Smith et al., 1967).

5.1.2.6 Regulation and Guidelines

The acceptable daily intake for chlorpyrifos is 0.003 mg/kg/day based on a plasma acetylcholinesterase NOEL of 0.03 mg/kg/day derived from a 20 day study with human volunteers (EPA, 1984).

5.1.2.7 Risk Characterization

Risk estimates for chlorpyrifos are based on specific types of worker and general public exposure. The estimates of single-day intake and noncancer risk from exposure to chlorpyrifos, expressed as the Hazard Index [single day dose(mg/kg/day)/reference dose (RFD) (mg/kg/day)] are shown in Table B2-7. Since chlorpyrifos is not considered a carcinogen, no unit potency estimate has been determined, and estimates of lifetime cancer risk were not derived.

5.1.3 Human Risk Assessment

Estimates of the single-day intake for spray truck drivers in the average scenario and in all worker categories under the maximum plausible case assumptions, result in Hazard Indices that exceed 1. This ratio indicates that adverse effects might occur in exposed workers if their intake of chlorpyrifos equals that estimated in the exposure assessment. It is unlikely that exposure will reach those estimated in this risk assessment because of the small quantities (up to 2.5 gallons) of spray or chlorpyrifos granules used at any one time by the Texas Department of Transportation, the conservativeness of the assumptions, and the precautions taken by trained pesticide applicators (protective clothing, goggles, etc.). Environmental exposures to the general public, under maximum plausible conditions, would not be expected to pose any risk of adverse effect, except for ingestion of lettuce and fish, for which the Hazard Indices show greater than 1. Since, in reality, only small quantities of chlorpyrifos would be used at any one time, the likelihood of inadvertent drifting of pesticide spray onto vegetables or pond water is extremely minimal. In addition, it was assumed that the lettuce was not washed before eating, and the amount of lettuce or fish ingested (corresponding to the 95^{th} percentile) would be very conservative assumptions. It is very unlikely that the maximum plausible case levels would be reached in these scenarios.

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Table B2-7. Average and Maximum Estimates of Single-Day Intake and Associated Estimates of Risk for Exposure to Chlorpyrifos

Exposure	Single-Day Estimated Intake (mg/kg/day)		Hazard Index	
	Average	Maximum	Average	Maximum
<u>Workers</u>				
Mixing/loading	2×10^{-3}	9×10^{-3}	6×10^{-1}	3×10^{0}
Driving spray truck	7×10^{-5}	4×10^{-2}	2×10^{0}	1×10^{1}
<u>Public</u>				
Contact with sprayed vegetation	4×10^{-6}	1×10^{-4}	1×10^{-3}	4×10^{-2}
Exposure to berry pickers:				
Dermal exposure	6×10^{-6}	2×10^{-4}	2×10^{-3}	5×10^{-2}
Ingestion of berries	3×10^{-5}	1×10^{-3}	1×10^{-2}	4×10^{-1}
Exposure by ingestion of vegetables:				
Tomatoes	4×10^{-6}	6×10^{-4}	1×10^{-3}	2×10^{-1}
Lettuce	6×10^{-5}	8×10^{-3}	2×10^{-2}	3×10^{0}
Beans	5×10^{-6}	8×10^{-4}	2×10^{-3}	3×10^{-1}
Exposure by ingestion of surface water	7×10^{-5}	4×10^{-4}	2×10^{-2}	1×10^{-1}
Exposure due to consumption of fish	1×10^{-3}	8×10^{-2}	3×10^{-1}	3×10^{1}
Exposure due to consumption of wild game:				
Ingestion of deer meat*	2×10^{-6}	1×10^{-5}	7×10^{-4}	4×10^{-3}
Exposure from ingestion of groundwater	negligible	negligible	negligible	negligible

* High consumption

5.2 Clopyralid (Transline)

Clopyralid (3,6-dichloro-2-pyridine carboxylic acid) is an herbicide used to control many broadleaf annual and perennial weeds (WSSA, 1989). Clopyralid is marketed by DowElanco under the trade names of Stinger and Transline. Transline is the only clopyralid product registered for use on rights-of-way.

5.2.1 Acute Toxicological Effects

5.2.1.1 Man

No human toxicity data were located in the current literature.

5.2.1.2 Animal Studies

Acute Oral Toxicity

Clopyralid is classified as a slightly to very slightly toxic chemical based on oral LD_{50}s in male rats. These ranged from 4,300 to greater than 5,000 mg/kg (WSSA, 1989).

Acute Dermal Toxicity

Clopyralid has been reported to be only slightly irritating in a 14-day dermal irritation study in rabbits (EPA, 1988).

Acute Ocular Toxicity

In a rabbit eye irritation study, clopyralid was found to be a severe irritant (Worthing and Walker, 1987). Clopyralid as the monoethanolamine salt and Transline are much less irritating than clopyralid in the acid form (DowElanco, 1981).

Acute Inhalation Toxicity

The acute inhalation LC_{50} for clopyralid in rats was determined to be greater than 5.03 mg/L for a one hour exposure (WSSA, 1989).

5.2.2 Subchronic and Chronic Toxicity Effects

In a subchronic oral (90 days) rat toxicity study, clopyralid produced no adverse effects and resulted in a NOEL of greater than 150 mg/kg/day, the highest dose tested (EPA, 1988). In a one year chronic study in dogs, a systemic NOEL of 100 mg/kg/day was established (EPA, 1988). In chronic (24 month) oral toxicity studies, clopyralid was administered to both rats and mice. Male mice showed a reduction in body weight at the highest dose

(2,000 mg/kg/day) tested. A systemic NOEL of 500 mg/kg/day was established. Female rats showed a reduction in mean body weight at the highest dose tested (150 mg/kg/day). Based on this reduction in body weight, EPA established a systemic NOEL of 50 mg/kg/day. In a second study, rats receiving 150 mg clopyralid/kg/day developed hyperplasia and thickening of the limiting ridge of the stomach. A systemic NOEL of 15 mg/kg/day was established in this study (EPA, 1988).

5.2.2.1 Reproductive Effects

In a two-generation rat reproduction study, clopyralid was not found to be fetotoxic at the highest dose tested (1,500 mg/kg/ day). A maternal systemic NOEL of 500 mg/kg/day was established based on a reduction in body weight gain in the 1500 mg/kg/day treatment group (EPA, 1988).

5.2.2.2 Teratogenicity

Clopyralid was not found to be teratogenic in either rats or rabbits. Fetotoxic and teratogenic NOELs greater than 250 mg/kg/day were established for both species. A maternal NOEL of 75 mg/kg/day was established in rats based on a decrease in body weight gain and food consumption observed in the highest (250 mg/kg/day) treatment group. A maternal NOEL of 250 mg/kg/day was reported for rabbits (highest dose tested) (EPA, 1988).

5.2.2.3 Carcinogenicity

Mice and rats were fed clopyralid for 24 months. No oncogenic effects were observed in either species at doses up to 2,000 mg/kg/day in mice or 1500 mg/kg/day in rats (EPA, 1988). Clopyralid is considered to be noncarcinogenic in this risk assessment.

5.2.2.4 Mutagenicity

Clopyralid has been reported to be nonmutagenic in the *Salmonella*/microsome assay, the host mediated assay, the dominant lethal assay, as well as in an *in vivo* cytogenetic assay (EPA, 1988).

5.2.2.5 Disposition

Rats have been shown to rapidly eliminate 3-6-dichloro-picolinic acid with 79% to 96% of a radiolabelled dose appearing in the urine within the first 24 hours after administration (DowElanco, 1991). The chemical is also rapidly eliminated in chickens with essentially all of the chemical excreted in 24 hours (DowElanco, 1977).

5.2.2.6 Regulation and Guidelines

An oral reference dose (RFD) of 0.5 mg/kg/day was established by EPA (1989) based on a two year rat study in which a NOEL of 50 mg/kg/day was determined. The RFD was derived from the NOEL of 50 mg/kg/day and a safety factor of 100.

5.2.2.7 Risk Characterization

Risk estimates for clopyralid would be based on specific types of worker and general public exposure. The estimates of single-day intake and noncancer risk from exposure to clopyralid, expressed as the Hazard Index [single day dose (mg/kg/day)/reference dose (RFD) (mg/kg/day)] are shown in Table B2-8. Since clopyralid is not considered a carcinogen, no unit potency estimate has been determined, and estimates of lifetime cancer risk were not derived.

5.2.3 Human Risk Assessment

Under the conditions specified in the Exposure Assessment, clopyralid is not likely to pose a hazard to workers or to the general public by any of the exposure pathways evaluated. Hazard Indices were less than 1 for all exposure conditions indicating that the amount of exposure is less than the RFD for both workers and the general public. Clopyralid is not expected to accumulate in animal tissues according to the biotransfer factor and was not evaluated by the game ingestion pathway.

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Table B2-8. Average and Maximum Estimates of Single-Day Intake and Associated Estimates of Risk for Exposure to Clopyralid

Exposure	Single-Day Estimated Intake (mg/kg/day)		Hazard Index	
	Average	Maximum	Average	Maximum
<u>Workers</u>				
Mixing/loading	2×10^{-3}	9×10^{-3}	4×10^{-3}	2×10^{-2}
Driving spray truck	2×10^{-5}	7×10^{-3}	3×10^{-5}	1×10^{-2}
<u>Public</u>				
Contact with sprayed vegetation	2×10^{-6}	4×10^{-5}	4×10^{-6}	8×10^{-5}
Exposure to berry pickers:				
Dermal exposure	3×10^{-6}	5×10^{-5}	6×10^{-6}	1×10^{-4}
Ingestion of berries	7×10^{-6}	2×10^{-4}	1×10^{-5}	4×10^{-4}
Exposure by ingestion of vegetables:				
Tomatoes	1×10^{-6}	1×10^{-4}	2×10^{-6}	2×10^{-4}
Lettuce	1×10^{-5}	1×10^{-3}	3×10^{-5}	3×10^{-3}
Beans	1×10^{-6}	1×10^{-4}	2×10^{-6}	3×10^{-4}
Exposure by ingestion of surface water	2×10^{-5}	7×10^{-5}	3×10^{-5}	1×10^{-4}
Exposure due to consumption of fish	3×10^{-6}	1×10^{-4}	7×10^{-6}	3×10^{-4}
Exposure due to consumption of wild game:				
Ingestion of deer meat	NA	NA	NA	NA
Exposure from ingestion of groundwater	4×10^{-5}	2×10^{-4}	9×10^{-5}	3×10^{-4}

Note: NA = Not Applicable

5.3 Diazinon (Diazinon)

Diazinon (*O,O*-diethyl *O*-(2-isopropyl-6-methyl-4-pyrimidinyl) phosphorothioate) is a nonsystemic organophosphate insecticide used to control household and agricultural insects, including foliage and soil insects (Hayes and Laws, 1991). Diazinon is marketed under trade names such as Knox Out, Spectracide, and Basudin.

5.3.1 Acute Toxicological Effects

5.3.1.1 Man

The estimated oral lethal dose for an adult is 25 g (Heyndrickx et al., 1974; Klemmer et al., 1978). A NOEL of 0.02 mg/kg for cholinesterase inhibition was established in human adult volunteers ingesting diazinon (FAO/WHO, 1967). Occupational intake of up to 0.014 mg/kg is considered to be safe and sufficiently low to compensate for variations in the toxicity of different diazinon formulations (Hayes and Laws, 1991).

5.3.1.2 Animal Studies

Acute Oral Toxicity

Because of the many different formulations of diazinon, the acute oral LD_{50} in rats has ranged from 66 to 635 mg/kg for females and 96 to 967 mg/kg in males (EPA, 1986). Based on this data, diazinon has been classified as a moderately toxic chemical. The toxicity of microencapsulated diazinon formulations is relatively low, as the diazinon is not readily released while in the intestinal tract.

Acute Dermal Toxicity

The acute dermal LD_{50} of diazinon (23.8%) has been reported to be 2150, 2750, and 2040 mg/kg for rats, mice, and rabbits, respectively (EPA, 1988).

Knox-Out, a commercial formulation containing 23% diazinon, has been reported to be nonirritating to rabbit skin (EPA, 1988) while other formulations have been reported to produce only minor skin irritation. No signs of skin sensitization have been reported (Nitka and Palanker, 1980).

Acute Ocular Toxicity

Diazinon has been reported to produce little ocular irritation in the Draize eye irritation assay (Nitka and Palanker, 1980).

Acute Inhalation Toxicity

Four-hour exposures of rats and mice to diazinon resulted in a LC_{50}s of 3.5 mg/l and 1600 mg/m^3, respectively (EPA, 1988).

5.3.2 Subchronic and Chronic Toxicity Effects

Mice administered diazinon in the diet at a concentration of 65 ppm for 10 months failed to show any gross toxic symptoms. Rats administered 50 mg/kg/day of diazinon for 72 weeks showed no overt signs of toxicity, but had decreased red cell and plasma cholinesterase activity. They did exhibit normal brain cholinesterase levels, however (Bruce et al., 1955).

Dogs administered 4.6 mg diazinon/kg/day over 43 weeks resulted in a marked inhibition of cholinesterase activity in both red cells and plasma. However, no overt toxicity was observed at 6.5 mg/kg/day, while doses of 9.3 mg/kg/day resulted in excitement, tremors, and loss of appetite (Bruce et al., 1955). In another study, the NOEL for cholinesterase inhibition in dogs was reported to be 0.015 mg/kg/day (Williams et al., 1959). In a third study, dogs fed 10 mg/kg/day for eight months had no fatalities, but dogs treated for one month at 20 mg/kg/day resulted in 100 % mortality (Eisler, 1986).

Monkeys gavaged daily with diazinon at doses of 0.05, 0.5, and 5.0 mg/kg/day for two years failed to show any neurological, hematological, or pathological effects. All animals developed soft stools and had weight gains that were slightly depressed. Inhibition of cholinesterase was not observed in the lowest treatment group, but was moderately inhibited in both red blood cells and plasma in animals treated with 0.5 mg/kg/day, and markedly reduced at the highest treatment level (EPA, 1987).

Diazinon has not been shown to produce delayed neurotoxicity in any experimental animal (EPA, 1988).

5.3.2.1 Reproductive Effects

Female Charles River rats were fed diazinon in the diet at 0.2 or 0.4 mg/kg/day in a three-generation reproduction study. No adverse effects were noted, and a NOEL of 0.4 mg/kg/day was identified (EPA, 1988).

5.3.2.2 Teratogenicity

Single intraperitoneal doses of diazinon administered to rats on day 11 of gestation were teratogenic only at doses which caused maternal toxicity (Kimbrough and Gaines, 1969). Rabbits gavaged with diazinon at a doses up to 100 mg diazinon /kg/day resulted in a maternal toxic NOEL of 25 mg/kg/day, but no terata were observed in the offspring (EPA, 1988).

5.3.2.3 Carcinogenicity

A chronic feeding study, lasting 103 weeks, did not result in any oncogenic effects in rats at doses up to 40 mg diazinon/kg/day. Mice administered up to 30 mg diazinon/kg/day also failed to show any oncogenic effect (NCI, 1979). In a second study, male mice fed up to 15 mg/kg/day for 19 months and female mice fed for 18 months failed to show any carcinogenic effects (Barnett and Kung, 1980). Diazinon is considered to be noncarcinogenic in this risk assessment.

5.3.2.4 Mutagenicity

Diazinon has been reported to be negative for mutagenic activity in the *Salmonella/* microsome and *Escherichia coli* bacterial assays, mouse dominant lethal assay, as well as in the sister chromatid exchange assay in Chinese hamster V79 cells, and in unscheduled DNA synthesis assays. Diazinon has been reported to produce an increase in sister chromatid exchanges in human B cells, but only with metabolic activation (EPA, 1988). Diazinon is not considered to be a mutagen in this risk assessment.

5.3.2.5 Disposition

Diazinon is readily absorbed from the gastrointestinal tract, and 50 % of the administered dose would be excreted within 12 hours, primarily in the urine (Mucke et al., 1970). In a second study, 90 % of the administered diazinon was excreted in 168 hours. The biological half-life of diazinon in male and female rats was estimated to be 7 hours and 12 hours, respectively (Menzie, 1974).

5.3.2.5 Groundwater

The K_{oc} for diazinon has been estimated to range from 417 to 744 depending on the soil examined. These values are 2- to 6-fold lower than the estimated K_{oc} predicted using water solubility or octanol-water partition coefficients. These values indicate that diazinon could adsorb to soils, but not so strongly that leaching is prevented. However, field and modelling studies suggest that diazinon seldom migrates below the first 13 centimeters of soil, and the downward movement of diazinon is insufficient to contaminate ground water aquifers (Jenkins et al., 1978; Branham and Wehner, 1985; Leistra, 1985).

5.3.2.6 Regulation and Guidelines

EPA (1989) established an oral reference dose (RFD) for diazinon of 0.09 mg/kg/day.

5.3.2.7 Risk Characterization

Risk estimates for diazinon would be based on specific types of worker and general public exposure. The estimates of single-day intake and noncancer risk from exposure to diazinon expressed as the Hazard Index [single day dose (mg/kg/day)/reference dose (RFD) (mg/kg/day)] are given in Table B2-9. Since diazinon is not considered a carcinogen, no unit potency estimate has been determined, and estimates of lifetime cancer risk were not derived.

5.3.3 Human Risk Assessment

Under the conditions specified in the Exposure Assessment, diazinon is not likely to pose a hazard to workers or to the general public by any of the exposure pathways evaluated. Hazard Indices were less than 1 for for all exposure conditions, indicating that the amount of exposure is less than the RFD for both workers and the general public.

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Table B2-9. Average and Maximum Estimates of Single-Day Intake and Associated Estimates of Risk for Exposure to Diazinon

Exposure	Single-Day Estimated Intake (mg/kg/day)		Hazard Index	
	Average	Maximum	Average	Maximum
Workers				
Mixing/loading	2×10^{-3}	9×10^{-3}	2×10^{-2}	1×10^{-1}
Driving spray truck	1×10^{-4}	4×10^{-2}	1×10^{-3}	4×10^{-1}
Public				
Contact with sprayed vegetation	2×10^{-5}	3×10^{-4}	2×10^{-4}	3×10^{-3}
Exposure to berry pickers:				
Dermal exposure	2×10^{-5}	3×10^{-4}	3×10^{-4}	3×10^{-3}
Ingestion of berries	6×10^{-5}	1×10^{-3}	7×10^{-4}	1×10^{-2}
Exposure by ingestion of vegetables:				
Tomatoes	8×10^{-6}	6×10^{-4}	9×10^{-5}	7×10^{-3}
Lettuce	1×10^{-4}	8×10^{-3}	1×10^{-3}	9×10^{-2}
Beans	1×10^{-5}	8×10^{-4}	1×10^{-4}	9×10^{-3}
Exposure by ingestion of surface water	1×10^{-4}	4×10^{-4}	1×10^{-3}	4×10^{-3}
Exposure due to consumption of fish	5×10^{-4}	2×10^{-2}	5×10^{-3}	2×10^{-1}
Exposure due to consumption of wild game:				
Ingestion of deer meat*	9×10^{-8}	3×10^{-7}	9×10^{-7}	3×10^{-6}
Exposure from ingestion of groundwater	negligible	negligible	negligible	negligible

* High consumption

5.4 Fenoxycarb (Logic)

Fenoxycarb (ethyl[2-(4-phenoxyphenoxy)ethyl] carbamate is an insecticide registered for use as a bait to control fire ants in or on turf, lawns, and nonagricultural lands. Fenoxycarb acts as a juvenile hormone to inhibit metamorphosis to the adult stage and induces interference with the molting of early instar larvae. It is marketed under the trade name Logic by Ciba-Geigy Corporation (EPA, 1986).

5.4.1 Acute Toxicological Effects

5.4.1.1 Man

No human toxicity data were located in the current literature.

5.4.1.2 Animal Studies

Acute Oral Toxicity

Fenoxycarb is classified as a very slightly toxic chemical based on oral LD_{50} of greater than 16,800 mg/kg in rats (EPA, 1986).

Acute Dermal Toxicity

The acute dermal LD_{50} is greater than 5,000 mg/kg in the rat (highest dose tested). No deaths occurred at this dosage level. Fenoxycarb was found to be only slightly irritating in a 21-day dermal irritation study in rabbits (EPA, 1986). It does not produce skin sensitization in guinea pigs (Worthing and Walker, 1987).

Acute Ocular Toxicity

In a rabbit eye irritation study, fenoxycarb was found to produce only minor irritation (Worthing and Walker, 1987).

Acute Inhalation Toxicity

The acute inhalation LC_{50} for fenoxycarb in rats was determined to be greater than 0.48 mg/l (Worthing and Walker, 1987).

5.4.1 Subchronic and Chronic Toxicity Effects

In a chronic oral toxicity study, fenoxycarb was administered to rats for a 24-month period. A systemic NOEL of 200 mg/kg/day was established (EPA, 1986).

5.4.2.1 Teratogenicity

Fenoxycarb was not reported to be teratogenic at doses up to 300 mg/kg/day (highest dose tested) (EPA, 1986).

5.4.2.2 Carcinogenicity

No oncogenic effects were reported in rats receiving up to 1800 ppm fenoxycarb in the diet for two years. In an 80-week oncogenic feeding study, male mice were found to have a possible dose-related increase in benign and malignant lung tumors. This was not observed in female mice (EPA, 1990). Fenoxycarb is considered to be noncarcinogenic in this risk assessment.

5.4.2.3 Mutagenicity

Fenoxycarb has been reported to be nonmutagenic (EPA, 1986).

5.4.2.3 Disposition

In a rat metabolism study, over 90% of an administered dose of fenoxycarb was excreted in 96 hours. Fenoxycarb does not bioaccumulate to any significant degree (EPA, 1986).

5.4.2.4 Regulation and Guidelines

An oral reference dose (RFD) for fenoxycarb has not been established by EPA. The RFD used in this risk assessment was derived from the NOEL of 200 mg/kg/day using a safety factor of 100 and a modifier of 3.

5.4.2.5 Risk Characterization

Risk estimates for fenoxycarb are based on specific types of worker and general public exposure. The estimates of single-day intake and noncancer risk from exposure to fenoxycarb, expressed as the Hazard Index [single day dose (mg/kg/day)/reference dose (RFD) (mg/kg/day)] are given in Table B2-10. Since fenoxycarb is not considered a carcinogen, no unit potency estimate has been determined, and estimates of lifetime cancer risk were not derived.

5.4.3 Human Risk Assessment

Under the conditions specified in the Exposure Assessment, fenoxycarb is not likely to pose a hazard to workers or to the general public by any of the exposure pathways evaluated. Hazard Indices were less than 1 for for all exposure conditions, indicating that the amount of exposure is less than the RFD for both workers and the general public.

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Table B2-10. Average and Maximum Estimates of Single-Day Intake and Associated Estimates of Risk for Exposure to Fenoxycarb

Exposure	Single-Day Estimated Intake (mg/kg/day)		Hazard Index	
	Average	Maximum	Average	Maximum
<u>Workers</u>				
Mixing/loading	2×10^{-3}	9×10^{-3}	9×10^{-3}	5×10^{-2}
Driving spray truck	1×10^{-4}	2×10^{-2}	7×10^{-4}	1×10^{-1}
<u>Public</u>				
Contact with sprayed vegetation	2×10^{-6}	1×10^{-5}	7×10^{-6}	6×10^{-5}
Exposure to berry pickers:				
Dermal exposure	2×10^{-6}	2×10^{-5}	1×10^{-5}	8×10^{-5}
Ingestion of berries	6×10^{-5}	6×10^{-4}	3×10^{-4}	3×10^{-3}
Exposure by ingestion of vegetables:				
Tomatoes	8×10^{-6}	3×10^{-4}	4×10^{-5}	2×10^{-3}
Lettuce	1×10^{-9}	4×10^{-3}	6×10^{-4}	2×10^{-2}
Beans	1×10^{-5}	4×10^{-4}	5×10^{-5}	2×10^{-3}
Exposure by ingestion of surface water	1×10^{-4}	2×10^{-4}	6×10^{-4}	1×10^{-3}
Exposure due to consumption of fish	2×10^{-3}	2×10^{-2}	7×10^{-3}	1×10^{-1}
Exposure due to consumption of wild game:				
Ingestion of deer meat*	8×10^{-7}	1×10^{-6}	4×10^{-6}	6×10^{-6}
Exposure from ingestion of groundwater	negligible	negligible	negligible	negligible

* High consumption

5.5 Glyphosate (Rodeo or Roundup)

Glyphosate, *N*-(phosphonomethyl)glycine, is a broadspectrum, nonspecific, nonresidual, postemergence herbicide used for crop, non-crop, and aquatic weed control. It controls a number of herbaceous and woody plants, but it is most effective on annual grasses (WSSA, 1989). Monsanto Company markets this herbicide under the trade names of Roundup and Rodeo. Roundup consists of 41.0% isopropylene salt of glyphosate with surfactants, while Rodeo consists of 53.5% isopropylamine salt of the active ingredient N-phosphonomethyl glycine without surfactants.

5.5.1 Acute Toxicological Effects

5.5.1.1 Man

Limited data for human toxicity are available in the current literature. Oral ingestion of Roundup results in irritation of the mucous membranes of the mouth, nausea, vomiting, and diarrhea (Monsanto, 1989). Accidental or intentional ingestion of large doses of glyphosate have been reported to produce hypotension and pulmonary edema (Monsanto, 1989). The Roundup formulation of glyphosate was applied to the skin of human subjects. Ninety-seven percent of the applied dose was recovered in skin washings (EPA, 1988). A conservative estimate of the average dermal absorption rate in man is approximately 3.5% (Shipp et al.,1986).

5.5.1.2 Animal Studies

Acute Oral Toxicity

The acute oral LD_{50} of technical grade glyphosate in rats ranged from 4,300 to 5,600 mg/kg, while the oral LD_{50}s for Roundup and Rodeo have been reported to be 5,400 mg/kg and 4,900 mg/kg, respectively (EPA, 1986). In rabbits, an LD_{50} of 3,800 mg/kg has been reported. Glyphosate, therefore, would be classified as a slightly toxic chemical.

Acute Dermal Toxicity

Glyphosate is poorly absorbed through the skin. No signs of toxicity were observed in rabbits exposed acutely to either glyphosate or Roundup at doses of up to 5,000 mg/kg. The acute dermal LD_{50} of glyphosate and Roundup in rabbits is, therefore, in excess of 5,000 mg/kg. In rats, the acute dermal LD_{50} of Roundup has been reported to be greater than 17,600 mg/kg (EPA, 1986). Technical grade glyphosate has been reported to be nonirritating to the skin of laboratory animals, while moderate skin irritation was reported following exposure to the formulated product Roundup. This has been attributed to the presence of surfactants in this product. No signs of skin sensitization have been reported in guinea pigs exposed to glyphosate.

Acute Ocular Toxicity

Glyphosate and Roundup have been reported to produce transient ocular irritation in the Draize Test (Shipp et al., 1986).

Acute Inhalation Toxicity

Four-hour exposures to either Roundup or Rodeo resulted in LC_{50}s of 3200 mg/m^3 and >1.3 mg/l, respectively (Monsanto, 1985). Rats subchronically exposed to an aerosol containing 0.36 mg of Roundup per liter of air resulted in only minor nasal irritation (Shipp et al., 1986).

5.5.2 Subchronic and Chronic Toxicity Effects

Mice fed glyphosate in their diet at concentrations of up to 50,000 ppm for 90 days showed reduced body weight gains. Chronic (lifetime) administration of up to 5,874 mg/kg/day resulted in a slight reduction in body weight and equivocal microscopic changes in the liver and kidney. Blood chemistries and organ function were not affected (Monsanto, 1985). Rats were fed up to 20,000 ppm technical glyphosate in their diets for 90 days. There were no mortalities or significant changes in either body weights or clinical chemistries. A chronic feeding study lasting 26 months found no observable adverse effects in male or female rats at dosages of up to 31 and 34 mg/kg/day, respectively. In a recently completed 24-month study, glyphosate was administered in the feed at levels up to 20,000 (approximately 1060 mg/kg). A NOEL of 8,000 ppm (approximately 410 mg/kg) was established based on reduced body weight gains in female rats and cataracts in male rats at the highest dose tested (Monsanto, 1991). Dogs were administered glyphosate (96.19% pure) at dosage levels up to 500 mg/kg/day for approximately one year. There were no significant changes in body or organ weights (EPA, 1986).

5.5.2.1 Reproductive Effects

A three-generation study of glyphosate conducted in 1980-81 with rats resulted in an equivocal increase in the incidence of renal tubular dilation in male pups of the third generation exposed to 30 mg glyphosate/kg/day. No effects were noted in the offspring exposed to 10 mg glyphosate/kg/day (EPA, 1988). A second rat reproduction study was conducted in 1990 using higher dosage levels than the 1981 study. Rats were fed up to 30,000 ppm (approximately 2268 mg/kg) in the diet. No histopathological lesions were observed in pup kidneys in this study. A NOEL of 10,000 ppm (approximately 740 mg/kg) was established based on a decreased weight gain in dams and decreased pup weights in the highest dose tested (Monsanto, 1990).

5.5.2.2 Teratogenicity

Rats given doses up to 3500 mg glyphosate/kg on days 6-19 of gestation did not result in any terata in the offspring, but there were maternal and fetotoxic effects. No fetotoxic effects occurred at the 1000 mg glyphosate/kg/day level. A maternal NOEL of 1000 mg/kg/day was established (EPA, 1988).

Rabbits gavaged on days 6 through 27 at a dosage of 350 mg glyphosate/kg/day resulted in maternal toxicity, but no terata were observed in the offspring. Based on these observations, a NOEL of 175 mg/kg/day was established (EPA, 1988).

5.5.2.3 Carcinogenicity

A lifetime feeding study (26 months) did not result in any oncogenic effects in rats at doses up to 31 mg glyphosate/kg/day. Mice administered 3,900 mg glyphosate/kg/day for 24 months resulted in benign renal tumors (renal tubular adenomas). A repeat oncogenic study in rats was recently reviewed by EPA. Rats were fed up to 20,000 ppm (approximately 1060 mg/kg) for 24 months. No evidence of treatment-related tumors was observed, and the cancer classification for glyphosate was changed to E, no evidence of carcinogenicity in man (Monsanto, 1991).

5.5.2.4 Mutagenicity

Glyphosate has been reported to be nonmutagenic in a number of prokaryotic and eukaryotic assays utilizing both *in vitro* and *in vivo* techniques (EPA, 1986).

5.5.2.5 Disposition

Glyphosate is poorly absorbed from the gastrointestinal tract and is excreted unchanged by mammals. Rats excrete over 99% and rabbits 90% of a single dose within 120 hours following a single exposure. Rats fed 100 ppm for 19 days resulted in tissue levels of 0.1 ppm or less. Glyphosate does not bioaccumulate in tissues to any significant extent, (Ghassemi et al., 1981) and has only limited capacity to undergo bioconcentration (USDA, 1984).

5.5.2.6 Regulation and Guidelines

EPA has established an oral reference dose of 2.0 mg/kg/day by applying a safety factor of 100 to the NOEL of 175 mg/kg/day determined in developmental toxicity study in rabbits (EPA, 1992).

5.5.2.7 Trace Contaminants

Technical grade glyphosate has been reported to contain small quantities of *N*-nitrosoglyphosate (0.1 ppm). This chemical has been shown to be of low toxicity and has been negative in all tests for mutagenicity and carcinogenicity (EPA, 1986).

The surfactant used in the commercial formulation Roundup® has been reported to contain low levels of 1,4-dioxane. 1,4-dioxane is a common laboratory solvent, and it occurs naturally in tomatoes, coffee, and shrimp. It is a trace level constituent in a large number of consumer preparations such as cosmetics, household detergents, and baby shampoo. It should not be confused with the unrelated chemical "dioxin."

The acute oral toxicity of 1,4 dioxane is low and is not a concern. 1,4 dioxane has been shown to cause tumors in laboratory animals given very high oral doses throughout their lifespan. Epidemiology studies have reported no association between cancer and individuals exposed occupationally to high levels of 1,4-dioxane.

The Food and Drug Administration has ruled that the risk associated with low levels of 1,4-dioxane was so low that it would be unnecessary to set specifications for 1,4-dioxane content in materials such as Roundup®. Although 1,4-dioxane is included in EPA List 1 Inerts of toxicological concern, the EPA's clear intent was and is to eliminate the compounds on List 1 as intentionally added ingredients in pesticide formulations. The use of 1,4-dioxane as an intentionally added inert ingredient would result in a concentration many times greater than its occurrence as a manufacturing impurity. It occurs in Roundup® as a manufacturing impurity, which may be difficult to detect.

5.5.2.8 Risk Characterization

Risk estimates for glyphosate would be based on specific types of worker and general public exposure. The estimates of single-day intake and noncancer risk from exposure to glyphosate, expressed as the Hazard Index [single day dose (mg/kg/day)/reference dose (RFD) (mg/kg/day)] are given in Table B2-11. Since glyphosate is not considered a carcinogen, no unit potency estimate has been determined, and estimates of lifetime cancer risk were not derived.

5.5.3 Human Risk Assessment

Under the conditions specified in the Exposure Assessment, glyphosate is not likely to pose a hazard to workers or to the general public by any of the exposure pathways evaluated. Hazard Indices were less than 1 for all exposure conditions, indicating that the amount of exposure is less than the RFD for both workers and the general public. Glyphosate is not expected to accumulate in animal tissues and was not evaluated by the game ingestion pathway.

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Table B2-11. Average and Maximum Estimates of Single-Day Intake and Associated Estimates of Risk for Exposure to Glyphosate

Exposure	Single-Day Estimated Intake (mg/kg/day)		Hazard Index	
	Average	Maximum	Average	Maximum
Workers				
Mixing/loading	1×10^{-3}	7×10^{-3}	5×10^{-4}	4×10^{-3}
Driving spray truck	3×10^{-4}	4×10^{-2}	2×10^{-4}	2×10^{-3}
Public				
Contact with sprayed vegetation	2×10^{-5}	1×10^{-4}	1×10^{-5}	5×10^{-5}
Exposure to berry pickers:				
Dermal exposure	3×10^{-5}	1×10^{-4}	2×10^{-5}	5×10^{-5}
Ingestion of berries	2×10^{-5}	1×10^{-4}	1×10^{-5}	5×10^{-5}
Exposure by ingestion of vegetables:				
Tomatoes	3×10^{-6}	5×10^{-5}	2×10^{-6}	3×10^{-5}
Lettuce	4×10^{-5}	7×10^{-4}	2×10^{-5}	4×10^{-4}
Beans	3×10^{-6}	7×10^{-5}	2×10^{-6}	4×10^{-5}
Exposure by ingestion of surface water	4×10^{-4}	5×10^{-4}	2×10^{-4}	3×10^{-4}
Exposure due to consumption of fish	2×10^{-5}	3×10^{-4}	1×10^{-5}	2×10^{-4}
Exposure due to consumption of wild game:				
Ingestion of deer meat	NA	NA	NA	NA
Exposure from ingestion of groundwater	2×10^{-5}	2×10^{-5}	1×10^{-5}	1×10^{-5}

Note: NA = Not Applicable

5.6 Hexazinone (Velpar)

Hexazinone [3-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(1H,3H)-dione] is a postemergence contact herbicide effective against a wide variety of annual and perennial weeds (WSSA, 1989). It is marketed by Dupont Chemical under the trade name Velpar.

5.6.1 Acute Toxicological Effects

5.6.1.1 Man

Little information on the human toxicity of hexazinone was located in the current literature. A 26-year old woman who inhaled an unknown concentration of hexazinone dust exhibited nausea and vomiting within 24 hours. The patient's recovery was uneventful, and no specific treatment was administered (EPA,1987).

5.6.1.2 Animal Studies

Acute Oral Toxicity

The oral LD_{50} for technical grade hexazinone in rats ranges from 1,690 to greater than 7,500 mg/kg (EPA, 1987). Based on these data, hexazinone is classified as slightly toxic. The oral LD_{50} for technical grade hexazinone in dogs is greater than 3,400 mg/kg (EPA, 1987).

Acute Dermal Toxicity

The acute dermal LD_{50} for technical grade hexazinone in rabbits has been reported to be greater than 5,278 mg/kg (EPA, 1991). Hexazinone has been shown to be negative in the guinea pig skin sensitization test and produced only slight irritation in the rabbit primary dermal irritation assay (EPA, 1991).

Acute Ocular Toxicity

Hexazinone has been reported to produce severe ocular irritation and is corrosive, causing irreversible eye damage (EPA, 1988).

Acute Inhalation Toxicity

The acute inhalation LC_{50} in male rats has been reported to be 7.48 mg/l for 95% hexazinone and >7.48 mg/l for technical grade hexazinone (EPA, 1991).

5.6.2 Subchronic And Chronic Toxicity Effects

Rats dosed with hexazinone (300 mg/kg) as a 5% suspension of either 89 or 98% active ingredient, administered five days/week for two weeks, resulted in no gross or histological tissue changes (EPA, 1991). Dogs and rats fed levels up to 5,000 ppm for 90 days had decreased body weights at the highest dose level. The NOEL for dogs and mice was 1000 ppm (EPA, 1987). Hamsters fed hexazinone in their diet for eight weeks at concentrations of up to 1500 mg/kg/day produced no observable adverse effects. Mice similarly treated exhibited decreased body weights and increased liver weights. A NOEL of 375 mg/kg/day was established based on these results (EPA, 1987).

5.6.2.1 Reproductive Effects

A three-generation study in which rats were fed up to 125 mg/kg/day of hexazinone failed to produce any adverse effects on reproduction or milk production. However, pup weaning weights at the highest dose level tested were significantly lower than in the control group (EPA, 1987). A NOEL of 50 mg/kg/day was established.

5.6.2.2 Teratogenicity

Rats administered hexazinone at doses up to 250 mg/kg/day on days 6 through 15 of gestation failed to produce any adverse developmental effects. Similarly, rabbits administered hexazinone at doses up to 125 mg/kg/day produced no observable adverse effects (EPA, 1987). Based on these studies, NOELs of 50 and 125 mg/kg/day were established for rats and rabbits, respectively.

5.6.2.3 Carcinogenicity

Chronic feeding studies lasting two years have been conducted with hexazinone at doses up to 125 mg/kg/day in rats and 1,500 mg/kg/day in mice. No oncogenic effects have been observed in either species (EPA, 1991).

5.6.2.4 Mutagenicity

Hexazinone has been reported to be nonmutagenic in the following assays: *in vivo* rat bone marrow cytogenic assay, unscheduled DNA synthesis assay, and *Salmonella typhimurium* assay with and without metabolic activation (EPA, 1991).

5.6.2.5 Disposition

Hexazinone is rapidly eliminated from rats following administration of a single dose. One study reported elimination of 97% of an oral dose in the rat within 3 to 6 days (EPA, 1987).

5.6.2.6 Regulations and Guidelines

An oral reference dose (RFD) of 0.033 mg/kg/day was established by EPA (1989) based on a two-year rat study in which a NOEL of 10 mg/kg/day was determined. A safety factor of 300 was applied to the NOEL.

5.6.2.7 Risk Characterization

Risk estimates for hexazinone would be based on specific types of worker and general public exposure. The estimates of single-day intake and noncancer risk from exposure to hexazinone, expressed as the Hazard Index [single day dose (mg/kg/day) / reference dose (RFD) (mg/kg/day)] are given in Table B2-12. Since hexazinone is not considered a carcinogen, no unit potency estimate has been determined, and estimates of lifetime cancer risk were not derived.

5.6.3 Human Risk Assessment

The estimated single-day intake for spray truck drivers under the maximum plausible case assumptions resulted in a Hazard Index of 2. This ratio indicates that adverse effects might occur in workers if their intake of hexazinone equals that estimated in the exposure assessment. This is not expected to occur because of the conservative rates applied, the relatively low level of toxicity of the herbicides, and the fact that clean protective clothing is required to be worn by TxDOT workers.

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Table B2-12. Average and Maximum Estimates of Single-Day Intake and Associated Estimates of Risk for Exposure to Hexazinone

Exposure	Single-Day Estimated Intake (mg/kg/day)		Hazard Index	
	Average	Maximum	Average	Maximum
Workers				
Mixing/loading	2×10^{-3}	9×10^{-3}	6×10^{-2}	3×10^{-1}
Driving spray truck	3×10^{-4}	8×10^{-2}	8×10^{-3}	2×10^{0}
Public				
Contact with sprayed vegetation	3×10^{-6}	5×10^{-5}	9×10^{-5}	2×10^{-3}
Exposure to berry pickers:				
Dermal exposure	5×10^{-6}	6×10^{-5}	1×10^{-4}	2×10^{-3}
Ingestion of berries	1×10^{-4}	2×10^{-3}	4×10^{-3}	7×10^{-2}
Exposure by ingestion of vegetables:				
Tomatoes	2×10^{-5}	1×10^{-3}	5×10^{-4}	4×10^{-2}
Lettuce	2×10^{-4}	2×10^{-2}	7×10^{-3}	5×10^{-1}
Beans	2×10^{-5}	2×10^{-3}	6×10^{-4}	5×10^{-2}
Exposure by ingestion of surface water	3×10^{-4}	8×10^{-4}	8×10^{-3}	2×10^{-2}
Exposure due to consumption of fish	3×10^{-5}	8×10^{-4}	8×10^{-4}	2×10^{-2}
Exposure due to consumption of wild game:				
Ingestion of deer meat	NA	NA	NA	NA
Exposure from ingestion of groundwater	1×10^{-4}	4×10^{-4}	4×10^{-3}	1×10^{-2}

Note: NA = Not Applicable

5.7 Imazapyr (Arsenal)

Imazapyr (2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazole-2-yl]-3-pyridine-carboxylic acid) is a broadspectrum herbicide which is used to control broadleaf weeds and annual grasses. It may be applied pre- or postemergence. It is marketed by American Cyanamid Company under the trade names Arsenal, Chopper, and Contain (WSSA, 1989).

5.7.1 Acute Toxicological Effects

5.7.1.1 Man

No human toxicity data were located in the current literature.

5.7.1.2 Animal Studies

Acute Oral Toxicity

Imazapyr is classified as very slightly toxic based on an acute oral LD_{50} of greater than 5,000 mg/kg in rats for both the technical material and Arsenal formulations (EPA, 1985).

Acute Dermal Toxicity

The acute dermal LD_{50} of imazapyr in both rats and rabbits was determined to be greater than 2,000 mg/kg (EPA, 1985). Imazapyr has been found to be only mildly irritating to rabbit skin (EPA, 1985). Imazapyr did not produce dermal sensitization in guinea pigs. In a 21-day dermal study conducted on rabbits, no systemic toxicity was observed at 400 mg/kg/day.

Acute Ocular Toxicity

In a rabbit eye irritation study, imazapyr was only slightly irritating, with full recovery within seven days (EPA, 1985).

Acute Inhalation Toxicity

No data was located as to the acute inhalation LC_{50} for imazapyr.

5.7.2 Subchronic and Chronic Toxicity Effects

In a subchronic oral (13 weeks) toxicity study in rats, imazapyr did not produce any adverse effects and resulted in a NOEL of greater than 500 mg/kg/day, the highest dose tested (American Cyanamid, 1985).

5.7.2.1 Teratogenicity

Imazapyr was not teratogenic in either rats or rabbits. A maternal NOEL of 300 mg/kg/day was established based on salivation observed in rats administered 1000 mg/kg/day (EPA, 1985). No adverse effects were observed in rabbits receiving up to 400 mg/kg/day.

5.7.2.2 Carcinogenicity

Rats were fed imazapyr for 12 months. No oncogenic effects were observed at doses up to 500 mg/kg/day (Biodynamics, Inc., undated).

5.7.2.3 Mutagenicity

Imazapyr has been reported to be nonmutagenic in the following assays: Salmonella/ microsome assay, Chinese hamster ovary cell HPRT assay, Chinese hamster ovary cell cytogenetic assay, in an unscheduled DNA repair assay, and in a dominant lethal mouse assay. Imazapyr is not considered to be mutagenic based on these studies.

5.7.2.4 Disposition

Imazapyr is rapidly eliminated by rats following a single dose, with over 87% eliminated within 24 hours (American Cyanamid, 1985).

5.7.2.5 Regulation and Guidelines

An oral reference dose (RFD) has not been determined for imazapyr. An RFD of 3 mg/kg/day was estimated based on a rat teratology study in which a maternal NOEL of 300 mg/kg/day was determined and a safety factor of 100 applied.

5.7.2.6 Risk Characterization

Risk estimates for imazapyr would be based on specific types of worker and general public exposure. The estimates of single-day intake and noncancer risk from exposure to imazapyr, expressed as the Hazard Index [single day dose (mg/kg/day)/reference dose (RFD) (mg/kg/day)], are given in Table B2-13. Since imazapyr is not considered a carcinogen, no unit potency estimate has been determined, and estimates of lifetime cancer risk were not derived.

5.7.3 Human Risk Assessment

Under the conditions specified in the Exposure Assessment, imazapyr is not likely to pose a hazard to workers or to the general public by any of the exposure pathways evaluated. Hazard Indices were less than 1 for for all exposure conditions, indicating that the amount of exposure is less than the RFD for both workers and the general public. Imazapyr is not expected to accumulate in animal tissues according to the biotransfer factor and was not evaluated by the game ingestion pathway.

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U.S. Environmental Protection Agency. 1985. Pesticide Fact Sheet for Imazapyr. Washington, D.C., Office of Pesticides and Toxic Substances.

Weed Science Society of America. 1989. Herbicide Handbook, 6th ed. Champaign,IL.

Table B2-13. Average and Maximum Estimates of Single-Day Intake and Associated Estimates of Risk for Exposure to Imazapyr

Exposure	Single-Day Estimated Intake (mg/kg/day)		Hazard Index	
	Average	Maximum	Average	Maximum
<u>Workers</u>				
Mixing/loading	2×10^{-3}	9×10^{-3}	6×10^{-3}	3×10^{-2}
Driving spray truck	3×10^{-4}	4×10^{-2}	9×10^{-4}	1×10^{-1}
<u>Public</u>				
Contact with sprayed vegetation	1×10^{-6}	1×10^{-5}	5×10^{-6}	4×10^{-5}
Exposure to berry pickers:				
Dermal exposure	2×10^{-6}	2×10^{-5}	8×10^{-6}	5×10^{-5}
Ingestion of berries	6×10^{-5}	6×10^{-4}	2×10^{-4}	2×10^{-3}
Exposure by ingestion of vegetables:				
Tomatoes	8×10^{-6}	3×10^{-4}	3×10^{-5}	1×10^{-3}
Lettuce	1×10^{-4}	4×10^{-3}	4×10^{-4}	1×10^{-2}
Beans	1×10^{-5}	4×10^{-4}	3×10^{-5}	1×10^{-3}
Exposure by ingestion of surface water	1×10^{-4}	2×10^{-4}	3×10^{-4}	6×10^{-4}
Exposure due to consumption of fish	2×10^{-5}	3×10^{-4}	7×10^{-5}	1×10^{-3}
Exposure due to consumption of wild game:				
Ingestion of deer meat	NA	NA	NA	NA
Exposure from ingestion of groundwater	2×10^{-4}	4×10^{-4}	8×10^{-4}	1×10^{-3}

Note: NA = Not Applicable

5.8 Metsulfuron Methyl (Escort)

Metsulfuron methyl (methyl 2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)-amino] carbonyl] amino]sulfonyl]benzoate) is a broadspectrum herbicide used to control broadleaf and some annual grass and weeds. It may be applied pre- or postemergence. It is marketed by Du Pont under the trade names of Ally or Escort as a 60% dry flowable (WSSA, 1989).

5.8.1 Acute Toxicological Effects

5.8.1.1 Man

No human toxicity data were located in the current literature.

5.8.1.2 Animal Studies

Acute Oral Toxicity

Metsulfuron methyl is classified as very slightly toxic based on an acute oral LD_{50} of greater than 5,000 mg/kg in rats (Worthing and Walker, 1987).

Acute Dermal Toxicity

The acute dermal LD_{50} of metsulfuron methyl in rabbits was determined to be greater than 2,000 mg/kg. Metsulfuron methyl (60% formulation) has been found to be moderately irritating to rabbits (EPA, 1988).

Acute Ocular Toxicity

In an eye irritation study using rabbits, metsulfuron methyl produced slight corneal clouding, moderate iritis, and moderate to severe conjunctivitis in unwashed eyes. All effects were reversed within 14 days (Du Pont, 1984).

Acute Inhalation Toxicity

The acute inhalation LC_{50} for metsulfuron methyl in rats has been reported to be greater than 5.0 mg/l based on four hours of exposure (Du Pont, 1984).

5.8.2 Subchronic and Chronic Toxicity Effects

In a subchronic oral (90 days) toxicity study in dogs, metsulfuron methyl did not produce any adverse effects and resulted in a NOEL of greater than 125 mg/kg/day, the highest dose tested (Du Pont, 1984). In a similar study in rats, a systemic NOEL of 50 mg/kg/day was established based on reduced body weight and serum protein levels observed in animals receiving 375 mg/kg/day (EPA, 1988).

In chronic oral toxicity studies, metsulfuron methyl was administered to rats, mice, and dogs for periods of 24, 18, and 12 months, respectively. No adverse effects were observed in mice, while rats showed a reduction in body weight gains, and dogs showed a reduction in the serum enzyme lactate dehydrogenase. Systemic NOELs of 25 mg/kg/day, 750 mg/kg/day, and 1.25 mg/kg/day were established for rats, mice, and dogs, respectively (EPA, 1988).

5.8.2.1 Reproductive Effects

In a two-generation rat reproduction study, metsulfuron methyl was not fetotoxic at the highest dose tested (250 mg/kg/day). A maternal systemic NOEL of 25 mg/kg/day was established based on a reduction in body weight gain observed in the 250 mg/kg/day treatment group (EPA, 1988).

5.8.2.2 Teratogenicity

Metsulfuron methyl was not found to be teratogenic in either rats or rabbits (Du Pont, 1984). Fetotxic and teratogenic NOELs of 1,000 mg/kg/day and 700 mg/kg/day (highest doses tested) were established for rats and rabbits, respectively (EPA, 1988).

5.8.2.3 Carcinogenicity

Mice and rats were fed metsulfuron methyl for 18 and 24 months, respectively. No oncogenic effects were observed in either species at doses up to 750 mg/kg/day in mice or 250 mg/kg/day in rats (EPA, 1988). Metsulfuron methyl is not considered to be a human carcinogen in this risk assessment.

5.8.2.4 Mutagenicity

Metsulfuron methyl has been reported to be nonmutagenic in the *Salmonella*/microsome assay, Chinese hamster ovary cell assay, an *in vivo* rat bone marrow cytogenetic assay, and an unscheduled DNA repair assay. However, Du Pont reported metsulfuron methyl to be mutagenic in the Chinese ovary cell assay (Du Pont, 1984). Metsulfuron methyl is not considered to be a potential human mutagen in this risk assessment.

5.8.2.5 Disposition

Metsulfuron methyl is rapidly eliminated from rats following a single administration. Over 90.2% is eliminated within three days (EPA, 1988).

5.8.2.6 Regulation and Guidelines

An oral reference dose (RFD) of 0.25 mg/kg/day was established by EPA (1989) based on a two-year rat study in which a NOEL of 25 mg/kg/day was determined. The RFD was derived from a NOEL of 25 mg/kg/day and a safety factor of 100.

5.8.2.7 Risk Characterization

Risk estimates for metsulfuron methyl would be based on specific types of worker and general public exposure. The estimates of single-day intake and noncancer risk from exposure to metsulfuron methyl, expressed as the Hazard Index [single day dose (mg/kg/day)/ reference dose (RFD) (mg/kg /day)] are given in Table B2-14. Since metsulfuron methyl is not considered a carcinogen, no unit potency estimate has been determined, and estimates of lifetime cancer risk were not derived.

5.8.3 Human Risk Assessment

Under the conditions specified in the Exposure Assessment, metsulfuron methyl is not likely to pose a hazard to workers or to the general public by any of the exposure pathways evaluated. Hazard Indices were less than 1 for for all exposure conditions, indicating that the amount of exposure is less than the RFD for both workers and the general public. Metsulfuron methyl was not expected to accumulate in animal tissues according to the biotransfer factor and was not evaluated by the game ingestion pathway.

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Worthing, C.R. and S.B. Walker, eds. The Pesticide Manual. 1987. The British Crop Protection Council. The Lavenham Press Ltd. Suffolk, England.

Table B2-14. Average and Maximum Estimates of Single-Day Intake and Associated Estimates of Risk for Exposure to Metsulfuron Methyl

Exposure	Single-Day Estimated Intake (mg/kg/day)		Hazard Index	
	Average	Maximum	Average	Maximum
<u>Workers</u>				
Mixing/loading	2×10^{-3}	9×10^{-3}	7×10^{-3}	4×10^{-2}
Driving spray truck	8×10^{-6}	2×10^{-3}	3×10^{-5}	1×10^{-2}
<u>Public</u>				
Contact with sprayed vegetation	9×10^{-8}	2×10^{-6}	4×10^{-7}	6×10^{-6}
Exposure to berry pickers:				
Dermal exposure	2×10^{-7}	2×10^{-6}	6×10^{-7}	8×10^{-6}
Ingestion of berries	4×10^{-6}	7×10^{-5}	2×10^{-5}	3×10^{-4}
Exposure by ingestion of vegetables:				
Tomatoes	5×10^{-7}	4×10^{-5}	2×10^{-6}	2×10^{-4}
Lettuce	7×10^{-6}	5×10^{-4}	3×10^{-5}	2×10^{-3}
Beans	6×10^{-7}	5×10^{-5}	2×10^{-6}	2×10^{-4}
Exposure by ingestion of surface water	8×10^{-6}	3×10^{-5}	3×10^{-5}	1×10^{-4}
Exposure due to consumption of fish	2×10^{-6}	5×10^{-5}	7×10^{-6}	2×10^{-4}
Exposure due to consumption of wild game:				
Ingestion of deer meat	NA	NA	NA	NA
Exposure from ingestion of groundwater	negligible	negligible	negligible	negligible

Note: NA = Not Applicable

5.9 Sulfometuron Methyl (Oust)

Sulfometuron methyl (2-[[[[(4,6-dimethyl-2-pyrimidinyl)amino]carbonyl]amino] sulfonyl] benzoate) is a broadspectrum herbicide marketed by Du Pont Chemical Company under the trade name of Oust. This commercial product contains 75% sulfometuron methyl. This herbicide acts by arresting cell division in root tips and is used to control grasses and broadleaf weeds. It may be applied either pre- or postemergence (WSSA, 1989).

5.9.1 Acute Toxicological Effects

5.9.1.1 Man

No information was located in the current literature on the toxicity of sulfometuron methyl to humans.

5.9.1.2 Animal Studies

Acute Oral Toxicity

Sulfometuron methyl is considered to be slightly toxic to mammals based on laboratory animal data. The acute oral LD_{50} of sulfometuron methyl in rats has been reported to be greater than 5,000 mg/kg (EPA, 1989).

Acute Dermal Toxicity

The acute dermal toxicity in rabbits has been reported to be greater than 2,000 mg/kg for both technical and commercial grades of sulfometuron methyl. Sulfometuron methyl is slightly to moderately irritating to rabbit skin. A skin sensitization test conducted on guinea pigs was negative.

Acute Ocular Toxicity

Sulfometuron methyl has been reported to be slightly to moderately irritating to rabbit eyes in the Draize Test (EPA, 1984).

Acute Inhalation Toxicity

No data on the inhalation toxicity of sulfometuron methyl was located in the literature.

5.9.2 Subchronic and Chronic Toxicity Studies

In a 90-day subchronic feeding study, rats received up to 0.5% sulfometuron methyl in the diet. Hematological effects (increased white blood cell counts) were observed in animals receiving 250 mg/kg day. No effects were seen at a dose of 50 mg/kg/day. In a two-year rat-feeding study, hemolytic effects, liver toxicity, and decreased brain weights were observed at 25 mg/kg/day. In a one-year dog-feeding study, anemia and increased liver weights were reported at the 25 mg/kg/day level. A systemic NOEL of 5 mg/kg/day was determined (Du Pont, 1986).

5.9.2.1 Reproductive Effects

In a one-generation rat reproduction study, no reproductive effects were observed in rats administered technical sulfometuron methyl in the diet at up to 250 mg/kg/day. In an additional two-generation study, a NOEL of 25 mg/kg/day was established based on decreased weight gain by dams and reduced numbers of offspring (EPA, 1988).

5.9.2.2 Teratogenicity

In a rat teratology study, no terata were observed at the highest dose administered (250 mg sulfometuron methyl/kg/day). Reduced body weight gains were observed in the dams, and fetotoxicity in the offspring was confined to reduced body weights. A NOEL of 50 mg/kg/day was determined. Rabbits administered up to 300 mg sulfometuron methyl/kg/day (highest dose tested) did not result in any adverse effects to either dams or offspring (EPA, 1984).

5.9.2.3 Carcinogenicity

In a two-year feeding study in rats and a one-year study in dogs, no oncogenic effects were seen. Based on these data, sulfometuron methyl is not considered carcinogenic in this risk assessment.

5.9.2.4 Mutagenicity

Sulfometuron methyl was found to be nonmutagenic in both the *Salmonella/* microsome assay and the Chinese hamster ovary cell assay (EPA, 1984). It has also been reported to be negative in both cytogenetic and unscheduled DNA synthesis assays (Du Pont, 1986).

5.9.2.5 Disposition

No metabolic studies on sulfometuron methyl were located in the literature.

5.9.2.6 Regulation and Guidelines

No regulatory criteria or guidelines were located. An oral reference dose (RFD) of 0.05 mg/kg/day was derived from a one-year chronic dog study. The RFD was derived from a NOEL of 5 mg/kg and a safety factor of 100.

5.9.2.7 Risk Characterization

Risk estimates for sulfometuron methyl would be based on specific types of worker and general public exposure. The estimates of single-day intake and noncancer risk from exposure to sulfometuron methyl, expressed as the Hazard Index [single day dose (mg/kg/day)/ reference dose (RFD) (mg/kg/day)], are given in Table B2-15. Since sulfometuron methyl is not considered a carcinogen, no unit potency estimate has been determined, and estimates of lifetime cancer risk were not derived.

5.9.3 Human Risk Assessment

Under the conditions specified in the Exposure Assessment, sulfometuron methyl is not likely to pose a hazard to workers or to the general public by any of the exposure pathways evaluated. Hazard Indices were less than 1 for for all exposure conditions, indicating that the amount of exposure is less than the RFD for both workers and the general public. Sulfometuron methyl is not expected to accumulate in animal tissues according to the biotransfer factor and, therefore, was not evaluated by the game ingestion pathway. Based on the low tendency to persist in water, sulfometuron methyl likely would not be found in groundwater and, therefore, this pathway poses little risk.

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Weed Science Society of America. 1989. Herbicide Handbook, 6th ed. Champaign, IL.

Table B2-15. Average and Maximum Estimates of Single-Day Intake and Associated Estimates of Risk for Exposure to Sulfometuron Methyl

Exposure	Single-Day Estimated Intake (mg/kg/day)		Hazard Index	
	Average	Maximum	Average	Maximum
Workers				
Mixing/loading	2×10^{-3}	9×10^{-3}	4×10^{-2}	2×10^{-1}
Driving spray truck	2×10^{-5}	3×10^{-3}	3×10^{-4}	7×10^{-2}
Public				
Contact with sprayed vegetation	2×10^{-7}	2×10^{-6}	4×10^{-6}	4×10^{-5}
Exposure to berry pickers:				
Dermal exposure	3×10^{-7}	3×10^{-6}	6×10^{-6}	5×10^{-5}
Ingestion of berries	7×10^{-6}	1×10^{-4}	2×10^{-5}	2×10^{-3}
Exposure by ingestion of vegetables:				
Tomatoes	1×10^{-6}	5×10^{-7}	2×10^{-5}	1×10^{-3}
Lettuce	2×10^{-5}	7×10^{-5}	3×10^{-4}	1×10^{-2}
Beans	1×10^{-6}	7×10^{-5}	2×10^{-5}	1×10^{-3}
Exposure by ingestion of surface water	2×10^{-5}	3×10^{-5}	3×10^{-4}	7×10^{-4}
Exposure due to consumption of fish	5×10^{-6}	1×10^{-4}	1×10^{-4}	2×10^{-3}
Exposure due to consumption of wild game:				
Ingestion of deer meat	NA	NA	NA	NA
Exposure from ingestion of groundwater	negligible	negligible	negligible	negligible

Note: NA = Not Applicable

5.10 Triclopyr (Pathfinder II)

Triclopyr [(3,5,6-trichloro-2-pyridinyl)oxyacetic acid] is a broadspectrum herbicide which acts as a growth regulator. It is effective against broadleaf weeds and woody plants (WSSA, 1989). DowElanco recently replaced the formulation Garlon 4® with the formulation Pathfinder II ® for trunk base treatment of mesquite and some other brush. Both are formulated as the butoxyethyl ester of triclopyr. Pathfinder II contains a vegetable oil as a principal solvent, replacing diesel oil in Garlon 4. Pathfinder II is applied as formulated, whereas Garlon 4 was diluted in diesel for application.

5.10.1 Acute Toxicological Effects

5.10.1.1 Man

No adverse effects were observed in human volunteers who ingested single oral doses (0.5 mg/kg body weight) of triclopyr (Carmichael et al., 1989).

5.10.1.2 Animal Studies

Acute Oral Toxicity

Triclopyr is classified as very slightly toxic based on acute oral LD_{50}s in rats. Pathfinder II® has reported acute LD_{50}s ranging from 4183 to 4464 mg/kg (MSDS dated March 17,1994).

Acute Dermal Toxicity

Triclopyr is slightly irritating to rabbit skin (EPA, 1986). No deaths were reported in rabbits dermally exposed to either triclopyr or its formulations at doses of 2,000 and 3,980 mg/kg, respectively. The acute dermal LD_{50} of triclopyr in rabbits was determined to be greater than 2,000 mg/kg (Worthing and Walker, 1987).

Acute Ocular Toxicity

In rabbit eye irritation studies, eye irritation varied with triclopyr formulation. Pathfinder II® (used by TxDOT) may cause slight temporary eye irritation, but corneal injury is unlikely, according to MSDS dated March 17, 1994. Eye irritation for the technical acid is mild and slight for the butoxyethyl esters Garlon 4® (Weed Science Society of American, 1994). The commercial triethylamine salt formulation Garlon 3® (not specified by TxDOT) may cause severe eye irritation or even blindness, according to MSDS dated January 31, 1995.

Acute Inhalation Toxicity

Acute inhalation of 5.3 ppm of technical triclopyr for one hour did not result in any adverse effects in rats. However, rats exposed to 0.82 ppm of Garlon 4 for four hours resulted in transitory nasal irritation (WSSA, 1989).

5.10.2 Subchronic and Chronic Toxicity Effects

Subchronic oral (14- and 90-day) toxicity studies have been conducted in mice and rats, respectively. Triclopyr produced decreased liver and increased brain and kidney weights in both species. Decreased weight gains were observed in both rats and mice at the highest doses tested (100 mg/kg/day in rats and 60 mg/kg/day in mice). A NOEL for males of each species was reported to be 30 and 20 mg/kg/day for rats and mice, respectively (EPA, 1986). Triclopyr administered orally to monkeys at a dose of 30 mg/kg for 28 days failed to produce any adverse effects.

In chronic oral toxicity studies, triclopyr was administered to rats and mice for 24 months and dogs for 6 and 7.5 months. No adverse effects were observed in either rats or mice at the highest doses tested, 30 and 36 mg/kg/day, respectively (EPA, 1986). Dogs showed a reduction in renal function based on phenolsulfonphalein excretion in the highest treatment group (2.5 mg/k/day for six months). A NOEL of 0.5 mg/kg/day was reported. In a second study in which dogs were fed triclopyr over a six-month period at doses of 5 mg/kg/day and higher, elevated renal and liver enzyme levels were observed. Based on this study, a systemic NOEL of 2.5 mg/kg/day was established. The adverse effects observed in dogs are thought to be due to the inability of dogs to effectively excrete organic anions. These effects are not expected to occur in man because triclopyr is rapidly excreted. The NOEL of 2.5 mg/kg/day may tend to overestimate expected effects in humans with normal renal function.

5.10.2.1 Reproductive Effects

In a three-generation rat reproduction study, no adverse effects were observed at the highest dose (30 mg/kg/day) tested (EPA, 1986).

5.10.2.2 Teratogenicity

Triclopyr was not found to be teratogenic in rats given 50, 100 or 200 mg/kg/day. Fetotoxic and maternal toxic NOELs of 25 mg triclopyr/kg/day were established based on retardation of fetal skull bone ossification and decreased maternal body weight gain (EPA, 1986). Triclopyr was not found to be teratogenic in two separate studies using rabbits at the highest doses tested (25 and 100 mg/kg/day) (EPA, 1986, 1988).

5.10.2.3 Carcinogenicity

Mice and rats were fed triclopyr orally for 24 months. No oncogenic effects were observed in either species at doses up to 30 mg/kg/day, respectively (EPA, 1986). In a second 24-month study in which rats were orally dosed with triclopyr, female rats in the high dose group (36 mg/kg/day) were found to have statistically significant increases in mammary tumors (USDA, 1984). However, these results were within the historical range for control animals (Dow, 1987), and triclopyr is not considered to be a human carcinogen in this risk assessment.

5.10.2.4 Mutagenicity

Triclopyr has been reported to be nonmutagenic in the *Salmonella*/microsome assay, host mediated assay in mice, Chinese hamster ovary cell assay, *in vivo* rat bone marrow cytogenetic assay, dominant lethal mouse assay and, in unscheduled DNA repair assay with rat hepatocytes. However, triclopyr has been reported to be weakly positive in the dominant lethal rat assay (EPA 1988). Triclopyr is not considered to be a potential human mutagen in this risk assessment.

5.10.2.5 Disposition

Triclopyr is rapidly eliminated from rats following administration of a single dose with a urinary half-life of 1.5 hours in the rat. Approximately 90% of the administered dose would be expected to be excreted in six hours (USDA, 1984).

5.10.2.6 Regulation and Guidelines

An oral reference dose for triclopyr has not been established. An equivalent RFD of 0.005 mg triclopyr/kg/day was derived based on a six-month feeding study in dogs in which a NOEL of 0.5 mg/kg/day was reported. A safety factor of 100 was applied to the NOEL.

5.10.2.7 Risk Characterization

Risk estimates for triclopyr would be based on specific types of worker and general public exposure. The estimates of single-day intake and noncancer risk from exposure to triclopyr, expressed as the Hazard Index [single day dose (mg/kg/day)/reference dose (RFD) (mg/kg/day)] are given in Table B2-16. Since triclopyr is not considered a carcinogen, no unit potency estimate has been determined, and estimates of lifetime cancer risk were not derived.

5.10.3 Human Risk Assessment

The estimated single day intake for spray truck drivers under the maximum plausible case assumptions resulted in a Hazard Index of 2. This ratio indicates that adverse effects might occur in workers if their intake of triclopyr equals that estimated in the exposure assessment.

This is not expected to occur because of change in formulation of the conservative rate of application, the short half-life of the herbicide, and the fact that clean protective clothing is required to be worn by workers. Environmental exposures to the general public, under maximum plausible conditions, would be expected to be without any risk of adverse effect, except for ingestion of lettuce for which the Hazard Index is greater than 1. Actually, only small quantities of triclopyr would be used at any one time, so the likelihood of inadvertent drifting of pesticide spray onto vegetables is extremely minimal. In addition, it was assumed the lettuce was not washed before eating, and the amount of lettuce ingested (corresponding to the 95th percentile) would be very conservative assumptions. It is very unlikely that the maximum plausible case levels would be reached in these scenarios.

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Table B2-16. Average and Maximum Estimates of Single-Day Intake and Associated Estimates of Risk for Exposure to Triclopyr

Exposure	Single-Day Estimated Intake (mg/kg/day)		Hazard Index	
	Average	Maximum	Average	Maximum
Workers				
Mixing/loading	4×10^{-4}	2×10^{-3}	7×10^{-2}	4×10^{-1}
Driving spray truck	3×10^{-5}	1×10^{-2}	5×10^{-3}	2×10^{0}
Public				
Contact with sprayed vegetation	2×10^{-6}	6×10^{-5}	5×10^{-4}	1×10^{-2}
Exposure to berry pickers:				
Dermal exposure	4×10^{-6}	7×10^{-5}	8×10^{-4}	1×10^{-2}
Ingestion of berries	6×10^{-5}	2×10^{-3}	1×10^{-2}	3×10^{-1}
Exposure by ingestion of vegetables:				
Tomatoes	8×10^{-6}	8×10^{-4}	2×10^{-3}	2×10^{-1}
Lettuce	1×10^{-4}	1×10^{-2}	2×10^{-3}	2×10^{0}
Beans	1×10^{-5}	1×10^{-3}	2×10^{-3}	2×10^{-1}
Exposure by ingestion of surface water	1×10^{-4}	5×10^{-4}	3×10^{-2}	1×10^{-1}
Exposure due to consumption of fish	1×10^{-4}	5×10^{-3}	3×10^{-2}	1×10^{0}
Exposure due to consumption of wild game:				
Ingestion of deer meat*	2×10^{-5}	7×10^{-5}	3×10^{-3}	1×10^{-2}
Exposure from ingestion of groundwater	negligible	negligible	negligible	negligible

* High consumption

6.0 Exposure Assessment

Exposure assessment involves the quantitative estimation of the amount of pesticide that a worker or a member of the general public would come into contact with. In this assessment, both those workers directly involved in pesticide application (mixers/loaders and spray truck drivers) and the general public (through dermal contact with sprayed vegetation and ingestion of food and water) were evaluated. The models used to derive these doses and the underlying assumptions were developed by Clement International Corporation and are used with their permission (Shipp, 1992). In cases where information on a specific pesticide was not available, exposure estimates were made from data on similar chemicals.

Pesticide applications may vary from region to region within the state. It is highly unlikely that the general public or workers in any given area would be exposed to all of the pesticides examined in this assessment. Average and high pesticide application rates obtained from the Texas Department of Transportation were used in conjunction with average and conservative exposure assumptions in determining the potential risk to man. The amount of pesticide that an individual may be exposed to under the various scenarios is only a theoretical estimate based on the assumptions and conditions outlined in the risk assessment. The assessment is not intended to show what will happen, but rather what could potentially occur if all the parameters and assumptions were met.

6.1 Potential Routes of Human Exposure

In order for an individual to be exposed to a pesticide, several conditions must be met. First, the pesticide must be present in the environment, and second, the individual must come into contact with the chemical. The quantity of chemical that is absorbed into the body (either through percutaneous absorption, inhalation, or through ingestion of contaminated food or water) constitutes the dose.

Activities in which individuals could potentially be exposed to pesticides are listed in Table B2-17. Workers directly involved in mixing and loading pesticides and those involved in applying pesticides under field conditions are expected to receive the largest dose of pesticide. For each activity outlined in Table B2-17, a set of parameters was used to characterize an activity, such as the amount of time spent in a particular activity, frequency of exposure to a pesticide, amount of fish, game, or vegetables consumed, etc. For each activity, an average or high plausible exposure was calculated using application rates currently used by the Texas Department of Transportation. Each pathway was evaluated and a single-day dose expressed on a milligram per kilogram per day weight (mg/kg/day) basis for a 70-kg adult (EPA, 1989) was determined for both average and high application rates.

The major route of pesticide exposure for workers is through dermal exposure. This may occur in the course of mixing and loading pesticides or when applying pesticides. Although workers may inhale vapors from volatile pesticides or spray droplets, field studies have demonstrated that this route of exposure is of minor significance in comparison to dermal absorption. Based on the data of Draper and Street (1982), spray truck drivers working eight hours per day and breathing 29 liters of air per minute would absorb a maximum of 0.03 milligrams of 2,4-D through their lungs compared to 18 milligrams through their skin. Therefore, inhalation of 2,4-D contributed less than 0.17% of the dermal exposure. In another study, Libich et al. (1984) reported that 50 times more 2,4-D was absorbed through the skin than through the lungs.

Although members of the public may be exposed to pesticides, the level of exposure is expected to be significantly less than those who work with these chemicals on a regular basis. Members of the public may be exposed to pesticides through pesticide spray drift, contact with sprayed vegetation, and through ingestion of contaminated food and water. Since inhalation only contributes a very small amount of pesticide to the overall body burden (USDA, 1984), only dermal and dietary routes of exposure were considered in this analysis.

6.2 Occupational Exposure

The amount of pesticide that a worker may potentially receive while involved in mixing/loading and spraying operations was determined for each of the 10 pesticides.

6.2.1 Pesticide Transport and Fate Modeling

The amount of pesticide that may be absorbed by a worker following dermal contact may be estimated from data obtained in field studies. Often these studies provide an indirect estimate of dermal exposure based on the amount of chemical deposited on absorbent fabric patches or through biological monitoring in which the amount of chemical excreted in the urine is used as a direct measure of the amount of pesticide absorbed. Feldman and Maibach (1974) reported that the absorption of 2,4-D was lower when applied to the forearm than when applied to the neck, face, and scalp. Based on these data, Shipp et al. (1986) calculated an average body dermal absorption rate for 2,4 -D of 10%. Using unpublished data from Monsanto (1984), Shipp et al. (1986) estimated an average dermal absorption rate of 3.5% for glyphosate, while Carmichael et al. (1989) reported a dermal absorption rate of 1.65% for triclopyr. When dermal absorption rates were not located for the other pesticides considered in this assessment, the assumption was made that they would be absorbed at a rate similar to that of 2,4-D, thus providing a conservative estimate of this parameter.

6.2.2 Exposure to Mixers/Loaders

Nash et al. (1982) estimated that a worker mixed and loaded 20 lbs active ingredient (a.i.) of a particular pesticide per day for the average case and 40 lbs a.i. under the maximum plausible case. Exposure of mixers/loaders was estimated on a basis of exposure per hr/1 lb a.i./acre, which was then corrected for the actual application rate used by the Texas Department of Transportation. It was assumed that mixers/loaders were exposed four hours per day in the average case and six hours per day in the maximum case. Single day doses were estimated for mixers/loaders using the following equation:

$$\mathbf{SDM/L = \frac{ED \times PLs \times DAH}{DAS}}$$

where:

SDM/L	=	single-day dose mixers/loaders (mg/kg)
ED	=	cumulative urinary excretion of 2-4 D over six days for monitored mixers/loaders following a single day exposure in Nash et al. (1982) (mg/kg/lb a.i. loaded)
PLs	=	lb a.i. loaded/day for single exposure
DAH	=	fraction of herbicide of interest dermally absorbed (unitless)
DAS	=	fraction of surrogate herbicide dermally absorbed (unitless)

Table B2-18 lists single-day doses of each pesticide for mixers/loaders.

6.2.3 Exposure to Spray Truck Drivers

Exposure of spray truck drivers was estimated from the results of a study by Carmen et al. (1984) in which dermal and inhalation exposure to the pesticide parathion were measured in spray rig drivers treating citrus groves. Based on this study, an average dermal exposure was determined to be 0.0041 mg/kg/hr for 1 lb a.i. when cab windows were closed and 0.267 mg/kg/hr for the maximum case when the cab windows were open. The agricultural estimates tend to overestimate potential exposure of spray truck drivers, as agricultural drivers reenter sprayed areas while spraying fields and orchards. Texas Department of Transportation employees do not reenter sprayed areas along highway rights-of-way. The inhalation exposure route was not included as it has been shown to contribute little to the overall total body burden. Single-day doses were estimated using the following equation:

$$SDTD = \frac{PD \times SA \times CF \times HR \times DA \times AP}{BW}$$

where:

SDTD	=	single-day dose for truck drivers (mg/kg/day)
PD	=	deposition on dermal monitoring patches (μg/cm^2/hr/lb a.i./acre)
SA	=	skin surface area exposed (cm^2)
CF	=	conversion factor (0.001 mg/μg)
HR	=	hours per day engaged in application by truck (hrs/day)
DA	=	fraction dermally absorbed (unitless)
AP	=	application rate (lb a.i./acre)
BW	=	average body weight (kg)

Table B2-19 lists single-day doses of each pesticide for spray truck drivers.

6.3 Estimates of Exposure to the Public

6.3.1 Dermal Doses

Contact with sprayed vegetation associated with public use of roadways may occur as a result of pesticide spray drift. The quantity of pesticide that may drift outside a target area is influenced by many factors such as wind velocity, temperature, humidity, pesticide droplet size, nozzle flow rate, and vehicle size. Exposure of the public via inhalation was not quantified as it has been shown that this route of exposure is of minimal importance to pesticide applicators and, therefore, the general public as well (Lavy et al. 1980b). Recently, Harris 1990 reported that individuals watching 2,4-D being applied to a lawn failed to show residue levels greater than the limit of detection of 4 μg/l. Lavy et al. (1980a) also failed to detect residues of 2,4,5-T on six fabric patches used to monitor dermal exposure with a detection limit of 10 μg.

In this scenario, it was assumed that pesticide deposition was 5 μg for the average case and 10 μg for the maximum case. It was also assumed that the individual walking through treated vegetation had exposed lower legs which made contact with the vegetation. This constituted 13% of the skin surface area of an adult in the average case (EPA, 1989a). For the maximum case, it was assumed that the lower legs, arms, hands and face which comprised 37% of the total body surface area of 19,000 cm^2 (EPA, 1989a) made contact with the pesticide. The estimated dermal exposures were adjusted for dermal absorption rates in estimating the absorbed dose. Single-day doses were estimated using the following equation:

$$SDED = \frac{PD \times SA \times AF \times CF \times DA \times AP}{BW}$$

where:

SDED	=	single-day dose for pedestrian (mg/kg/day)
PD	=	assumed deposition on dermal monitoring patches (μg/cm^2/lb a.i./acre)
SA	=	total skin surface area (cm^2)
AF	=	fraction of surface area exposed (unitless)
CF	=	conversion factor (0.001 mg/μg)
DA	=	fraction dermally absorbed (unitless)
AP	=	application rate (lb a.i./acre)
BW	=	average body weight (kg)

Table B2-20 lists single-day doses of each pesticide for individuals who contact sprayed vegetation.

6.3.2 Dermal Exposure to Berry Pickers

Exposure of the public to contaminated foliage resulting from pesticide spray drift during vegetation control was evaluated. Zweig et al. (1985) studied workers in strawberry fields and determined a dermal transfer coefficient of 4400 cm^2/hr and a foliar loading of 4.6 μg/cm^2 normalized to 1 lb a.i./acre. In a study by Marrs et al. (1989), dislodgeable foliar residues from pesticide spray drift on plants within 1 to 1,000 m of a treated area were estimated. Deposition on plants ranged from 1.5% of the application rate at a distance of 2 m, to less than 1% at 5 m. Previous studies summarized by Marrs et al. (1989) reported deposition rates of 0.5 to 6% of the application rate at a distance of 5 m.

For this example, it was assumed that berry bushes were located 2 m from the roadside and that pesticide deposition occurred at a rate of 1.5% of the application rate for the average case and 5% for the maximum case. For the average case, the estimated adult skin surface area exposed to the pesticide was 0.41 m^2 (forearms, hands and lower legs) and 0.52 m^2 (forearms, hands, lower legs and head) for the maximum case. It was assumed that an individual picked for two hours per day in each case. The estimated dermal exposures were adjusted for dermal absorption rates to estimate the absorbed dose. Single day doses were estimated using the following equation:

$$SDDB = \frac{DR \times SA \times H \times CF \times DF \times DA \times AP}{BW}$$

where:

SDDB = single-day dermal dose for berry pickers (mg/kg/day)
DR = dose rate (μg/hr/total body surface area (1.9 m^2)/lb a.i./acre)
SA = skin surface area (m^2)
H = hours per day exposed (hr/day)
CF = conversion factor (0.001 mg/μg)
DF = fraction of application rate deposited by drift (unitless)
DA = fraction dermally absorbed (unitless)
AP = application rate (lb a.i./acre)
BW = average body weight (kg)

Table B2-21 lists single-day doses for each pesticide for dermal exposure to berry pickers.

6.3.3 Exposure by Ingestion of Berries

Individuals who pick and eat berries adjacent to areas where roadside spraying has occurred may be exposed to pesticide residues. In this example, it was assumed that 70-kg adults ate unwashed berries immediately after spraying. For the average case, the individual ate 100 grams (½ cup) and 200 grams (1 cup) for the maximum case. It was assumed that the average blackberry had a surface area of 5 cm^2 of which 50% was exposed, and that deposition of spray drift occurred at a rate of 1.5% of the application rate in the average case and 5.0% in the maximum case (Marrs et al., 1989). Single-day doses were estimated using the following equation:

$$SDBI = \frac{BL \times IR \times CF \times DF \times AP}{BW}$$

where:

SDBI = single-day dose for eating berries (mg/kg/day)
BL = loading of herbicide onto berries (μg/gm berries/lb a.i./acre)
IR = ingestion rate of berries (gm/day)
CF = conversion factor (0.001 mg/μg)
DF = fraction of application rate deposited by drift (unitless)
AP = application rate (lb a.i./acre)
BW = average body weight (kg)

Table B2-22 lists single-day doses for each herbicide for exposure from eating berries.

6.3.4 Exposure by Ingestion of Vegetables

The quantity of pesticide intake by ingestion of lettuce, beans, and tomatoes grown 10 m from the edge of a sprayed area was estimated in this scenario. It was assumed that the pesticide did not undergo degradation, nor did it damage the plants. In a 1972 study, Hoerger and Kenaga reported residue data from 22 studies in which pesticides had been applied to various crops. In this analysis, the mean value of the reported range for each vegetable was used for the assumed residual level on directly sprayed vegetables. Pesticide residues were found to persist longer on vegetables with waxy or oily surfaces such as tomatoes and green beans because this type of surface decreases the effects of weathering and acts as a sink for the more lipophilic pesticides. Residue levels used in this scenario were 35 mg/kg lettuce/lb a.i./acre, 2.4 mg/kg tomatoes/lb a.i./acre, and 4 mg/kg beans lb a.i./acre. It was assumed that deposition on vegetables from drift averaged 1.5% of the application rate for the average case and 5% for the maximum case. It was also assumed that when the vegetables were washed, 50% of the residues were removed in the average case and, in the maximum case, the vegetables were not washed or peeled prior to being eaten. The amount of vegetables consumed in the average case was based on the 50^{th} percentile of U.S. nationwide ingestion and the 95^{th} percentile in the maximum case. For lettuce, tomatoes, and green beans this was 31, 30, and 23 grams, respectively, in the average case and 110, 123 and 93 grams, respectively, in the maximum case (Pao et al., 1982). It was also assumed that 100% of the pesticide residues were absorbed into the body following ingestion. Uptake from the soil into vegetables was not considered because of the low quantities of pesticide that are estimated to drift (1.5%-5.0% of the applied amount) over public gardens. Single-day doses were estimated using the following equation:

$$\mathbf{SDVI} = \frac{\mathbf{RL \times IR \times RF \times DF \times AP}}{\mathbf{BW}}$$

where:

SDVI	=	single-day dose from ingestion of vegetables (mg/kg/day)
RL	=	residual level for vegetable (mg/kg vegetable/lb a.i./acre)
IR	=	ingestion rate of vegetable (kg/day)
RF	=	fraction of residue remaining after washing or handling (unitless)
DF	=	fraction of application rate deposited by drift (unitless)
AP	=	application rate (lb a.i./acre)
BW	=	average body weight (kg)

Tables B2-23 through B2-25 list single-day doses for individuals eating vegetables.

6.3.5 Exposure from the Ingestion of Surface Water

Accidental drift of pesticides from roadside spraying has the potential to reach adjacent bodies of water. In this example, it was assumed that the average deposition of pesticide spray drift occurred at a rate of 1.5% of the application rate in the average case and 5.0% in the maximum case (Marrs et al., 1989) and contaminated a 0.25-acre pond, 4 feet deep. The concentration in the water was determined as follows:

$$\mathbf{WC = \frac{V \times CF}{DF \times AP}}$$

where:

WC	=	estimated surface water concentration (mg/l based on pesticide application rates)
V	=	volume of pond water in acre-feet
CF	=	conversion factor (1,233 x 10^6 l/acre-feet)
DF	=	fraction of application rate deposited by drift (unitless)
AP	=	application rate (lb a.i./acre)

Estimated surface water pesticide concentrations are shown in Table B2-26.

It was assumed that a 70-kg individual ingests 0.5 liters of water from this pond per day. Single-day doses were estimated using the following equation:

$$\mathbf{SDWC = \frac{WC \times WI}{BW}}$$

where:

SDWC	=	single-day dose from ingestion of surface water (mg/kg/day)
WC	=	estimated surface water concentration (mg/l based on pesticide application rates)
WI	=	water intake (l/day)
BW	=	average body weight (kg)

Table B2-27 lists single-day doses for an individual ingesting surface water.

6.3.6 Exposure Due to the Ingestion of Fish

Pesticide residues in freshwater fish were estimated using a bioconcentration factor (BCF) for each pesticide. A BCF is the ratio of the concentration of a chemical in fish tissue (mg/kg) to the concentration in the surrounding water (mg/l). A BCF greater than 1 suggests that a chemical is likely to concentrate in tissues to a greater degree than that found in water. When a BCF has not been determined experimentally for a chemical, it is possible to estimate a BCF from the octanol-water partition coefficient (K_{ow}) or water solubility of the chemical. These values often overestimate the true BCF, as they do not account for biotransformation and/or excretion of the parent compound or its metabolites. Experimental or estimated BCFs for the 10 pesticides are listed in Table B2-27. The concentration of each chemical found in fish exposed to pesticides in surface water was estimated by multiplying the surface water concentration for each chemical by the BCF for that chemical.

$$CF = BCF \times CW$$

where:

CF	=	concentration in fish (mg/kg)
BCF	=	bioconcentration factor (l/kg)
CW	=	concentration in water (mg/l)

Table B2-28 lists bioconcentration factors for freshwater fish.

In this scenario, it was assumed that a 70-kg individual would consume 113 grams of fish per day (50^{th} percentile for fish consumed in the U.S.) for the average case and 255 grams of fish (95^{th} percentile for fish consumed in the U.S.) for the maximum case (Pao et al., 1982). Single-day doses were estimated using the following equation:

$$SDFI = \frac{WC \times BCF \times FI \times FC}{BW}$$

where:

SDFI	=	single-day dose from ingestion of fish (mg/kg/day)
WC	=	surface water concentration (mg/l) (based on application rates)
BCF	=	pesticide bioconcentration factor (l/kg)
FI	=	ingestion of fish (kg/day)
FC	=	fraction of fish from streams with pesticide residues
BW	=	average body weight (kg)

Table B2-29 lists single-day doses for an individual eating fish.

6.3.7 Exposure Due to Ingestion of Wildgame

Public exposure by this route involves the consumption of wild game such as deer which may have come into contact with pesticide-treated foliage. The total pesticide intake by game animals could be estimated by the following equation:

Total Intake(mg/kg) = Dermal + Grooming + Dietary(vegetation + soil) + Drinking

Estimated pesticide intake for 68-kg deer are shown in Tables B2-30 and B2-31.

Pesticide concentrations in deer meat were calculated using a biotransfer factor (BTF). The BTF is the ratio between the pesticide concentration in the meat (mg/kg) to the daily intake of chemical (mg/day). The BTF may be used to estimate the pesticide concentration in deer meat according to the following equation:

Meat Concentration (mg/kg) = BTF (day/kg) x Total intake (mg/day)

Often the BTFs have not been determined experimentally and must be estimated based on the pesticide's octanol-water partition coefficient (K_{ow}) using a regression equation developed by Travis and Arms (1988) for predicting residues in beef:

$$\log BTF = -7.6 + \log K_{ow}$$

Since deer meat contains only 1% fat content compared to the 25% fat content of beef, the above equation was corrected by multiplying it by 1/25. Estimated BTFs have a high degree of uncertainty associated with them as they fail to take into account the potential metabolic biotransformation and elimination of the chemical. Experimental or estimated BTFs for the pesticides are shown in Table B2-32.

Triclopyr has been reported to have a BTF of 4×10^{-4} (Yackovich and Baudriedel, 1976) while glyphosate was not detected in either beef or pork (Monsanto, 1984). In this assessment, only pesticides having a BTF greater than 1×10^{-6} were evaluated. It was assumed that a 70-kg individual might consume 125 g of deer meat under the average condition and 250 g under the maximum exposure condition, based on beef consumption (Pao et al., 1982). Single-day doses were estimated using the following equation:

$$SDG = \frac{DG \times BTF \times MI}{BW}$$

where:

SDG	=	single-day dose from ingestion of wild game (mg/kg/day)
DG	=	total dose to game from dermal, grooming, diet, and soil (mg/day) (based on application rates)
BTF	=	pesticide specific biotransfer factor (day/kg)
MI	=	ingestion of wild game (kg/day)
BW	=	average body weight (kg)

Table B2-33 lists single-day doses for an individual eating deer meat.

6.3.8 Exposure from the Ingestion of Groundwater

Potential migration of pesticides into groundwater used for drinking water is of great concern. Diazinon has been detected in groundwater from two wells in Yoakum County, while chlorpyrifos and triclopyr have been detected in groundwater samples obtained from Yoakum and Martin Counties, respectively (see Table B2-34).

Migration of pesticides through soil into groundwater is a highly complex phenomena involving the chemical properties of the pesticide, the physical and chemical nature of the soil, climatic conditions at the time of application, and the water table level. Pesticide concentrations in groundwater were estimated using a chemical transport model developed by Enfield et al. (1982). This model takes into account retardation of chemical transport by absorption onto the aquifer solids, unsaturated Darcian flow, and first-order decay processes. It does not, however, take into account dispersive processes such as horizontal movement. It is, therefore, assumed that the pesticide arrives at the water table as a discrete pulse of chemical.

Concentrations in groundwater directly below the treated area were calculated by assuming that the pesticide applied to one square meter of soil would reach the water table and completely mix in a volume of water equal to one square meter times the aquifer thickness times the porosity of the aquifer. It was assumed that the individual obtained his water supply from this well located within the treated area, and that the pesticide did not degrade, nor was it diluted prior to reaching the individual.

Three sets of environmental parameters were identified as representative of low, medium, and high potential for migration to groundwater. Conditions that may favor high migration to groundwater include high annual rainfall and recharge to groundwater, low soil organic content, and high soil moisture. The depth to groundwater is assumed to be 300 centimeters in all cases and is a conservative assumption.

Environmental parameter values used in the unsaturated zone transport model are presented in Tables B2-35 and B2-36. Soil organic carbon content and annual recharge rate were varied between the low, medium, and high transport scenarios. All the other parameters were held constant between the three scenarios in order to provide a comparison of the effects of climate and soil type with equal depth to groundwater. A default porosity of 0.4, volumetric water content of 0.2, and bulk density of 1.5 gm/cm^2 were assumed (EPA, 1985).

Pesticide half-lives in soil were used to determine the degradation or decay rate constants using the following equation:

$$K = \frac{0.693}{t_{1/2}}$$

where:

K	=	decay rate constant (day^{-1})
$t_{1/2}$	=	half-life (days)

For those pesticides for which a range of half-lives have been reported in the literature, the value of K used in this analysis was based on the longest reported half-life (see Table B2-37). The decay rate constant has the greatest effect of any environmental parameter on the quantity of pesticide reaching groundwater, thus, the use of a conservative k factor is likely to severely overestimate exposure. Estimated ground water concentrations are shown in Table B2-38.

In this example, it was assumed that a 70-kg individual consumed 2 liters of groundwater per day. Single-day doses were estimated using the following equation:

$$SDGW = \frac{WC \times CF \times WI}{BW}$$

where:

SDGW	=	single-day dose from ingestion of groundwater (mg/kg/day)
WC	=	estimated groundwater concentration (μg/l) (based on application rates)
CF	=	conversion factor (mg/μg)
WI	=	water intake (l/day)
BW	=	average body weight (kg)

Single-day doses for pesticides that are estimated to produce single-day doses greater than 1×10^{-7} are presented in Table B2-39. The average and maximum doses were based on the groundwater concentrations predicted using high range values for groundwater transport.

The transport equations used in this assessment only take into account the transport of pesticides through the primary porosity of the soil. In some soils, particularly clay soils with low primary porosity, the secondary porosity of the soil may have a large impact on the migration of chemicals to groundwater (Grover, 1988). The presence of macropores in soils has been implicated in the migration to groundwater of pesticides that are generally considered to be immobile in soils (Jury et al., 1986).

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Table B2-17. Potential Routes of Human Exposure

Activity	Route
<u>WORKER</u>	
Mixing/Loading	all routes
Driving spray truck	dermal exposure via drift
<u>PUBLIC</u>	
Hiking	dermal exposure to directly sprayed vegetation
Berry Picking	dermal contact with vegetation contaminated by spray drift
Eating berries	ingestion of berries contaminated by spray drift
Eating vegetables	ingestion of vegetables contaminated by spray drift
Eating fish or game	ingestion of fish or game from contaminated areas
Drinking water	ingestion of contaminated surface or groundwater

Table B2-18. Estimates of Average and Maximum Single-Day Dose for Mixers/Loaders

Pesticide	Single-Day Estimated Intake (mg/kg/day)	
	Average	Maximum
<u>**HERBICIDES**</u>		
Clopyralid	2×10^{-3}	9×10^{-3}
Glyphosate	1×10^{-3}	7×10^{-3}
Hexazinone	2×10^{-3}	9×10^{-3}
Imazapyr	2×10^{-3}	9×10^{-3}
Metsulfuron methyl	2×10^{-3}	9×10^{-3}
Sulfometuron methyl	2×10^{-3}	9×10^{-3}
Triclopyr	4×10^{-4}	2×10^{-3}
<u>**INSECTICIDES**</u>		
Chlorpyrifos	2×10^{-3}	9×10^{-3}
Diazinon	2×10^{-3}	9×10^{-3}
Fenoxycarb	2×10^{-3}	9×10^{-3}

Table B2-19. Estimates of Average and Maximum Single-Day Dose for Spray Truck Drivers

Pesticide	Single-Day Estimated Intake (mg/kg/day)	
	Average	Maximum
<u>HERBICIDES</u>		
Clopyralid	2×10^{-5}	7×10^{-3}
Glyphosate	3×10^{-4}	4×10^{-2}
Hexazinone	3×10^{-4}	8×10^{-2}
Imazapyr	3×10^{-4}	4×10^{-2}
Metsulfuron methyl	8×10^{-6}	2×10^{-3}
Sulfometuron methyl	2×10^{-5}	3×10^{-3}
Triclopyr	3×10^{-5}	1×10^{-2}
<u>INSECTICIDES</u>		
Chlorpyrifos	7×10^{-5}	4×10^{-2}
Diazinon	2×10^{-3}	9×10^{-3}
Fenoxycarb	1×10^{-4}	2×10^{-2}

Table B2-20. Estimates of Average and Maximum Single-Day Dose for Contact with Sprayed Vegetation

Pesticide	Single-Day Estimated Intake (mg/kg/day)	
	Average	Maximum
HERBICIDES		
Clopyralid	2×10^{-6}	4×10^{-5}
Glyphosate	2×10^{-5}	1×10^{-4}
Hexazinone	3×10^{-6}	5×10^{-5}
Imazapyr	1×10^{-6}	1×10^{-5}
Metsulfuron methyl	9×10^{-8}	2×10^{-6}
Sulfometuron methyl	2×10^{-7}	2×10^{-6}
Triclopyr	2×10^{-6}	6×10^{-5}
INSECTICIDES		
Chlorpyrifos	4×10^{-6}	1×10^{-4}
Diazinon	2×10^{-5}	3×10^{-4}
Fenoxycarb	2×10^{-6}	1×10^{-5}

Table B2-21. Estimates of Average and Maximum Single-Day Dose to Berry Pickers - Dermal Exposure

Pesticide	Single-Day Estimated Intake (mg/kg/day)	
	Average	Maximum
<u>HERBICIDES</u>		
Clopyralid	3×10^{-6}	5×10^{-5}
Glyphosate	3×10^{-5}	1×10^{-4}
Hexazinone	5×10^{-6}	6×10^{-5}
Imazapyr	2×10^{-6}	2×10^{-5}
Metsulfuron methyl	2×10^{-7}	2×10^{-6}
Sulfometuron methyl	3×10^{-7}	3×10^{-6}
Triclopyr	4×10^{-6}	7×10^{-5}
<u>INSECTICIDES</u>		
Chlorpyrifos	6×10^{-6}	2×10^{-4}
Diazinon	2×10^{-5}	3×10^{-4}
Fenoxycarb	2×10^{-6}	2×10^{-5}

Table B2-22. Estimates of Average and Maximum Single-Day Dose from Ingestion of Berries

Pesticide	Single-Day Estimated Intake (mg/kg/day)	
	Average	Maximum
<u>HERBICIDES</u>		
Clopyralid	7×10^{-6}	2×10^{-4}
Glyphosate	2×10^{-5}	1×10^{-4}
Hexazinone	1×10^{-4}	2×10^{-3}
Imazapyr	6×10^{-5}	6×10^{-4}
Metsulfuron methyl	4×10^{-6}	7×10^{-5}
Sulfometuron methyl	7×10^{-6}	1×10^{-4}
Triclopyr	6×10^{-5}	2×10^{-3}
<u>INSECTICIDES</u>		
Chlorpyrifos	3×10^{-5}	1×10^{-3}
Diazinon	6×10^{-5}	1×10^{-3}
Fenoxycarb	6×10^{-5}	6×10^{-4}

Table B2-23. Estimates of Average and Maximum Single-Day Dose from the Ingestion of Tomatoes

Pesticide	Single-Day Estimated Intake (mg/kg/day)	
	Average	Maximum
<u>**HERBICIDES**</u>		
Clopyralid	1×10^{-6}	1×10^{-4}
Glyphosate	3×10^{-6}	5×10^{-5}
Hexazinone	2×10^{-5}	1×10^{-3}
Imazapyr	8×10^{-6}	3×10^{-4}
Metsulfuron methyl	5×10^{-7}	4×10^{-5}
Sulfometuron methyl	1×10^{-6}	5×10^{-7}
Triclopyr	8×10^{-6}	8×10^{-4}
<u>**INSECTICIDES**</u>		
Chlorpyrifos	4×10^{-6}	6×10^{-4}
Diazinon	8×10^{-6}	6×10^{-4}
Fenoxycarb	8×10^{-6}	3×10^{-4}

Table B2-24. Estimates of Average and Maximum Single-Day Dose for the Ingestion of Lettuce

Pesticide	Single-Day Estimated Intake (mg/kg/day)	
	Average	Maximum
<u>**HERBICIDES**</u>		
Clopyralid	1×10^{-5}	1×10^{-3}
Glyphosate	4×10^{-5}	7×10^{-4}
Hexazinone	2×10^{-4}	2×10^{-2}
Imazapyr	1×10^{-4}	4×10^{-3}
Metsulfuron methyl	7×10^{-6}	5×10^{-4}
Sulfometuron methyl	2×10^{-5}	7×10^{-5}
Triclopyr	1×10^{-4}	1×10^{-2}
<u>**INSECTICIDES**</u>		
Chlorpyrifos	6×10^{-5}	8×10^{-3}
Diazinon	1×10^{-4}	8×10^{-3}
Fenoxycarb	1×10^{-9}	4×10^{-3}

Table B2-25. Estimates of Average and Maximum Single-Day Dose for the Ingestion of Beans

Pesticide	Single-Day Estimated Intake (mg/kg/day)	
	Average	Maximum
HERBICIDES		
Clopyralid	1×10^{-6}	1×10^{-4}
Glyphosate	3×10^{-6}	7×10^{-5}
Hexazinone	2×10^{-5}	2×10^{-3}
Imazapyr	1×10^{-5}	4×10^{-4}
Metsulfuron methyl	6×10^{-7}	5×10^{-5}
Sulfometuron methyl	1×10^{-6}	7×10^{-5}
Triclopyr	1×10^{-5}	1×10^{-3}
INSECTICIDES		
Chlorpyrifos	5×10^{-6}	8×10^{-4}
Diazinon	1×10^{-5}	8×10^{-4}
Fenoxycarb	1×10^{-5}	4×10^{-4}

Table B2-26. Estimates of Surface Water Pesticide Concentrations Under Various Conditions

Pesticide	Application Rate - Average		Application Rate - Maximum	
	Low Drift	High Drift	Low Drift	High Drift
	Surface Water Concentration (mg/l)		Surface Water Concentration (mg/l)	
HERBICIDES				
Clopyralid	7×10^{-4}	2×10^{-3}	3×10^{-3}	9×10^{-3}
Glyphosate	2×10^{-2}	6×10^{-2}	2×10^{-2}	7×10^{-2}
Hexazinone	1×10^{-2}	4×10^{-2}	3×10^{-2}	1×10^{-1}
Imazapyr	6×10^{-3}	2×10^{-2}	8×10^{-3}	3×10^{-2}
Metsulfuron methyl	4×10^{-4}	1×10^{-3}	1×10^{-3}	3×10^{-3}
Sulfometuron methyl	7×10^{-4}	2×10^{-3}	1×10^{-3}	5×10^{-3}
Triclopyr	6×10^{-3}	2×10^{-2}	2×10^{-2}	7×10^{-2}
INSECTICIDES				
Chlorpyrifos	3×10^{-3}	9×10^{-3}	2×10^{-2}	6×10^{-2}
Diazinon	6×10^{-3}	2×10^{-2}	2×10^{-2}	6×10^{-2}
Fenoxycarb	6×10^{-3}	2×10^{-2}	8×10^{-3}	3×10^{-2}

Table B2-27. Estimates of Single-Day Dose from the Ingestion of Surface Water Average and Maximum Application Rates and High Drift

Pesticide	Surface Water (mg/l)		Single-Day Dose (mg/kg/day)	
	Average	Maximum	Average	Maximum
HERBICIDES				
Clopyralid	2×10^{-3}	9×10^{-3}	2×10^{-5}	7×10^{-5}
Glyphosate	6×10^{-2}	7×10^{-2}	4×10^{-4}	5×10^{-4}
Hexazinone	4×10^{-2}	1×10^{-1}	3×10^{-4}	8×10^{-4}
Imazapyr	2×10^{-2}	3×10^{-2}	1×10^{-4}	2×10^{-4}
Metsulfuron methyl	1×10^{-3}	3×10^{-3}	8×10^{-6}	3×10^{-5}
Sulfometuron methyl	2×10^{-3}	5×10^{-3}	2×10^{-5}	3×10^{-5}
Triclopyr	2×10^{-2}	7×10^{-2}	1×10^{-4}	5×10^{-4}
INSECTICIDES				
Chlorpyrifos	9×10^{-3}	6×10^{-2}	7×10^{-5}	4×10^{-4}
Diazinon	2×10^{-2}	6×10^{-2}	1×10^{-4}	4×10^{-4}
Fenoxycarb	2×10^{-2}	3×10^{-2}	1×10^{-4}	2×10^{-4}

Table B2-28. Bioconcentration Factors for Freshwater Fish

Pesticide	Bioconcentration Factor (l/kg)	Reference
<u>HERBICIDES</u>		
Clopyralid	4	Estimated[a]
Glyphosate	1	USDA, 1984
Hexazinone	2	Estimated
Imazapyr	3	Estimated
Metsulfuron methyl	4	Estimated
Sulfometuron methyl	6	Estimated
Triclopyr	20	Estimated
<u>INSECTICIDES</u>		
Chlorpyrifos	417	Estimated
Diazinon	77	Estimated
Fenoxycarb	225	Estimated

[a] Estimated from water solubility using the regression equation:

log BCF = 2.79 - 0.564 log water solubility (Kenoga and Goring, 1978).

Table B2-29. Estimates of Single-Day Dose from the Ingestion of Fish Taken from Average Application-High Drift and Maximum Application-High Drift Contaminated Waters

Pesticide	Fish Concentration (mg/kg) Application Rate		Single-Day Dose Low Intake (mg/kg/day)		Single-Day Dose High Intake (mg/kg/day)	
	Average - High Drift	Maximum - High Drift	Average	Maximum	Average	Maximum
HERBICIDES						
Clopyralid	9×10^{-3}	4×10^{-2}	2×10^{-5}	6×10^{-5}	3×10^{-6}	1×10^{-4}
Glyphosate	6×10^{-2}	7×10^{-2}	9×10^{-5}	1×10^{-4}	2×10^{-5}	3×10^{-4}
Hexazinone	7×10^{-2}	2×10^{-1}	1×10^{-4}	4×10^{-4}	3×10^{-5}	8×10^{-4}
Imazapyr	5×10^{-2}	8×10^{-2}	9×10^{-5}	1×10^{-4}	2×10^{-5}	3×10^{-4}
Metsulfuron methyl	5×10^{-3}	1×10^{-2}	7×10^{-6}	2×10^{-5}	2×10^{-6}	5×10^{-5}
Sulfometuron methyl	1×10^{-2}	3×10^{-2}	2×10^{-5}	5×10^{-5}	5×10^{-6}	1×10^{-4}
Triclopyr	4×10^{-1}	2×10^{0}	6×10^{-4}	2×10^{-3}	1×10^{-4}	5×10^{-3}
INSECTICIDES						
Chlorpyrifos	4×10^{0}	23×10^{1}	6×10^{-3}	4×10^{-2}	1×10^{-3}	8×10^{-2}
Diazinon	1×10^{0}	4×10^{0}	2×10^{-3}	7×10^{-3}	5×10^{-4}	2×10^{-2}
Fenoxycarb	4×10^{0}	6×10^{0}	7×10^{-3}	1×10^{-2}	2×10^{-3}	2×10^{-2}

Table B2-30. Estimated Average Acute Doses to Deer Average Application Rate - High Residency

Pesticide	Dose (mg/kg/day)	Dermal Intake (mg/day)	Grooming Intake (mg/day)	Dietary Intake (mg/day)	Water Intake (mg/day)	Soil Intake (mg/day)
HERBICIDES						
Clopyralid	2×10^{-2}	6×10^{-4}	1×10^{-2}	1×10^{0}	4×10^{-3}	4×10^{-4}
Glyphosate	5×10^{-1}	1×10^{-2}	3×10^{-1}	3×10^{1}	8×10^{-2}	9×10^{-3}
Hexazinone	3×10^{-1}	9×10^{-3}	2×10^{-1}	2×10^{1}	6×10^{-2}	6×10^{-3}
Imazapyr	2×10^{-1}	5×10^{-3}	1×10^{-1}	1×10^{1}	3×10^{-2}	3×10^{-3}
Metsulfuron methyl	1×10^{-2}	3×10^{-4}	6×10^{-3}	7×10^{-1}	2×10^{-3}	2×10^{-4}
Sulfometuron methyl	2×10^{-1}	6×10^{-4}	1×10^{-2}	1×10^{0}	4×10^{-3}	4×10^{-4}
Triclopyr	2×10^{-1}	5×10^{-3}	1×10^{-1}	1×10^{1}	3×10^{-2}	3×10^{-3}
INSECTICIDES						
Chlorpyrifos	9×10^{-2}	2×10^{-3}	5×10^{-2}	6×10^{0}	1×10^{-2}	2×10^{-3}
Diazinon	2×10^{-1}	5×10^{-3}	1×10^{-1}	1×10^{1}	3×10^{-2}	3×10^{-3}
Fenoxycarb	2×10^{-1}	5×10^{-3}	1×10^{-1}	1×10^{1}	3×10^{-2}	63×10^{-3}

Table B2-31. Estimated Average Acute Doses to Deer Maximum Application Rate - High Residency

Pesticide	Dose (mg/kg/day)	Dermal Intake	Grooming Intake	Dietary Intake	Water Intake	Soil Intake
		(mg/day)				
HERBICIDES						
Clopyralid	8×10^{-2}	2×10^{-3}	5×10^{-2}	6×10^{0}	1×10^{-2}	2×10^{-3}
Glyphosate	7×10^{-1}	2×10^{-2}	4×10^{-1}	5×10^{1}	1×10^{-1}	1×10^{-2}
Hexazinone	1×10^{-0}	3×10^{-2}	6×10^{-1}	7×10^{1}	2×10^{-1}	2×10^{-2}
Imazapyr	3×10^{-1}	7×10^{-3}	2×10^{-1}	2×10^{0}	4×10^{-2}	5×10^{-3}
Metsulfuron methyl	3×10^{-2}	8×10^{-4}	2×10^{-2}	2×10^{0}	5×10^{-3}	6×10^{-4}
Sulfometuron methyl	4×10^{-2}	1×10^{-3}	3×10^{-2}	3×10^{0}	7×10^{-3}	7×10^{-4}
Triclopyr	7×10^{-1}	2×10^{-2}	4×10^{-1}	5×10^{1}	1×10^{-1}	1×10^{-2}
INSECTICIDES						
Chlorpyrifos	5×10^{-1}	1×10^{-2}	3×10^{-1}	3×10^{1}	8×10^{-2}	9×10^{-3}
Diazinon	5×10^{-1}	1×10^{-2}	3×10^{-1}	3×10^{1}	8×10^{-2}	9×10^{-3}
Fenoxycarb	3×10^{-1}	7×10^{-3}	2×10^{-2}	2×10^{1}	4×10^{-2}	5×10^{-3}

Table B2-32. Mammalian Biotransfer Factors for Selected Pesticides

Pesticide	Biotransfer Factor (day/kg)	Reference
HERBICIDES		
Clopyralid	2×10^{-9}	Estimated[a]
Glyphosate	Negligible	USDA, 1984
Hexazinone	Negligible	Estimated[a]
Imazapyr	1×10^{-9}	Estimated[a]
Metsulfuron methyl	1×10^{-8}	Estimated[a]
Sulfometuron methyl	4×10^{-9}	Estimated[a]
Triclopyr	4×10^{-4}	Yackovich and Baudriedel, 1976
INSECTICIDES		
Chlorpyrifos	9×10^{-5}	Estimated[b]
Diazinon	2×10^{-6}	Estimated[b]
Fenoxycarb	2×10^{-5}	Estimated[b]

[a] Estimated from water solubility using the regression equation:

$$\log S = 0.922 \log K_{ow} + 4.184$$ (Kenaga and Goering, 1978)

and

$$\log BTF = 7.6 \log K_{ow} - 0.23$$ (Travis and Arms, 1988)

[b] Estimated from octanol-water partition coefficient (Travis and Arms, 1988).

Table B2-33. Estimates of Single-Day Dose from Ingestion of Deer Meat

Pesticide	BTF (days/kg)	Total Deer Intake (mg/day)		Single-Day Dose*** (mg/kg/day)	
		Average*	Max**	Average	Max
HERBICIDE					
Clopyralid				NA****	NA
Glyphosate				NA	NA
Hexazinone				NA	NA
Imazapyr				NA	NA
Metsulfuron methyl				NA	NA
Sulfometuron methyl				NA	NA
Triclopyr	4×10^{-4}	12	46	2×10^{-5}	7×10^{-5}
INSECTICIDES					
Chlorpyrifos	9×10^{-5}	6	34	2×10^{-6}	1×10^{-5}
Diazinon	2×10^{-6}	12	34	9×10^{-8}	3×10^{-7}
Fenoxycarb	2×10^{-5}	12	17	8×10^{-7}	1×10^{-6}

* Average application rate, high residency.
** High application rate, high residency.
*** High consumption.
**** NA = not applicable.

Table B2-34. Pesticides Detected in Texas Groundwater 1990 - 1991

Pesticide	Residue Detected (μg/l)	Number of Wells	County
Triclopyr	0.58	1	Martin
Chlorpyrifos[a]	0.15	1	Yoakum
Diazinon[a]	0.16 1.04	2	Yoakum

[a] reported from the same well

Source: Texas Water Commission, 1991

Table B2-35. Equations Used to Estimate Pesticide Transport to Groundwater Unsaturated Zone Transport[a]

$$V_c = \frac{V^{pw}}{1 + (K_D * B/0}$$

V^{pw}	=	velocity of soil pore water (cm/day)
Q	=	annual recharge to groundwater (cm/day)
θ	=	volumetric moisture content of soil (unitless)
K_D	=	soil/water partition coefficient (ml/g), estimated for organic chemical by K_{oc} * f_{oc}, where f_{oc} is the fraction of organic carbon in the soil
B	=	soil bulk density (g/cm^3)
(t)	=	d/V_c
t	=	time of travel to water table (days)
d	=	depth of water table (cm)
V_c	=	apparent velocity of chemical in soil pore water (cm/day)

$$C_W = C_i * e^{-kt}$$

C_w	=	amount of chemical reaching water table (mg/m^2)
C_i	=	initial quantity of chemical applied to the soil surface (mg/m^2)
e	=	base of the natural logarithm
k	=	decay rate constant (day^{-1})
t	=	time of travel to water table (days)

[a] Enfield *et al.*, 1982

Table B2-36. Environmental Parameters Used to Estimate Pesticide Transport in the Groundwater Transport Screening Model

Parameter	Symbol	Values Held Constant		
Depth to water table (cm)	d	300		
Soil bulk density (g/cm^3)	B	1.5		
Volumetric moisture content	θ	0.2		
Application rate (lb/acre) (mg/m^2)	C_i	1 112		
Aquifer thickness (m)	b	5		
Porosity (unitless)	p	0.4		
		Values Varied Between Cases		
		Low	Medium	High
Fraction of organic carbon	f_{oc}	0.05	0.01	0.005
Annual recharge rate (cm/day)	Q	0.003	0.03	0.11

Table B2-37. Pesticide Half-Lives in Soil

Pesticide	Half-Life (days)	Degradation Rate Constant (K)[a] (day^{-1})	Reference
HERBICIDES			
Clopyralid	15-287	0.002	Swann et al., 1976
Glyphosate	3-130	0.005	USDA, 1984
Hexazinone	30-180	0.004	Worthing and Walker, 1987
Imazapyr	90-730	0.001	WSSA, 1989
Metsulfuron methyl	14-40	0.023	Worthing and Walker, 1987
Sulfometuron methyl	28	0.025	Worthing and Walker, 1987
Triclopyr	46	0.015	Worthing and Walker, 1987
INSECTICIDES			
Chlorpyrifos	80-279	0.002	Hartley and Kidd, 1987
Diazinon	30-46	0.015	Rao and Davidson, 1982
Fenoxycarb	1.5*	0.462	EPA, 1986

[a] Degradation constant was calculated as $0.693/t_{1/2}$, where $t_{1/2}$ is the half-life in days. The rate constant was calculated based on the maximum reported half-life.
* Estimated.

Table B2-38. Estimated Groundwater Concentrations under High, Medium and Low Model Conditions

Pesticide	K_{oc} (ml/g)	High Model (μg/l)		Medium Model (μg/l)		Low Model (μg/l)	
		Average	Maximum	Average	Maximum	Average	Maximum
<u>HERBICIDES</u>							
Clopyralid	5	2×10^{0}	6×10^{0}	1×10^{-2}	4×10^{-1}	N	N
Glyphosate	25	6×10^{-1}	8×10^{-1}	8×10^{-12}	1×10^{-11}	N	N
Hexazinone	14	5×10^{0}	13×10^{1}	1×10^{-5}	4×10^{-5}	N	N
Imazapyr	22	9×10^{0}	13×10^{1}	3×10^{-3}	4×10^{-3}	N	N
Metsulfuron methyl	28	2×10^{-11}	6×10^{-11}	N	N	N	N
Sulfometuron methyl	89	2×10^{-25}	3×10^{-25}	N	N	N	N
Triclopyr	154	2×10^{-35}	N	N	N	N	N
<u>INSECTICIDES</u>							
Chlorpyrifos	13,600	N	N	N	N	N	N
Diazinon	440	N	N	N	N	N	N
Fenoxycarb	86	N	N	N	N	N	N

N = Negligible

Table B2-39. Estimated Single-Day Dose from the Ingestion of Groundwater

Pesticide	Single-Day Estimated Intake (mg/kg/day)		K_{oc} (ml/g)	Water Concentration (μg/l)	
	Average	Maximum		Average	Maximum
<u>**Herbicides**</u>					
Clopyralid	4×10^{-5}	2×10^{-4}	5	2×10^{0}	6×10^{0}
Glyphosate	2×10^{-5}	2×10^{-5}	25	6×10^{-1}	8×10^{-1}
Hexazinone	1×10^{-4}	4×10^{-4}	14	5×10^{0}	13×10^{1}
Imazapyr	2×10^{-4}	4×10^{-4}	22	9×10^{0}	13×10^{1}
Metsulfuron methyl	N	N	28	N	N
Sulfometuron methyl	N	N	89	N	N
Triclopyr	N	N	154	N	N
<u>**Insecticides**</u>					
Chlorpyrifos	N	N	13,600	N	N
Diazinon	N	N	440	N	N
Fenoxycarb	N	N	86	N	N

N = Negligible

7.0 Human Health Risk Analysis

The risk of adverse noncarcinogenic effects to workers and the general public are presented in this section. The analysis uses estimated human exposure data (single-day dose) and oral reference doses (RFDs) derived from laboratory animal studies in which the no observable effect level (NOEL) is modified by a safety factor. The ratio between the estimated human exposure dose and the oral reference dose is referred to as the hazard index (HI):

$$\mathbf{HI} = \frac{\textbf{estimated single day dose}}{\textbf{oral reference dose}}$$

The hazard index is used to estimate the relative risk that an individual may experience under conditions similar to those outlined in the section on risk exposure. Chemicals having hazard indices equal to or less than 1 are presumed to have minimal impact on human health. As the estimated dose increases and exceeds the RFD, the hazard index exceeds 1, and the probability that the pesticide under consideration may produce toxic effects also increases. Since the reference doses are often based on data derived from chronic studies in which the pesticide is fed daily, the risk to the general public from a single exposure is often overestimated. Hazard indices were derived for workers as well as for members of the general public using average and maximum pesticide application rates used by the Texas Department of Transportation.

7.1 Risk to Workers

Hazard indices associated with increased noncancer risk for both mixer/loaders and spray truck drivers are presented in Table B2-40. All of the herbicides examined using average application rates had hazard indices equal to or less than 1 (see Tables B2-41 and B2-42). Only the insecticide chlorpyrifos was found to present an increased risk to spray truck drivers having a hazard index of 2. Chlorpyrifos applied at the maximum rate was found to have hazard indices of 3 for mixer/loaders and 10 for spray truck drivers. In addition, the herbicides hexazinone and triclopyr were found to have hazard indices of 2 for spray truck drivers. Although the hazard index for chlorpyrifos was found to be greater than 1, this does not automatically indicate that toxicity will occur in these workers. It is unlikely that exposure will reach these estimated levels because the Texas Department of Transportation only uses small quantities of chlorpyrifos (2.5 gallons) at any one time, and because of the conservativeness of the assumptions as well as the precautions taken by trained pesticide applicators (wearing protective clothing, gloves, goggles, etc.). Likewise, exposure to spray truck drivers from the herbicides hexazinone and triclopyr is not expected to occur because of the relatively short biological half-lives of these chemicals and the conservativeness of the assumptions used in the risk assessment.

7.2 Risk to General Public

Hazard indices associated with increased noncancer risk for members of the public are presented in Table B2-40. Exposure to the public from average pesticide application rates was found to be associated with low risk for all of the scenarios evaluated (see Tables B2-43 through B2-52). Increased risk of adverse systemic effects for members of the public eating lettuce inadvertently contaminated with triclopyr or chlorpyrifos spray drift and fish taken from waters contaminated by chlorpyrifos spray were identified. It is unlikely that exposure to these pesticides will reach those estimated in this risk assessment. The Texas Department of Transportation mixes only small quantities of chlorpyrifos for spot application, and pesticides are sprayed only under prescribed wind conditions. This reduces the likelihood of pesticide drift onto vegetables or pond water. In addition, conservative assumptions such as not washing the lettuce prior to eating, the large amount of lettuce consumed, and the short biological half-lives of these pesticides would tend to over-estimate the amount of pesticide ingested. Both products are used as spot applications with backpack sprayers; drift is not a problem.

7.3 Effects on Sensitive Individuals

There exists within the human population a small number of individuals who react in an exaggerated manner to very small quantities of a chemical. These individuals are said to be hypersensitive to the chemical. The reason for this hypersensitivity is often unknown, but may be due to genetic, nutritional, or other health factors. Under a Gaussian distribution, this population of individuals lies outside three standard deviations of the mean, and makes up less than 0.13% of the total population. In order to reduce the likelihood of an adverse response, regulatory agencies often apply a safety factor to the no observable effect level (NOEL) obtained in the most sensitive laboratory species to obtain a reference dose (RFD). The following equation is often used to establish a RFD.

$$\mathbf{RFD} = \frac{\mathbf{NOEL}}{\mathbf{10 \times 10}}$$

A safety factor of 100 is often used, with the justification of a factor of 10 for interspecies variation and an additional factor of 10 used for interindividual differences in the human population. In the absence of an experimentally derived NOEL, the lowest observable effect level (LOEL) may be used and an additional safety factor of 10 applied. In addition, a modifying factor ranging from 1 to 10 may also be applied. These modifiers are used to reflect the degree of confidence in the data upon which the RFD is based. It is possible that some hypersusceptible individuals may still experience adverse effects at this level of exposure. However, since these individuals make up such a small fraction of the general population, the probability that these individuals will be exposed to pesticides used by the Texas Department of Transportation is remote.

7.4 Protective Clothing

Many of the assumptions used to estimate the exposure of mixer/loaders and spray truck drivers are based on data from workers who took no special precautions when handling pesticides. Field studies have demonstrated that workers involved in spraying rights-of-way and using protective clothing (clean coveralls and gloves) dramatically reduced their exposure by up to 68% compared to workers who did not take these precautions (Libich et al., 1984; Putnam et al., 1983). More than 97% of the total exposure to pesticide applicators is through dermal absorption, especially through the hands, with only a minor amount being absorbed through the respiratory tract (Kolmodin-Hedman et al., 1983; Wolfe, 1972). Exposure to workers engaged in these activities may be minimized by wearing protective clothing. Although protective clothing will result in reduced exposure to a chemical, the amount of protection will depend upon the pesticide and the application system used. The Texas Department of Transportation requires that its workers take these precautions when handling pesticides.

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Table B2-40. Increased Noncancer Risk Associated with Pesticide Exposure

Exposure Scenario / Pesticide	Hazard Index Average	Hazard Index Maximum
Worker		
Mixer / Loader		
Chlorpyrifos		3×10^0
Spray Truck Driver		
Chlorpyrifos	2×10^0	1×10^1
Hexazinone		2×10^0
Triclopyr		2×10^0
Public		
Ingestion of Lettuce		
Triclopyr		2×10^0
Chlorpyrifos		3×10^0
Ingestion of Fish		
Chlorpyrifos		3×10^1

Table B2-41. Estimates of Average and Maximum Single-Day Dose Risk for Mixers/Loaders

Pesticide	Hazard Index	
	Average	Maximum
<u>**HERBICIDES**</u>		
Clopyralid	4×10^{-3}	2×10^{-2}
Glyphosate	5×10^{-4}	4×10^{-3}
Hexazinone	6×10^{-2}	3×10^{-1}
Imazapyr	6×10^{-3}	3×10^{-2}
Metsulfuron methyl	7×10^{-3}	4×10^{-2}
Sulfometuron methyl	4×10^{-2}	2×10^{-1}
Triclopyr	7×10^{-2}	4×10^{-1}
<u>**INSECTICIDES**</u>		
Chlorpyrifos	6×10^{-1}	3×10^{0}
Diazinon	2×10^{-2}	1×10^{-1}
Fenoxycarb	9×10^{-3}	5×10^{-2}

Table B2-42. Estimates of Average and Maximum Single-Day Dose Risk for Spray Truck Drivers

Pesticide	Hazard Index	
	Average	Maximum
<u>**HERBICIDES**</u>		
Clopyralid	3×10^{-3}	1×10^{-2}
Glyphosate	2×10^{-4}	2×10^{-3}
Hexazinone	8×10^{-3}	2×10^{0}
Imazapyr	9×10^{-4}	1×10^{-1}
Metsulfuron methyl	3×10^{-5}	1×10^{-2}
Sulfometuron methyl	3×10^{-4}	7×10^{-2}
Triclopyr	5×10^{-3}	2×10^{0}
<u>**INSECTICIDES**</u>		
Chlorpyrifos	2×10^{0}	1×10^{1}
Diazinon	1×10^{-3}	4×10^{-1}
Fenoxycarb	7×10^{-4}	1×10^{-1}

Table B2-43. Estimates of Average and Maximum Single-Day Dose Risk from Contact with Vegetation

Pesticide	Hazard Index	
	Average	Maximum
HERBICIDES		
Clopyralid	4×10^{-6}	8×10^{-5}
Glyphosate	1×10^{-5}	5×10^{-5}
Hexazinone	9×10^{-5}	2×10^{-3}
Imazapyr	5×10^{-6}	4×10^{-5}
Metsulfuron methyl	4×10^{-7}	6×10^{-6}
Sulfometuron methyl	4×10^{-6}	4×10^{-5}
Triclopyr	5×10^{-4}	1×10^{-2}
INSECTICIDES		
Chlorpyrifos	1×10^{-3}	4×10^{-2}
Diazinon	2×10^{-4}	3×10^{-3}
Fenoxycarb	7×10^{-6}	6×10^{-5}

Table B2-44. Estimates of Average and Maximum Single-Day Dose Risk to Berry Pickers - Dermal Exposure

Pesticide	Hazard Index	
	Average	Maximum
HERBICIDES		
Clopyralid	6×10^{-6}	1×10^{-4}
Glyphosate	2×10^{-5}	5×10^{-5}
Hexazinone	1×10^{-4}	2×10^{-3}
Imazapyr	8×10^{-6}	5×10^{-5}
Metsulfuron methyl	6×10^{-7}	8×10^{-6}
Sulfometuron methyl	6×10^{-6}	5×10^{-5}
Triclopyr	8×10^{-4}	1×10^{-2}
INSECTICIDES		
Chlorpyrifos	2×10^{-3}	5×10^{-2}
Diazinon	3×10^{-4}	3×10^{-3}
Fenoxycarb	1×10^{-5}	8×10^{-5}

Table B2-45. Estimates of Average and Maximum Single-Day Dose Risk from Ingestion of Berries

Pesticide	Hazard Index	
	Average	Maximum
HERBICIDES		
Clopyralid	1×10^{-5}	4×10^{-4}
Glyphosate	1×10^{-5}	5×10^{-5}
Hexazinone	4×10^{-3}	7×10^{-2}
Imazapyr	2×10^{-4}	2×10^{-3}
Metsulfuron methyl	2×10^{-5}	3×10^{-4}
Sulfometuron methyl	2×10^{-5}	2×10^{-3}
Triclopyr	1×10^{-2}	3×10^{-1}
INSECTICIDES		
Chlorpyrifos	1×10^{-2}	4×10^{-1}
Diazinon	7×10^{-4}	1×10^{-2}
Fenoxycarb	3×10^{-4}	3×10^{-3}

Table B2-46. Estimates of Average and Maximum Single-Day Dose Risk from Ingestion of Tomatoes

Pesticide	Hazard Index	
	Average	Maximum
HERBICIDES		
Clopyralid	2×10^{-6}	2×10^{-4}
Glyphosate	2×10^{-6}	3×10^{-5}
Hexazinone	5×10^{-4}	4×10^{-2}
Imazapyr	3×10^{-5}	1×10^{-3}
Metsulfuron methyl	2×10^{-6}	2×10^{-4}
Sulfometuron methyl	2×10^{-5}	1×10^{-3}
Triclopyr	2×10^{-3}	2×10^{-1}
INSECTICIDES		
Chlorpyrifos	1×10^{-3}	2×10^{-1}
Diazinon	9×10^{-5}	7×10^{-3}
Fenoxycarb	4×10^{-5}	2×10^{-3}

Table B2-47. Estimates of Average and Maximum Single-Day Dose Risk from Ingestion of Lettuce

Pesticide	Hazard Index	
	Average	Maximum
HERBICIDES		
Clopyralid	3×10^{-5}	3×10^{-3}
Glyphosate	2×10^{-5}	4×10^{-4}
Hexazinone	7×10^{-3}	5×10^{-1}
Imazapyr	4×10^{-4}	1×10^{-2}
Metsulfuron methyl	3×10^{-5}	2×10^{-3}
Sulfometuron methyl	3×10^{-4}	1×10^{-2}
Triclopyr	2×10^{-3}	2×10^{0}
INSECTICIDES		
Chlorpyrifos	2×10^{-2}	3×10^{0}
Diazinon	1×10^{-3}	9×10^{-2}
Fenoxycarb	6×10^{-4}	2×10^{-2}

Table B2-48. Estimates of Average and Maximum Single-Day Dose Risk from Ingestion of Beans

Pesticide	Hazard Index	
	Average	Maximum
HERBICIDES		
Clopyralid	2×10^{-6}	3×10^{-4}
Glyphosate	2×10^{-6}	4×10^{-5}
Hexazinone	6×10^{-4}	5×10^{-2}
Imazapyr	3×10^{-5}	1×10^{-3}
Metsulfuron methyl	2×10^{-6}	2×10^{-4}
Sulfometuron methyl	2×10^{-5}	1×10^{-3}
Triclopyr	2×10^{-3}	2×10^{-1}
INSECTICIDES		
Chlorpyrifos	2×10^{-3}	3×10^{-1}
Diazinon	1×10^{-4}	9×10^{-3}
Fenoxycarb	5×10^{-5}	2×10^{-3}

Table B2-49. Estimates of Average and Maximum Single-Day Dose Risk from Ingestion of Surface Water

Pesticide	Hazard Index	
	Average	Maximum
HERBICIDES		
Clopyralid	3×10^{-5}	1×10^{-4}
Glyphosate	2×10^{-4}	3×10^{-4}
Hexazinone	8×10^{-3}	2×10^{-2}
Imazapyr	3×10^{-4}	6×10^{-4}
Metsulfuron methyl	3×10^{-5}	1×10^{-4}
Sulfometuron methyl	3×10^{-4}	7×10^{-4}
Triclopyr	3×10^{-2}	1×10^{-1}
INSECTICIDES		
Chlorpyrifos	2×10^{-2}	1×10^{-1}
Diazinon	1×10^{-3}	4×10^{-3}
Fenoxycarb	6×10^{-4}	1×10^{-3}

Table B2-50. Estimates of Average and Maximum Single-Day Dose Risk from High Intake of Fish

Pesticide	Hazard Index	
	Average	Maximum
HERBICIDES		
Clopyralid	7×10^{-6}	3×10^{-4}
Glyphosate	1×10^{-5}	2×10^{-4}
Hexazinone	8×10^{-4}	2×10^{-2}
Imazapyr	7×10^{-5}	1×10^{-3}
Metsulfuron methyl	7×10^{-6}	2×10^{-4}
Sulfometuron methyl	1×10^{-4}	2×10^{-3}
Triclopyr	3×10^{-2}	1×10^{0}
INSECTICIDES		
Chlorpyrifos	3×10^{-1}	3×10^{1}
Diazinon	5×10^{-3}	2×10^{-1}
Fenoxycarb	7×10^{-3}	1×10^{-1}

Table B2-51. Estimates of Average and Maximum Single-Day Dose Risk from Ingestion of Deer Meat

Pesticide	Hazard Index	
	Average	Maximum
HERBICIDES		
Clopyralid	NA	NA
Glyphosate	NA	NA
Hexazinone	NA	NA
Imazapyr	NA	NA
Metsulfuron methyl	NA	NA
Sulfometuron methyl	NA	NA
Triclopyr	3×10^{-3}	1×10^{-2}
INSECTICIDES		
Chlorpyrifos	7×10^{-4}	4×10^{-3}
Diazinon	9×10^{-7}	3×10^{-6}
Fenoxycarb	4×10^{-6}	6×10^{-6}

NA = Not Applicable

Table B2-52. Estimates of Average and Maximum Single-Day Dose Risk from High Consumption of Deer Meat Obtained Under Various Conditions

Pesticide	Application Rate: Average Residency Time: Low Hazard Index	Average High Hazard Index	Maximum Low Hazard Index	Maximum High Hazard Index
HERBICIDE				
Clopyralid	NA	NA	NA	NA
Glyphosate	NA	NA	NA	NA
Hexazinone	NA	NA	NA	NA
Imazapyr	NA	NA	NA	NA
Metsulfuron methyl	NA	NA	NA	NA
Sulfometuron methyl	NA	NA	NA	NA
Triclopyr	2×10^{-3}	3×10^{-3}	9×10^{-3}	1×10^{-2}
INSECTICIDES				
Chlorpyrifos	4×10^{-4}	7×10^{-4}	3×10^{-3}	4×10^{-3}
Diazinon	6×10^{-7}	9×10^{-7}	2×10^{-6}	3×10^{-6}
Fenoxycarb	3×10^{-6}	4×10^{-6}	4×10^{-6}	6×10^{-6}

NA = Not Applicable

Table B2-53. Estimates of Average and Maximum Single-Day Dose Risk from the Ingestion of Groundwater

	Hazard Index	
Pesticide	Average	Maximum
<u>HERBICIDES</u>		
Clopyralid	9×10^{-5}	3×10^{-4}
Glyphosate	1×10^{-5}	1×10^{-5}
Hexazinone	4×10^{-3}	1×10^{-2}
Imazapyr	8×10^{-4}	1×10^{-3}
Metsulfuron methyl	N	N
Sulfometuron methyl	N	N
Triclopyr	N	N
<u>INSECTICIDES</u>		
Chlorpyrifos	N	N
Diazinon	N	N
Fenoxycarb	N	N

N = Negligible

Appendix B - Chapter 3

Appendix B - Chapter Three

Assessment of Risks to Terrestrial and Aquatic Wildlife from Chemical Use

The ten chemical compounds under evaluation in this report include seven herbicides and three insecticides. All of these compounds have been approved by the Environmental Protection Agency (EPA) for uses consistent with the needs of the TxDOT. Roadsides throughout the state provide wildlife habitat similar to nearby non-roadside areas. Roadsides may exhibit different vegetational states due to lack of livestock grazing and, in some cases, shading from trees. Other manipulations such as occasional mowing, special plantings, weed control, drainage, and topographic modifications all affect the ecological balance and the habitat provided for, and used by, wildlife and aquatic animals. Some ROW may offer habitat not present elsewhere.

The thousands of acres of roadsides throughout the state provide areas of similar habitats in some regions that are collectively large and continuous, even though narrow. Some animals would seek out and prefer these habitats while others would make little use of, or avoid, the roadsides, and aquatic organisms may be swept in or out by heavy rains. High concentrations of animals on the roadsides could pose an accident risk to motorists and, in some cases, overuse of roadsides could result in increased animal mortality from passing cars. The balance is to provide roadside maintenance that protects motorists and animals, but does not degrade the environment.

Chemicals added to the environment for the purpose of vegetation or insect control along roadsides could impact the roadside ecology. The habitat would change and the animal community structure associated with it would change. The purpose of this report is to evaluate the potential for toxic effects of the herbicides and insecticides on the animal species and non-target plant species using roadsides. This involves individual responses to the proposed chemicals and an extrapolation to the species at large, and to other wildlife species. It is not intended to reflect the impact on the complex community structure of roadsides and the adjacent land.

1.0 Methodology

The roadsides of Texas offer a great diversity of habitats and complex community structures throughout the state. A number of animal species use or pass through those habitats daily. The goal here is to identify animals that make extensive use of roadside habitats and would be expected to be maximum exposure species such that information on any chemical toxicities can be inferred to be representative of other species. In general, chemical toxicity data on animals in the wild is sparse. In most cases, strains of laboratory animals that tend to be sensitive to chemicals are tested, but in some cases domestic or captive wild animals have been evaluated for responses to various chemical doses. It is important to evaluate species with sufficient chemical testing data to lead to reasonable conclusions that would be representative of the wild animal species expected to be impacted.

1.1 Target Species

Extensive chemical testing data do not exist for a wide range of chemicals on any species of terrestrial or aquatic animal. A variety of birds and mammals have been tested for toxicity to most of the chemicals. Information on chemicals toxities to amphibian and reptile species are virtually non-existent.

Toxicity values exist for a number of fish. Only a comparatively few species, however, are examined routinely for extensive toxicological study. These fish were chosen to represent warm and cold water situations, and most occur in fresh water.

A number of animal species have been employed to test the toxicological effects of chemicals on aquatic invertebrates. An important feature of the majority of these species is that at least some stage of their life cycle could be efficiently maintained in the laboratory. The majority of these animals occur primarily in fresh water.

1.1.1 Terrestrial Vertebrates

The best target species among birds is the Bobwhite Quail (*Colinus virginianus*) which occurs widely throughout the state and has a high potential for exposure as a ground bird. The bobwhite quail tends to be a frequent inhabitant of roadside areas where it feeds predominantly on plant material, nests on the ground, and uses roadside areas for resting areas. The Bobwhite quail and other quail species, particularly the Japanese quail, tend to have more chemical toxicity testing data than most birds.

The Eastern cottontail rabbit (*Sylvilagus floridanus*) is a small mammal that is wide spread throughout the state. Rabbits tend to regularly inhabit roadsides where they forage on a variety of grasses, herbaceous plants, and woody plants. They occupy rather small home ranges and could be impacted by high chemical exposure. Domestic rabbits have been tested for toxicities on a wide variety of chemicals.

The White-tailed deer (*Odocoileus virginianus*) enjoys a large range over most of Texas. It is a large herbivore which eats a variety of shrubs, trees, grasses and herbaceous plants. Deer are important game animals, and much is known about their life history and ecology. Unfortunately, little toxicity data are available for any of the wild herbivores and must be extrapolated from domestic species.

1.1.2 Fishes

The fathead minnow (*Pimephales promelas*) was one of the most commonly examined fish in the toxicological investigations surveyed. This animal is a chubby minnow with a blunt, rounded snout and short, rounded fins. Adults range in length from approximately 40 to 70 mm. This is a freshwater species that has a tolerance for high temperature, high turbidity, and low oxygen levels. Because of these attributes, this fish is well capable of surviving in stagnant pools. The distribution of this species is widespread east of the Rocky Mountains in North America. This animal is frequently employed as a bait fish, and its occurrence throughout Texas is presumably a result of bait releases.

The bluegill (*Lepomis macrochirus*) is a large sunfish with a deep, compressed body. Representatives of this species may reach lengths of 230 mm. Insects are the staple food for adults, but small fish, crayfish, and snails also are eaten. When these food items are scarce, algae and other vegetation may be eaten. The bluegill is a freshwater fish that is abundant in man-made impoundments and is common in the deeper pools or streams. This species has been introduced widely as a sport and forage fish. The bluegill occurs widely throughout the United States east of the Rocky Mountains and occurs statewide in Texas.

The rainbow trout (*Salmo gairdneri*=*Oncorhynchus mykiss*) and the cutthroat trout (*Salmo clarki*=*Oncorhynchus clarki*) are commonly employed to represent cold, freshwater fishes. The bodies of these fish are fusiform and somewhat compressed. These trout feed on aquatic and terrestrial insects, snails, and small fish. The rainbow trout is not native to Texas but has been stocked in a few places within the state. The only self-sustaining population of these fish is in the Guadalupe Mountains. The cutthroat trout currently occurs in the headwaters of a few rivers that flow through Texas. This species is thought to have historically occurred in Texas but is now presumed to be extirpated from the state.

1.1.3 Aquatic Invertebrates

1.1.3.1

Amphipods, also called scuds, are relatively small animals (3 to 12 mm in length) that are related to and resemble isopods. Fresh water amphipods, such as *Hyalella* sp. and *Gammarus* sp., are mostly bottom dwellers in streams and shallow weed beds of lakes. In general, these animals are scavengers, and organic detritus is often eaten by these filter feeders.

1.1.3.2

Chronimids are the larval forms of an aquatic fly called a midge. These larvae are characteristic of the benthic fauna of deeper portions of eutrophic bodies of water.

1.1.3.3

Cladocerans are minute (typically 1.5 mm in length) and have a distinct head and body that are covered by an unhinged bivalve carapace. These animals form an important portion of the plankton and can be found in various types of water ranging from temporary ponds to stable bodies of water. Cladocerans of the genus *Daphnia* are frequently employed in toxicological studies to represent aquatic invertebrates. These animals are filter feeders and serve as prey for plankton eaters.

1.1.3.4

Copepods are also quite small. The adults of these forms are cylindrical, partially segmented, and have two long antennae. These animals can be found in a variety of types of water ranging from fresh water to littoral situations. They occur in bottom deposits, on vegetation, and in the plankton.

1.1.3.5

Decapods are crustaceans of the Order Decapoda including commonly tested animals such as crayfish, grass shrimp, mysid shrimp, penaeid shrimp, and fiddler crabs. These animals are often used in toxicological investigations to represent estuarine invertebrates. The oyster, a bottom dwelling filter feeding mollusk, was also occasionally employed in toxicologic investigations.

1.1.3.6

Rotifers are minute animals that are abundant in natural waters. Some of these animals occur in plankton, others are attached to solid objects in the water, and a large number of them occur in the mud or debris of bodies of water. Representatives of this group can be sac-like or elongated in shape and have a hardened shell-like rigid covering that is frequently ornamented with spines.

1.1.3.7

Stoneflies are 15 to 50 mm in length, are elongated in shape, and have long antennae. The aquatic immature form of stoneflies (naiads) have gills and lack wings but otherwise resemble adults. Immature stoneflies live beneath the stones of clean, swift streams. Most of the species of this group are herbivorous.

1.2 Toxicity Assumptions

In most cases, there are few chemical data on wildlife and aquatic animals, and most toxicity assumptions are based on extrapolations from laboratory animal studies. In many cases, data on rats are used to infer chemical toxicity for rabbits and deer, with appropriate adjustments for weight and body surface. Wherever possible, the most closely related animal species tested is used for the toxicity reference. It is assumed that the more closely related the species, the more similar the chemical response.

The chemical toxicity data come in a variety of effect, or no effect, values. In some cases, acute exposure levels are determined to be the amount of a particular chemical that is lethal to 50% of the test organisms. This is referred to as the LD_{50} and is usually expressed in milligrams (mg) of the chemical per kilogram (kg) of the test organism's body weight, and tends to be a single dose, or a short time period is specified. The value used for birds is usually a feeding study based on concentration of chemical in the feed that is lethal to 50% of the test organisms, called the LC_{50}. This is normally expressed as parts per million (ppm) or mg/kg of the chemical in the feed. Concentrations in food, LC_{50}, were converted to mg of chemical to kg of animal body weight in the calculation of acute toxicity levels for this report. The lowest lethal doses found were used as the basis for the acute toxicity calculations. The acute oral toxicity data for the ten chemicals used in this analysis are presented in Tables B3-3 through B3-42. In cases where specific LD or LC values were not available for the target species, 10% of the value of the most closely related species was used as the acute dose in an effort to insure a safe level of exposure. This tenfold safety factor is intended to be conservative and account for the uncertainty of the extrapolation of toxicity values from distantly related species such as rats and deer.

The values for chronic toxicities of the chemicals become even more difficult to obtain since they depend on sublethal doses of the chemical over a long period of time. In the absence of data on how the organism metabolizes, eliminates, or stores the chemical, these chronic toxicity studies may not have a very meaningful endpoint. In many cases, animals were treated with particular doses with no observable effect, and the level at which some effect could be detected is unknown. In some cases, the dosage could be near the upper limit, or it could be hundreds of times below the toxic level. In some cases, chronic doses are observed where the dosage is not lethal, but has a noticeable effect on the animal; this is referred to as the "lowest observable effect level" or LOEL. Dosages below the LOEL are sometimes determined that produce no observable effect on the animal, and are referred to as the NOEL. In the absence of a NOEL value, 10% of the LOEL value is used in the medical field to express the NOEL value. Again, the extrapolation between unrelated species incorporated an additional reduction by a factor of 10 to the LOEL and NOEL to account for the uncertainty of correspondence.

1.3 Exposure Assumptions

The roadsides provide a narrow and linear habitat for wildlife species to roam and feed and, in some cases for aquatic species to spend their entire lives. These roadsides are not considered to be the total home range of any terrestrial animal populations, but may be the larger part of the home range of some smaller wildlife species. In most cases, the animals flee from chemical applications from trucks or individual applicators, and are not sprayed directly. For this analysis, two values are used here to express for acute toxicities: "Worst Case," which assumes the animal was actually covered with the spray, moved about only in the sprayed area, and consumed only food and water treated within the sprayed area; "Realistic," would be the case where the animal was not in the area during the time it was being sprayed, but used it as part of its normal home range to feed and move about.

The total exposure of the target wildlife species would be a sum of the amount ingested with food and water, the amount ingested during grooming, the amount inhaled during the spraying, and the amount absorbed through the skin from being sprayed and through contact with the sprayed vegetation. The "worst case" values would be a sum of these components, while the "realistic" values would incorporate the movement of the animal throughout its range into the exposure. The terrestrial animals home ranges were calculated to be rectangular with the side along the road being two times longer than the side perpendicular to the road. The long side, the roadside, was estimated to be 10 m wide along that edge.

The target terrestrial species considered for this analysis are Bobwhite quail, Eastern cottontail rabbit, and White-tailed deer (Table B3-1). Each is expected use roadside habitats, be wide-spread throughout the state, and be indicative of the impacts to be expected on other wildlife species. The target aquatic species emphasized here is the fathead minnow and the water flea, Daphnia. These aquatic species occur widely throughout the state and have been the subject of considerable laboratory testing. To proceed with potential impacts, we must assume some generalized individual animal values for the target species.

1.3.1

Bobwhite quail. The Bobwhite is considered cosmopolitan in Texas, avoiding only the extremes of deep woods and barren lands. It feeds primarily on seeds, weeds, and grasses, but eats available insects. Bobwhites normally live less than two years

(Lehmann, 1984) and have average body weights of 6.5 oz (184 g) (Oberholser, 1974). Daily food intake is considered to be 20% of body weight, a value of 37 g/day of forage and 0.1 l/day of water (USDA, 1988). Hoerger and Kenaga (1972) evaluated pesticide residues on plants after spraying and provided values for various food item types. The food chemical concentrations based on application rates of 1 kg of active ingredients per hectare yielded a "realistic" value of 0.1816 mg/kg and an "extreme" dose of 10.8438 mg/kg of the total food ingested. Some chemical ingestion may take place during dermal grooming and preening. The Bobwhite is reported to groom 39% of its body daily, and 74% of its body contacts vegetation (USDA, 1988). The body surface area of a 184 g quail would be 324 cm^2 based on the formula of Schmidt-Nielsen (1972), body surface area = 10 x (body weight in grams)$^{.667}$. The breathing rate for the Bobwhite is calculated to be 0.08 l/min based on the respiration rate formula of birds, liters/minute = 284 X (body weight in grams/1000)$^{.77}$/1000, of Lasiewski and Calder (1971). The home range of the Bobwhite varies throughout the state depending on season and quality of habitat. Lovestrand (1986), using the convex polygon method, found the home of bobwhites varied from 9.5 to 54.5 hectares (ha) in south Texas. His study concluded that the home range normally would be 29.3 ha, but could vary with local conditions. The value of 29.3 ha is used for the "realistic" home range value in this analysis.

1.3.2

Eastern Cottontail Rabbit. The Eastern cottontail occurs widely throughout Texas and the eastern United States. Chapman et al. (1980) report the size of the Eastern cottontail to be about 1.2 kg and the home range to vary from 0.95 to 2.8 ha, with the conservative value of 1 ha being used for this analysis. The diet consists of plant material and takes in approximately 132 g of plant material and 0.25 l of water per day (USDA, 1988). Hoerger and Kenaga (1972) evaluated pesticide residues on plants after spraying and provided values for various food item types. The food chemical concentrations based on application rates of 1 kg of active ingredients per hectare yielded a "realistic" value of 1.2661 mg/kg and an "extreme" dose of 71.5190 mg/kg of the total food ingested. The body surface area of a 1,200 g rabbit, using the formula of Schmidt-Nielsen (1972) is 1,132 cm^2. The eastern cottontail grooms 23% of its body daily, and 62% of its surface area contacts vegetation (USDA, 1988). The chemical exposure due to breathing vapors is calculated based on respiration rates extrapolated for mammals from Lasiewski and Calder (1971). Their formula for mammals breathing rates is expressed in liters/minute and equals 379 x (body weight in grams/1000)$^{.80}$ / 1000, which equals 0.44 l/min.

1.3.3

White-tailed Deer. The White-tailed deer occurs throughout Texas and most of the United States in a wide variety of habitats and is considered one of the most adaptable animals in the world (Hesselton and Hesselton, 1982). Davis (1974) cites weights for Texas White-tailed deer in the range of 30 to 70 kg with the average of 50 kg used for this analysis. The average Texas deer would be expected to ingest 1838 g of forage and 1.5 l of water per day (USDA, 1988). Hoerger and Kenaga (1972) evaluated pesticide residues on plants after spraying and provided values for various food item types. The food chemical concentrations based on application rates of 1 kg of active ingredients per hectare yielded a "realistic" value of 0.6102 mg/kg and an "extreme" dose of 39.9508 mg/kg of the total food ingested. Inglis (1979) computed home range of deer employing an area usage formula and found does to have average home ranges of 62 ha +/- 6 ha, and bucks 66 ha +/- 8 ha. The smaller value found for does is used here (62 ha), since they are, in general, less wary and more likely to inhabit roadsides. Deer were estimated to groom 7% of their bodies on a daily basis, and 39% of its surface area contacts vegetation (USDA, 1988). Using the formula for computing body surface area that could be exposed to chemicals of Schmidt-Nielsen (1972), the white-tailed deer has a surface area of 13,621 cm^2. The calculated respiration rate for the white-tailed deer using the formula for mammals of Lasiewski and Calder (1971) is 8.67 l/min.

Generalized assumptions can be made about chemical concentrations in water. In the "realistic" case where the animal waters at a stream of water source not in the sprayed roadside, the chemical concentration of the water can be estimated to be 0.000268 mg/liter (USDA, 1988). The corresponding value for chemical concentrations in water within the sprayed area are 0.000562 mg/L, at the rate of 1 kg of active ingredients per hectare.

Inhalation of chemicals provides a short term exposure that can produce airborne concentrations of 0.0002 mg/L per kg of active ingredients to the hectare (USDA,1988). In the "worst case" presented here, the animal is expected to stay at the spray site and inhale the spray concentration for 15 minutes. In the "realistic" case, the target species is expected to flee and return and inhale drift spray, or spray vapors when returning, for 7.5 minutes.

Table B3-1. Biological Parameters of Target Species Used in the Analysis.

TARGET SPECIES	HOME RANGE hectares	WEIGHT grams	DAILY FORAGE INGESTED grams	DAILY WATER INGESTED liters	BREATHING RATE l/min	BODY SURFACE AREA cm^2	DAILY CONTACTING VEGETATION %	SELF GROOMING %
Bobwhite Quail	29.3	184	37	0.1	0.08	324	74	39
Eastern Cottontail Rabbit	1.0	1200	132	0.25	0.44	1132	62	23
White-tailed Deer	62.0	50000	1838	1.5	8.67	13621	39	7

1.4 Toxicity Terminology

1.4.1

LD_{50} - Lethal Dose. Refers to the dosage of a substance that in a single or short term exposure produces 50% mortality in an experimental population of organisms. This term is normally used in acute toxicity studies of mammals and birds. The common units of measure in these studies are mg/kg, milligrams (mg) of substance per kilogram (kg) of body weight of the animal, for doses that are administered orally. Breathing toxic substances could produce death or other symptoms. In inhalation studies, the animal exposure is expressed as the amount of the substance in a liter (L) of air, expressed as mg/L.

1.4.2

LC_{50} - Lethal Concentration. Refers to the concentration of a substance that in a single or short term exposure produces 50% mortality in an experimental population of organisms. This term commonly is used in studies of acute toxicity of aquatic organisms. The common unit of measure in these studies is parts per million (ppm). This term also is used in subchronic investigations of birds and refers to the concentration of a substance in the diet of that animal that is lethal to 50% of the population.

1.4.3

EC_{50} - Effect Concentration. Refers to the concentration of a substance that, over a stipulated period of time, causes a specified effect in 50% of the test animals. Examples of such effects would be loss of movement in a 50% sample of animals, a 50% reduction in survival, development of deformities in 50% of the animals tested, etc.

1.4.4

NOEL - No Observed Effect Level. This refers to the highest known concentration of a chemical that causes no apparent effect to the parameters being examined (i.e., reproductive NOEL would be the value of the highest concentration of a substance that causes no effect on reproduction in the test animals). In compiling the data for the toxicity tables, it could not always be determined from a data source whether a NOEL was the highest possible concentration of a chemical that will cause no effect or the highest dose tested to cause no effect. Regardless of the criteria used to categorize a dose level as a NOEL, any dose at or below such levels can be considered to cause no apparent effect.

1.4.5

Acute Toxicity - This term represents the determination of the levels of a substance that cause 50% mortality to a population of organisms exposed to the substance for short period of time.

Studies that produce LD_{50}s involve administration of a single dose of a substance (or a cumulative series of exposures over a period of less than 24 hrs).

Studies that produce LC_{50}s involve exposure of a substance to an organism for a short period of time (generally 96 hrs but sometimes 48 hrs).

1.4.6
Subchronic Toxicity - This term defines a study in which the purpose is to determine the effects of a substance that is administered to organisms in multiple or continuous doses for a period of time greater than is examined in acute toxicity studies, but not as long as in chronic studies. The length of time employed in subchronic studies is frequently 3 to 90 days and is generally less then half of the life time of the organisms tested.

1.4.7
Chronic Toxicity - This is a type of study that is generally used to determine the effects of a substance through administration to organisms through multiple or continuous doses for an extended period of time, generally more then half of the animals life time.

Toxicity values for the various responses, or lack of response, to chemicals in various concentrations and formulations (Tables B3-3 to B3-42) were obtained from the source in which they were initially reported. In some cases, toxicity values were not part of the published literature but were derived solely from chemical company files and personal communications. In these instances, the values reported were taken from other publications and summary reports such as Eisler (1986), Hudson et al. (1984), Johnson and Finley (1980), Sassman et al. (1984), Sczerzenie et al. (1987), Smith (1987), U.S. EPA (various dates), and Weed Science Society of America (1983). The source reporting the secondary citations values was also given.

When the grade, concentration, or formulation of the test substance was specified in the data source, it is reported here. Unless otherwise specified, toxicity values provided in Material Data Safety Sheets (MSDS) and U.S. EPA chemical fact sheets were assumed to be for the formulation given in the title of the referenced product. If the grade, concentration, or formulation could not be determined, then the chemical value was reported as not specified.

Table B3-2. EPA Classifications of Chemicals Toxicities.

	VERY HIGHLY TOXIC	HIGHLY TOXIC	MODERATELY TOXIC	SLIGHTLY TOXIC	PRACTICALLY NON-TOXIC
MAMMAL					
LD_{50} (mg/kg)	<10	10 - 50	51 - 500	501 - 2000	>2000
LC_{50} (ppm)	<50	51 - 500	501 - 1000	1001 - 5000	>5000
BIRD					
LD_{50} (mg/kg)	<10	10 - 50	51 - 500	501 - 2000	>2000
LC_{50} (ppm)	<50	51 - 500	501 - 1000	1001 - 5000	>5000
AQUATIC					
LC_{50} (ppm)	<0.1	0.1 - 1.0	>1 - 10	>10 - 100	>100

2.0 Hazard Assessment Evaluations

The roadsides of Texas provide a unique habitat that is frequented by many animal species. The balance between animal habitat, danger to motorists, danger to the animals from being hurt or killed by traffic, and possible chemical toxicity from roadside management, is not easy to achieve. Each chemical is evaluated here for what is known about the chemical relative to the impacts it has on wildlife and aquatic animals. The results of this report are presented in Table B3-45 and discussed here for each chemical.

2.1 Chlorpyrifos (Dursban)

2.1.1 General Information

The studies of Hudson et al. (1984) and Smith (1987) provide significant test data on chlorpyrifos. Results of these and other toxicity studies are summarized in Tables B3-3 to B3-7.

2.1.2 Mammals

2.1.2.1 Acute Toxicity Effects

The acute oral LD_{50}s for chlorpyrifos (unspecified concentrations) range from 97 to 276 mg/kg in rats. Technical chlorpyrifos has an acute oral toxicity value of 151 mg/kg. The dermal LD_{50} of an unspecified concentration of this chemical in rats is 202 mg/kg. Injection of technical chlorpyrifos at doses of 45 mg/kg into neonate rats and doses of 279 mg/kg into adult rats resulted in no mortalities. In the rabbit, unspecified concentrations of chlorpyrifos have acute LD_{50} values of 1,000 to 2,000 mg/kg and a dermal LD_{50} of >2,000 mg/kg. The acute oral LD_{50} value for an unspecified concentration of chlorpyrifos in the guinea pig is 500 mg/kg. The technical grade of this chemical has an acute toxicity value of 500 to 1,000 mg/kg for the goat.

In the analysis presented here, chlorpyrifos did not indicate acute toxic effects using the maximum labeled application rates for the "realistic" animal exposures (Table B3-45). The "worst case" exposure for deer exceeded the referenced LD_{50} value which was derived as 10% of the value for the goat.

2.1.2.2 Subchronic and Chronic Toxicity Effects

Exposure of an unspecified concentration of chlorpyrifos for 90 days exhibited no effect at doses of 0.03 ppm in rats and 0.01 ppm in dogs. Maternal and fetal toxicity, but not developmental toxicity, were observed in mice at an exposure of 25 mg/kg/day of technical chlorpyrifos.

The values computed in this study for the deer and rabbit were below the NOEL value for the "realistic" case. The values for "worst case" exposure were exceeded in both species. These values were derived from 1/1000 the acute dosage for a rat (rabbit) and 1/1000 the acute dosage for the goat (deer).

2.1.2.3 Ecological Effects

Clements and Bale (1988) compared untreated sites and sites sprayed with chlorpyrifos (Dursban 4) and suggested that there were no long-term effects to hares because these animals continued to use treated areas and exhibited no abnormal behavior.

2.1.3 BIRDS

2.1.3.1 Acute Toxic Effects

Acute oral LD_{50} values for chlorpyrifos exposed to various species of quail range from 13.3 to 68.3 mg/kg. Doses of <15 mg/kg caused no mortality or cholinesterase inhibition in juvenile quail. The majority of the acute LD_{50} values for chlorpyrifos exposed to passerine birds range from 5 to 75 mg/kg, and most of these values are below 30 mg/kg. A few additional acute toxicity values are available that are lower then the ones mentioned above. These lower values are for nestling passerine birds and range from 1.26 to $\geq$6.5 mg/kg.

The mallard duck has acute oral LD_{50} values for technical chlorpyrifos of 112 and 75.6 mg/kg for ducklings and adults, respectively. The acute LD_{50} values of this chemical are 40 to 80 mg/kg for Canadian geese, 8.41 and 17.7 mg/kg for the ring-necked pheasant, 60.7 and 61.1 mg/kg for the chuckar, and 25 to 50 mg/kg for the sandhill crane. No mortality occurred in house sparrows following ingestion of 5 granules of chlorpyrifos (Lorsban 15G formulation); however, 20% mortality was observed in this species after consumption of 10 and 20 granules (Balcomb et al., 1984). Red-winged blackbirds, also examined in this previous study, exhibited no mortality following their consumption of up to 20 granules of insecticide.

The values computed for the bobwhite quail in this analysis for both "realistic" and "worst case" exposures were well below the acute reference LD_{50} known for quail.

2.1.3.2 Subchronic and Chronic Effects

Five-day feeding trials of Japanese quail yielded LC_{50} values of 293 ppm for technical chlorpyrifos and 492 ppm for a Dursban formulation of this pesticide. Maguire and Williams (1987a, 1987b) examined the effects of temperature stress and increasing concentrations of technical grade Dursban in feeding studies of juvenile bobwhite quail. Cold exposure amplified certain toxic effects of the insecticide (Maguire and Williams, 1987a, 1987b); however, a warming period of 12 hours tended to mitigate these effects (Maguire and Williams, 1987a). Heavier mortality was observed in bobwhite quail during years of more frequent application of organophosphorus pesticides which included chlorpyrifos (White et al., 1990).

The dietary LC_{50} of technical chlorpyrifos is 940 ppm for the mallard duck and 553 ppm for the ring-necked pheasant. The lowest dosage of this chemical that produced one or two deaths in 30 days was less than 2.5 mg/kg/day for mallard ducks.

The NOEL was computed as 1/100 of the LD_{50} for quail, with the "realistic" exposure value well below that level. The "worst case" value computed here exceeded the NOEL reference value.

2.1.3.3 Ecological Effects

Several species of birds continued to use areas treated with Dursban 4 and exhibited no abnormal behavior on these sites (Clements and Bale, 1988). Because of these findings, the previous authors suggested that this insecticide caused no long-term effects to these birds. Mullié and Keith (1993) found that aerial application of chlorpyrifos on 2x3 kilometer study plots resulted in temporary decreases in bird abundance, decreases in bird food abundance, and inhibition of brain cholinesterase in several species of African birds. Decreases in bird abundance were attributed to decreases in abundance of the insects eaten by these birds. Cholinesterase inhibition was brief, and mortality in adults was low. Chlorpyrifos may have reduced reproductive success by killing young (Mullié and Keith, 1993). These authors suggested that such reproductive effects could cause long-term population effects on the birds. It should be pointed out, however, that the application methods employed in this study encompassed more area then would be covered along road right-of-ways. No short-term effects on the behavior or health of wild geese were observed following treatment of a field in which these animals feed (Clements et al., 1992). Chlorpyrifos residue in the herbage eaten by these geese and in goose feces declined to negligible levels within a few days of treatment (Clements et al., 1992).

2.1.4 Amphibians

2.1.4.1 Acute Toxicity Effects

The acute LD_{50} for technical chlorpyrifos exposed to the bullfrog is >400 mg/kg. This value for Dursban 4E in a newt is >96 ug/L.

2.1.4.2 Subchronic and Chronic Toxicity Effects

No studies were found for this category.

2.1.5 FISH

2.1.5.1 Acute Toxicity Effects

The 96 hour LC_{50}s for technical chlorpyrifos and Dursban 10CR exposed to larval fathead minnows range from 0.12 to 0.28 mg/L. There appears to be an inverse relationship between period of exposure and the LC_{50} value. The 24 hour LC_{50} for technical chlorpyrifos is 0.32 mg/L and for Dursban 10CR is 0.40 mg/L. The one hour LC_{50} for Dursban 10CR is >1.0 mg/L. The effective concentration of Dursban 10CR that causes 50% deformities in developing fathead minnow larvae after a 96 hour exposure (EC_{50}) is 0.055 mg/L. As with the LC_{50} values, the concentration at which an EC_{50} occurs is higher with decreasing time of exposure. The 72 hour LC_{50} for Dursban EC exposure to mosquitofish is 0.26 ppm. Acute toxicity values for chlorpyrifos exposure in fish from areas of known pesticide use have been found to be higher than the LC_{50}s of fish from areas of little pesticide use. Mosquitofish, golden shinners, and green sunfish obtained from areas of little pesticide use had LC_{50}s of 215 & 230 ug/L, 35 & 45 ug/L, and 22.5 & 37.5 ug/L, respectively. These species of fish obtained from an area of high pesticide use had respective values of 595 ug/L, 125 ug/L, and 125 ug/L. The LC_{50}s obtained for bluegill vary depending on the formulation of chlorpyrifos used, the exposure period, and nature of the holding facility. The LC_{50} for this species in a static 96 hour exposure test was 2.4 mg/kg. In an experiment in which the exposure concentration was determined by averaging over a 24 hour period and the fish were held in a littoral enclosure, the LC_{50} was 2.67 ug/L. The 72 hour LC_{50} of Dursban EC to green sunfish was 0.04 ppm. Channel catfish have an acute LC_{50} of 280 mg/kg for technical chlorpyrifos in a static bioassay and an LC_{50} of 0.806 mg/L in a continuous flow bioassay with an unspecified concentration of this chemical. Trout vary in the LC_{50} values for exposure to chlorpyrifos from 7.1 to 98 mg/kg. Spinal deformities were observed in developing rainbow trout following a 72 hour exposure to 5.0 ug/L of technical chlorpyrifos. The majority of the estuarine fish examined for acute toxicity to chlorpyrifos had similar LC_{50} values (atlantic silverside - 1.7 ug/L, longnose killifish - 4.1 ug/L, striped mullet - 5.4 ug/L). Of the estuarine fish examined, the sheephead minnow had a noticeably higher LC_{50} of 136 ug/L.

2.1.5.2 Subchronic and Chronic Toxicity Effects

Extensive tests have been conducted regarding the effects of technical chlorpyrifos and Dursban 10CR on reproduction and development in the fathead minnow (Holcombe et al., 1982; Jarvinen and Tanner, 1982; Jarvinen et al., 1988). In general, longer exposure periods require less of a chemical to elicit an effect. Following a five hour exposure to 0.155 mg/L (155.0 ug/L) of Dursban 10CR, an increase in deformities and a reduction in growth of developing fathead minnow larvae was observed. In a population of fathead minnows exposed to Dursban 10CR for 200 days, concentrations of 0.12 ug/L of this product significantly reduced growth and biomass of 30 day old, second generation fish. The no observed effect level for the development of deformities in fathead minnows was between 0.0016 and 0.0032 mg/L. The no effect level for growth in developing young was between 0.0022 and 0.0048 mg/L. It has been found that growth rates of larval fathead minnows are reduced following application of sublethal concentrations of this substance (Siefert et al., 1989; Brazner and Kline, 1990). This reduction in growth rate was not considered a direct effect of the chemical on the fish but rather an indirect effect caused by the reduction of chlorpyrifos-sensitive invertebrates that forced dietary changes in the fish that in turn caused reduced growth rate. Three species of silversides exhibited significant mortality following 28 day exposures to concentrations of $\geq$0.48 to $\geq$1.8 ug/L technical chlorpyrifos.

2.1.6 Aquatic Invertebrates

2.1.6.1 Acute Toxicity Effects

Concentrations of chlorpyrifos products that have been found to effect the mobility, mortality, and population size of cladocerans range from 0.3 to <0.65 ug/L. Similar values (>0.37 to <0.65 ug/L) have been observed to be the lowest values tested to affect a reduction in population size of rotifers. The two stoneflies tested for reaction to chlorpyrifos had notably different LC_{50} values. The stonefly *Pteronarcys* had an LC_{50} of 10 ug/L, while the stonefly *Claassenia* had a value of 0.57 ug/L. The crayfish *Procambarus* and *Orconectus* had 96 hour LC_{50} values of 0.021 and 0.006 mg/L. The mysid shrimp had an LC_{50} of 0.035 ug/L.

2.1.6.2 Ecological Effects

Treatments of freshwater ponds with Dursban at levels of 0.028 and 0.28 kg/ha resulted in higher reduction of insect larvae and nymphs than insect adults and reflected, in part, the increased ability of the adults to emigrate and immigrate (Hurlbert et al., 1972). Second and third treatments in this study caused greater reductions in the occurrence of predaceous insects compared to herbivorous insects. Predaceous insect levels generally returned to control levels more slowly than herbivorous insects populations.

2.1.6.3 Subchronic and Chronic Toxicity Effects

No studies were found for this category.

2.1.7 Threatened and Endangered Animals

Little information is known about the effects of chlorpyrifos on wild animal populations, and particularly amphibians and reptiles. Hudson et al. (1984) reported that the bullfrog LD_{50} was over 20 times greater (>400) than that of the quail. It is generally thought that this chemical is not particularly toxic to reptiles or amphibians, but as an insecticide, it removes the food source of many of these animals. Following the labelled application rates and applying over limited areas should have little impact on threatened or endangered animals.

Table B3-3.

CHLORPYRIFOS
Dursban

MAMMALS

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RAT			
		Acute Toxicity	
Tech.	Oral	LD_{50} 151 mg/kg	Hudson et al., 84
Not specified	Oral	LD_{50} 97 to 276 mg/kg	Berg, 82 (*in* Smith, 87)
Not specified	Dermal	LD_{50} 202 mg/kg	Kenaga & Morgan, 78 (*in* Smith, 87)
Tech. $\geq$98%	Injection/neonates	45 mg/kg--highest dose causing no mortality after 7 days	Pope et al., 91
Tech. $\geq$98%	Injection/adults	279 mg/kg--highest dose causing no mortality after 7 days	Pope et al., 91
		Chronic Toxicity	
Not specified	Dietary/90 day exposure	0.03 ppm--no effect was observed at this dose	Kenaga & Morgan, 78 (*in* Smith, 87)

Table B3-3. Chlorpyrifos (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
MOUSE (*Mus musculus*)		<u>Reproductive/Developmental Toxicity</u>	
Tech. 96.8%	Oral/pregnant females dosed days 6 to 15 of gestation	25 mg/kg--severe maternal toxicity occurred as evidenced by statistically significant increases in salivation, tremors, ataxia lethargy, & death	Deacon et al., 80
Tech. 96.8%	Oral/pregnant females dosed days 6 to 15 of gestation	1 & 10 mg/kg--significant decrease in plasma & erythrocyte cholinesterase levels in maternal animals	Deacon et al., 80
Tech. 96.8%	Oral/pregnant females dosed days 6 to 15 of gestation	NOEL 0.1 mg/kg--no decrease in plasma & erythrocyte cholinesterase levels in maternal mice	Deacon et al., 80
Tech. 96.8%	Oral/pregnant females dosed days 6 to 15 of gestation	25 mg/kg--fetotoxic as evidenced by decreased fetal body measurements and increased incidence of minor skeletal variants	Deacon et al., 80
Tech. 96.8%	Oral/pregnant females dosed days 6 to 15 of gestation	NOEL $\leq$25 mg/kg--no significant effect on developing young	Deacon et al., 80
RABBIT		<u>Acute Toxicity</u>	
Not specified	Oral	LD_{50} 1,000 to 2,000 mg/kg	Kenaga & Morgan, 78 (*in* Smith, 87)
Not specified	Dermal	LD_{50} >2,000	Berg, 82 (*in* Smith, 87)

Table B3-3. Chlorpyrifos (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
GUINEA PIG (*Cavia cobava*)		Acute Toxicity	
Not specified	Oral	LD_{50} 500 mg/kg	Berg, 82 (*in* Smith, 87)
DOG (*Canis familiaris*)		Subchronic Toxicity	
Not specified	Dietary/90 day exposure	0.01 ppm--no effects were observed at this dose	Kenaga & Morgan, 78 (*in* Smith, 87)
GOAT		Acute Toxicity	
Tech. 94.5%	Oral	LD_{50} 500 to 1,000 mg/kg	Hudson et al., 84

Table B3-4.

CHLORPYRIFOS
Dursban

BIRDS

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
QUAIL (*Coturnix*)		Acute Toxicity	
Not specified	Oral	LD_{50} 13.3 mg/kg	Schafer et al., 83
NORTHERN BOBWHITE QUAIL (*Colinus virginianus*)		Acute Toxicity	
Tech. 99%	Oral	LD_{50} 32 mg/kg	Hill & Camerdese, 84
Tech. 94%	Oral/juveniles	NOEL <15 mg/kg--no mortality or detectable depression in cholinesterase production	Cairns et al., 91
Tech. 94%	Oral/juveniles	30 to 45 mg/kg--causes significant depression in cholinesterase production with 12 to 50% mortality occurring at the higher end of this range	Cairns et al., 91
CALIFORNIA QUAIL (*Callipepla californica*)		Acute Toxicity	
Tech. 94.5%	Oral	LD_{50} 68.3 mg/kg	Hudson et al., 84

Table B3-4. Chlorpyrifos (Cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
JAPANESE QUAIL (*Coturnix japonica*)			
		Acute Toxicity	
Tech. 94.5%	Oral	LD_{50}s 15.9 & 17.8 mg/kg	Hudson et al., 84
		Subchronic Toxicity	
Tech. 97%	Dietary/5 day exposure	LC_{50} 293 ppm	Hill & Camardese, 86
Dursban	Dietary/5 day exposure	LC_{50} 492 ppm	Hill & Camardese 86
ROCK DOVE (*Columbia livia*)			
		Acute Toxicity	
Tech. 94.5%	Oral	LD_{50} 26.9 mg/kg	Hudson et al., 84
HOUSE SPARROW (*Passer domesticus*)			
		Acute Toxicity	
Tech. 94.5%	Oral	LD_{50} 21.0 mg/kg	Hudson et al., 84
Not specified	Oral	LD_{50} 10 mg/kg	Schafer, 72
STARLING (*Sturnus vulgaris*)			
		Acute Toxicity	
Not specified	Oral/adults	LD_{50} 5.0 mg/kg	Schafer, 72
Tech. 94%	Oral/nestlings	$LD_{>50}$ $\geq$2.5 mg/kg	Meyers et al., 92

Table B3-4. Chlorpyrifos (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
STARLING (*Sturnus vulgaris*) (cont.)		Acute Toxicity (cont.)	
Tech. 94%	Oral/nestlings	3.75 to 6.5 mg/kg--caused 50% depression in cholinesterase production	Meyers et al., 92
Not specified	Oral	LD_{50} 75 mg/kg	Schafer et al., 83
REDWING BLACKBIRD (*Angelaius phoeniceus*)		Acute Toxicity	
Not specified	Oral/adults	LD_{50} 13 mg/kg	Schafer, 72
Tech. 94%	Oral/nestlings	LD_{44} 2.0 mg/kg	Meyers et al., 92
Tech. 94%	Oral/nestlings	1.26 to 2.5 mg/kg--caused 50% depression in cholinesterase production	Meyers et al., 92
COMMON GRACKLE (*Quiscalus quiscula*)		Acute Toxicity	
Not specified	Oral	LD_{50} 13 mg/kg	Schafer, 72
COMMON CROW		Acute Toxicity	
Not specified	Oral	LD_{50} >32 mg/kg	Schafer, 72

Table B3-4. Chlorpyrifos (Cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
MALLARD DUCK (*Anas platyrhynchos*)			
		Acute Toxicity	
Tech. 99%	Oral/ducklings	LD_{50} 112 mg/kg	Hudson et al., 84
Tech. 99%	Oral/adults	LD_{50} 75.6 mg/kg	Hudson et al., 84
		Subchronic Toxicity	
Tech. 97%	Dietary	LC_{50} 940 ppm	Hill et al, 75 (*in* Smith 87)
Tech.	Dietary/30 day exposure	Empirical Minimum Lethal Dose that produced 1 or 2 deaths in six trial subjects was < 2.5 mg/kg	Hudson et al., 84
CANADA GOOSE (*Branta canadensis*)			
		Acute Toxicity	
Tech. 99%	Oral	LD_{50} 40 to 80 mg/kg	Hudson et al., 84
RING-NECKED PHEASANT (*Phasianus colchicus*)			
		Acute Toxicity	
Tech. 94.5%	Oral	LD_{50}s 8.41 & 17.7 mg/kg	Hudson et al., 84
		Subchronic Toxicity	
Tech. 97%	Dietary	LC_{50} 553 ppm	Hill et al., 75 (*in Smith 87*)

Table B3-4. Chlorpyrifos (Cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
CHUCKAR (*Alectoris chukar*)		Acute Toxicity	
Tech. 99%	Oral	LD_{50}s 60.7 & 61.1 mg/kg	Hudson et al., 84
SANDHILL CRANE (*Grus canadensis*)		Acute Toxicity	
Tech. ≥94.5	Oral	LD_{50} 25 - 50 mg/kg	Hudson et al., 84

Table B3-5.

CHLORPYRIFOS
Dursban

AMPHIBIANS

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
BULLFROG (*Rana catesbeiana*)		Acute Toxicity	
Tech. 94.5	Oral	LD_{50} >400 mg/kg	Hudson et al., 84
NEWT (*Triturus vulgaris*)		Acute Toxicity	
Dursban 4E	Semistatic bioassay/ 96 hour exosure	LC_{10} >96 ug/L	van Wijngaarden et al., 93

Table B3-6.

CHLORPYRIFOS
Dursban

FISH

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
FATHEAD MINNOW (*Pimephales promelas*)		Acute Toxicity	
Tech.	Static bioassay/ larvae/96 hour exposure	LC_{50}s 0.17 mg/L (fresh solution) 0.15 mg/L (aged solution)	Jarvinen & Tanner, 82
Dursban 10CR	"	LC_{50}s 0.13 mg/L (fresh solution) 0.28 mg/L (aged solution)	Jarvinen & Tanner, 82
Tech.	Continuous flow bioassay/larvae/ 96 hour exposure	LC_{50} 0.14 mg/L	Jarvinen & Tanner, 82
Dursban 10CR	"	LC_{50} 0.12 mg/L	Jarvinen & Tanner, 82
Dursban 10CR	Static bioassay/ larvae/1, 2, 4, 8, 24, 96 hour exposure	LC_{50}s 1 hr >1,000 ug/L 2 hr >1,000 ug/L 4 hr 782.2 ug/L 8 hr 335.4 ug/L 24 hr 400.4 ug/L 96 hr 122.2 ug/L	Jarvinen et al., 88
Dursban 10CR	Static bioassay/ larvae/1, 2, 4, 8, 24, 96 hour exposure/ measure of dose causing 50% deformities	EC_{50}s 1 hr 760.9 ug/L 2 hr 365.7 ug/L 4 hr 215.5 ug/L 8 hr 183.7 ug/L 24 hr 30.4 ug/L 96 hr 54.9 ug/L	Jarvinen et al., 88

Table B3-6. Chlorpyrifos (Cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
FATHEAD MINNOW (*Pimephales promelas*)(cont.)		Acute Toxicity (cont.)	
Tech. 99.99%	Continuous flow bioassay/larvae/ 24, 48, 72, 96 hour exposure	LC_{50}s 24 hr 320.0 ug/L 48 hr 248.0 ug/L 72 hr 220.0 ug/L 96 hr 203.0 ug/L	Holcombe et al., 82
		Reproductive/Developmental Toxicity	
Dursban 10CR	Static bioassay/ larvae/5 hour exposure/transfer to clean water for the remainder of the 30 day test period	155.0 ug/L (similar to the 96hr LC_{50})--causes significant chronic effects such as increase in deformities and reduction in growth in developing larvae	Jarvinen et al., 88
Dursban 10CR	Static bioassay/ larvae/15 hour exposure/transfer to clean water for the remainder of the 96 hour test period	122.2 ug/L--50% deformities, typically a lateral bend in the spine of $<90^{\circ}$, within 96 hours	Jarvinen et al., 88
Dursban 10CR	Continuous flow bioassay/30 day exposure	2.1 ug/L--resulted in significant increase in deformities in developing larvae	Jarvinen et al., 88

Table B3-6. Chlorpyrifos (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
FATHEAD MINNOW (*Pimephales promelas*)(cont.)			
		Reproductive/Developmental Toxicity (cont.)	
Tech.	Continuous flow bioassay/embryo-	0.0032 mg/L--significant decrease in growth exhibited by developing young larvae/32day exposure	Jarvinen & Tanner, 82
Dursban 10CR	Continuous flow bioassay/embryo-larvae/ 32 day exposure	0.0048 mg/L--significant decrease in growth & survival exhibited by developing young	Jarvinen & Tanner, 82
Tech.	"	NOEL-->0.0016 - <0.0032 mg/L--no significant increase in deformities in developing young	Jarvinen & Tanner, 82
Dursban 10CR	"	NOEL-->0.0022 - <0.0048 mg/L--no effect on growth in developing young	Jarninen & Tanner, 82
Dursban 10CR	Continuous flow bioassay/200 day exposure	2.68 ug/L--significant increase in deformities occurred and significant reduction in growth of developing young within 30 days	Jarvinen et al., 83
Dursban 10CR	"	2.68 ug/L--survival of first generation fish was significantly reduced between 30 and 60 days	Jarvinen et al., 83
Dursban 10CR	"	≥0.63 ug/L--reproduction of first generation fish significantly reduced	Jarvinen et al., 83
Dursban 10CR	"	0.12 ug/L--growth and biomass of 30-day old second generation fish significantly reduced	Jarvinen et al., 83

Table B3-6. Chlorpyrifos (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
FATHEAD MINNOW (*Pimephales promelas*)(cont.)			
		Reproductive/Developmental Toxicity (cont.)	
Tech. 99.9%	Continuous flow bioassay/larvae	$\geq$47 ug/L--schooling behaviour disrupted after 24 hours, several fish developed spinal deformities after 48 hours	Holcombe et al., 82
MOSQUITOFISH (*Gambusia affinis*)			
		Acute Toxicity	
Dursban EC	Static bioassay/ 24, 48, 72 hour exposure	LC_{50}s 24 hr 1.40 ppm 48 hr 0.44 ppm 72 hr 0.26 ppm	Davey et al., 76
Tech. 99%	Static bioassay/fish obtained from an area of known pesticide use/36 hour exposure	LC_{50}s 595 ug/L	Ferguson et al., 66
Tech. 99%	Static bioassay/fish obtained from an area of little pesticide use/36 hour exposure	LC_{50}s 215 & 230 ug/L	Ferguson et al., 66

Table B3-6. Chlorpyrifos (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
LONGNOSE KILLIFISH (*Fundulus similis*)		Acute Toxicity	
Tech. 92%	Continuous flow bio-assay/96 hour exposure	LC_{50} 4.1 ug/L	Schimmel et al., 83
INLAND SILVERSIDE (*Menidia beryllina*)		Subchronic Toxicity	
Tech.	Continuous flow bioassay/28 day exposure	≥1.8 ug/L--significant reduction in survival of fry (53% mortality)	Goodman et al., 85
ATLANTIC SILVERSIDE (*Menidia menidia*)		Acute Toxicity	
Tech. 92%	Continuous flow bioassay/96 hour exposure	LC_{50} 1.7 ug/L	Schimmel et al., 83
		Subchronic Toxicity	
Tech.	Continuous flow bioassay/28 day exposure	≥0.48 ug/L--significant reduction in survival of fry (83% mortality)	Goodman et al., 85
TIDEWATER SILVERSIDE (*Menidia peninsulae*)		Subchronic Toxicity	
Tech.	Continuous flow bioassay/28 day exposure	≥0.78 ug/L--significant reduction in survival of fry (69% mortality)	Goodman et al., 85

Table B3-6. Chlorpyrifos (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
SHEEPHEAD MINNOWS (*Cyprinodon variegatus*)		Acute Toxicity	
Tech. 92%	Continuous flow bioassay/96 hour exposure	LC_{50} 136 ug/L	Schimmel et al., 83
BLUEGILL (*Lepomis macrochirus*)		Acute Toxicity	
Tech.	Static bioassay/ 96 hour exposure	LC_{50} 2.4 mg/kg	Johnson & Finley, 80
Not Specified	Continuous flow bio-assay/96 hour exposure	LC_{50} 0.010 mg/L	Phipps & Holcombe, 85
Dursban 2E	Littoral enclosure/96 hour exposure/LC_{50} is a 1 hour peak concentration	LC_{50} 7.24 ug/L	Siefert et al., 89
Dursban 2E	Littoral enclosure/96 96 hour exposure/LC_{50} is a 24 hour weighted average concentration	LC_{50} 2.67 ug/L	Siefert et al, 89
GREEN SUNFISH (*Lepomis cyanellus*)		Acute Toxicity	
Dursban EC	Static bioassay/ 24, 48, 72 hour exposure	LC_{50}s 24 hr 0.11 ppm 48 hr 0.05 ppm 72 hr 0.04 ppm	Davey et al., 76

Table B3-6. Chlorpyrifos (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
GREEN SUNFISH (*Lepomis cyanellus*) (cont.)		Acute Toxicity (cont.)	
Tech. 99%	Static bioassay/fish obtained from an area of known pesticide use/ 36 hour exposure	LC_{50}s 125 ug/L	Ferguson et al., 66
Tech. 99%	Static bioassay/fish obtained from an area of little pesticide use/ 36 hour exposure	LC_{50}s 22.5 & 37.5 ug/L	Ferguson et al., 66
CHANNEL CATFISH (*Ictalurus punctatus*)		Acute Toxicity	
Tech.	Static bioassay/ 96 hour exposure	LC_{50} 280 mg/kg	Johnson & Finley, 80
Not specified	Continuous flow bioassay/96 hour exposure	LC_{50} 0.806 mg/L	Phipps & Holcombe, 85
STRIPED MULLET (*Mugil cephalus*)		Acute Toxicity	
Tech. 92%	Continuous flow bioassay/96 hour exposure	LC_{50} 5.4 ug/L	Schimmel et al., 83

Table B3-6. Chlorpyrifos (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RAINBOW TROUT (*Salmo gairdneri*)			
		Acute Toxicity	
Tech.	Static bioassay/ 96 hour exposure	LC_{50} 7.1 mg/kg	Johnson & Finley, 80
Not specified	Continuous flow bioassay/96 hour exposure	LC_{50} 0.009 mg/L	Phipps & Holcombe, 85
Tech. 99.9%	Continuous flow bioassay/juveniles/48, 72, 96 hour exposure	LC_{50}s 48 hr 11.4 ug/L 72 hr 8.0 ug/L 96 hr 8.0 ug/L	Holcombe et al., 82
		Reproductive/Developmental Toxicity	
Tech. 99.9%	Continuous flow bioassay/juveniles/ 72 hour exposure	5.0 ug/L--spinal deformities obvious after 30 hours, 41% of surviving animals developed deformed vertebral cloumns after 72 hours	Holcombe et al., 82
CUTTHROAT TROUT (*Salmo clarki*)			
		Acute Toxicity	
Tech.	Static bioassay/ 96 hour exposure	LC_{50} 18 mg/kg	Johnson & Finley, 80

Table B3-6. Chlorpyrifos (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
GOLDEN SHINNER (*Notemigonus crysoleucas*)		<u>Acute Toxicity</u>	
Tech. 99%	Static bioassay/fish obtained from an area of known pesticide use/36 hour exposure	LC_{50}s 125 ug/L	Ferguson et al., 66
Tech. 99%	Static bioassay/fish obtained from an area of little pesticide use/36 hour exposure	LC_{50}s 35 & 45 ug/L	Ferguson et al., 66
LAKE TROUT (*Salvelinus namaycush*)		<u>Acute Toxicity</u>	
Tech.	Static bioassay/ 96 hour exposure	LC_{50} 98 mg/kg	Johnson & Finley, 80

Table B3-7.

CHLORPYRIFOS
Dursban

AQUATIC INVERTEBRATES

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
GASTROPODA (3 species)		Acute Toxicity	
Tech. 99.8%	Discontiuous flow bio-assay/96 hour exposure	EC_{10} >94 ug/L	van Wijngaarden et al., 93
SNAIL (*Aplexa*)		Acute Toxicity	
Not Specified	Continuous flow bio-assay/96 hour exposure	LC_{50} >0.806 mg/L	Phipps & Holcombe, 85
CLADOCERA (2 species)		Acute Toxicity	
Dursban 4E	Discontiuous flow bio-assay/96 hour exposure	EC_{50}s 0.3 & 0.4 ug/L 50% immobility	van Wijngaarden et al., 93
Dursban 4E	"	LC_{50}s 0.3 & 0.5 ug/L 50% mortality	van Wijngaarden et al., 93

Table B3-7. Chlorpyrifos (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
CLADOCERA (5 species)		<u>Field Toxicity</u>	
Dursban 2E	Littoral enclosure/ 96 hour exposure/ measured 1 hour after application	>0.37 <0.65 ug/L--lowest observed effect concentration to cause a significant reduction in population size	Siefert et al., 89
ROTIFER (*Monostyla*)		<u>Field Toxicity</u>	
Dursban 2E	Littoral enclosure/ 96 hour exposure/ measured 1 hour after application	>0.37 <0.65 ug/L--lowest observed effect concentration to cause a significant reduction in population size	Siefert et al., 89
COPEPODA (Copododites)		<u>Field Toxicity</u>	
Dursban 2E	Littoral inclosure/ 96 hour exposure/ measured 1 hour after application	>24.1 <35.7 ug/L--lowest observed effect concentration to cause a significant reduction in population size	Siefert et al., 89
COPEPODA (*Acanthocyclops*)		<u>Field Toxicity</u>	
Dursban 2E	Littoral inclosure/ 96 hour exposure/ measured 1 hour after application	>5.26 <7.75 ug/L--lowest observed effect concentration to cause a significant reduction in population size	Siefert et al., 89

Table B3-7. Chlorpyrifos (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
SCUD (*Gammarus*)		Acute Toxicity	
Tech.	Static bioassay/ 48 hour exposure	LC_{50} 0.11 ug/L	Johnson & Finley, 80
Dursban 4E	Discontinuous flow/ 96 hour exposure	LC_{50} 0.07ug/L	van Wijngaarden et al., 93
STONEFLY (*Pteronarcys*)		Acute Toxicity	
Tech.	Static bioassay/ 48 hour exposure	LC_{50} 10 ug/L	Johnson & Finley, 80
STONEFLY (*Claassenia*)		Acute Toxicity	
Tech.	Static bioassay/ 48 hour exposure	LC_{50} 0.57 ug/L	Johnson & Finley, 80
CRAYFISH (*Procambarus*)		Acute Toxicity	
Tech. 99.8%	Static bioassay/ 24, 48, 72, 96 hour exposure	LC_{50}s 24 hr 0.037 mg/L 48 hr 0.023 mg/L 72 hr 0.022 mg/L 96 hr 0.021 mg/L	Cebrián et al., 92

Table B3-7. Chlorpyrifos (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
CRAYFISH (*Orconectes*)		Acute Toxicity	
Not Specified	Continuous flow bioassay/96 hour exposure	LC_{50} 0.006 mg/L	Phipps & Holcombe, 85
MYSID SHRIMP (*Mysidopsis bahia*)		Acute Toxicity	
Tech 92%	Continuous flow bioassy/96 hour exposure	LC_{50} 0.035 ug/L	Schimmel et al., 83

2.2 Clopyralid (Transline)

2.2.1 General Information

Additional information regarding clopyralid (listed under its common chemical name of 3,6,-Dichloropicolinic Acid) is given in WSSA (1983). Results of toxicity studies are presented in Tables B3-8 to B3-11

2.2.2 Mammals

2.2.2.1 Acute Toxicity Effects

Acute oral toxicity values for rats and mice exposed to technical clopyralid range from 4,300 to >5,000 mg/kg. The acute dermal toxicity of technical clopyralid in rabbits is >5,000 mg/kg. No effect was observed in the rat following exposure, via inhalation, of 5.03 mg/L of clopyralid to the rat.

The values calculated for this analysis (Table B3-45) indicated a low toxicity for this chemical in both the "realistic" and "worst case" situations.

2.2.2.2 Subchronic and Chronic Toxicity Effects

Results of studies of subchronic exposures of technical clopyralid to rats, dogs, and rabbits found no effect levels of 150, 150, and 250 mg/kg/day, respectively. Chronic toxicity studies of the mouse and rat revealed no effect values of 350 ppm and 50 mg/kg/day, respectively, for technical clopyralid. This substance has been shown to not interfere with reproduction in rats; exposures high enough to effect the mother (250 mg/kg/day) resulted in no apparent effect on the offspring (Hayes et al., 1984). No maternal effect or effects on the developing young were observed in the rabbit following doses of technical clopyralid of ≤250 mg/kg/day. Repeated high exposures of clopyralid may affect the liver and kidneys, but it has not been found to be carcinogenic in long-term animal studies (organisms and formulation not specified; Dow Chemical, 1989). All mutagenicity tests for clopyralid were negative (organisms and formulation not specified; Dow Chemical, 1989).

The NOEL values for both deer and rabbits were extrapolated from laboratory rat data and were valued at 1/1000 of the dosage that produced no effect in the rat. The "worst case" for the deer exceeded the NOEL value.

2.2.3 BIRDS

2.2.3.1 Acute Toxicity Effects

No values for acute toxicity studies could be found for birds.

Little is known about the toxic effects of clopyralid on birds, but all indications are that labelled application and exposure rates provide chemical concentrations well below toxic effect levels.

2.2.3.2 Subchronic and Chronic Toxicity Effects

Subchronic toxicity values for dietary exposure of technical clopyralid to mallard ducks and bobwhite quail are >4,640 mg/kg. This chemical is considered to have a low order of toxicity in birds (WSSA, 1983).

2.2.4 FISH

2.2.4.1 Acute Toxicity Effects

The 96 hour LC_{50} values of technical clopyralid for rainbow trout and bluegill are 103.5 and 125.4 mg/kg, respectively. This chemical is considered to be of a low order of toxicity to fish (Haagsma, 1975).

2.2.4.2 Subchronic and Chronic Toxicity Effects

No studies could be found for this category.

2.2.5 Aquatic Invertebrates

2.2.5.1 Acute Toxicity Effects

The LC_{50} value for daphnia is 230 mg/L. A solution of 1 ppm clopyralid was not found to affect the species of daphnia or snail tested (no further details specified; WSSA, 1983).

2.2.5.2 Subchronic and Chronic Toxicity Effects

No studies could be found for this category.

2.2.6 Threatened and Endangered Animals

Studies on clopyralid appear to indicate little cause for concern for wildlife species. It appears that use of this chemical as labelled rarely produces toxic effects.

Table B3-8.

CLOPYRALID
Transline

MAMMALS

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RAT			
		Acute Toxicity	
Tech.	Oral	LD_{50} >5,000 mg/kg	WSSA, 83; Haagsma, 75
Tech.	Oral	LD_{50} 4,300 mg/kg	WSSA, 83; Haagsma, 75
		Subchronic Toxicity	
Tech.	Not specified/ 90 day exposure	NOEL 150 mg/kg/day	WSSA, 83
		Chronic Toxicity	
Tech.	Not specified/ 18 month exposure	NOEL 50 mg/kg/day	WSSA, 83
Tech.	Inhalation/1 hour exposure	NOEL 5.03 mg/L	WSSA, 83
		Reproductive/Developmental Toxicity	
Tech.	Gavage/pregnant animals/days 6-15 of gestation	250 mg/kg/day--maternal toxicity-decreased body weight gain	Hayes et al., 84
Tech.	"	NOEL $\leq$250 mg/kg/day--no effect on developing young	Hayes et al., 84

Table B3-8. Clopyrald (Cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
MOUSE			
		Acute Toxicity	
Tech.	Oral	LD_{50} >5,000 mg/kg	WSSA, 83
		Chronic Toxicity	
Tech.	Not specified/ 18 month exposure	NOEL 350 ppm	WSSA, 83
RABBIT			
		Acute Toxicity	
Tech.	Dermal	LD_{50} >2,000	WSSA, 83
		Subchronic Toxicity	
Tech.	Dermal/exposure duration not specified	NOEL 250 mg/kg/day	WSSA, 83
		Reproductive/Developmental Toxicity	
Tech.	Gavage/pregnant animals/days 6-18 of gestation	NOEL ≤250 mg/kg/day--no maternal effect	Hayes et al., 84
Tech.	"	NOEL ≤250 mg/kg/day--no effect on developing young	Hayes et al., 84

Table B3-8. Clopyrald (Cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
DOG (*Canis familiaris*)			
		Subchronic Toxicity	
Tech.	180 day exposure	150 mg/kg/day -- no systematic effects	WSSA, 83

Table B3-9.

CLOPYRALID
Transline

BIRDS

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
BOBWHITE QUAIL (*Colinus virginianus*)		Subchronic Toxicity	
Tech.	Dietary/8 day exposure	LC_{50} >4,640 mg/kg	WSSA, 83; Haagsma, 75
MALLARD DUCK (*Anas platyrhynchos*)		Subchronic Toxicity	
Tech.	Dietary/8 day	LC_{50} >4,640 mg/kg	WSSA, 83; Haagsma, 75

Table B3-10.

CLOPYRALID
Transline
FISH

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
BLUEGILL (*Lepomis macrochirus*)		Acute Toxicity	
Tech.	96 hour exposure	LC_{50} 125.4 mg/L	WSSA, 83; Haagsma, 75
RAINBOW TROUT (*Salmo gairdneri*)		Acute Toxicity	
Tech.	96 hour exposure	LC_{50} 103.5 mg/L	WSSA, 83; Haagsma, 75

Table B3-11.

CLOPYRALID
Transline

AQUATIC INVERTEBRATES

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
DAPHNIA			
		Acute Toxicity	
Not Specified	48 hour exposure	LC_{50} 230 mg/L	Batchelder, pers. comm. *in* Leitch & Fagg, 85
		Subchronic Toxicity	
Tech.	Not specified	NOEL 1 ppm	WSSA, 83

2.3 Diazinon (Diazinon)

2.3 General Information

Reviews of information regarding diazinon are presented in EPA (1988a & 1988c), and an extensive discussion of the biological impacts of this chemical and its formulations is given in Eisler (1986). Results of toxicity studies are presented in Tables B3-12 to B3-16.

2.3.2 Mammals

2.3.2.1 Acute Toxicity Effects

Acute oral LD_{50} values for technical diazinon exposed to rats range from 66 to 967 mg/kg. EPA 1988a lists an acute oral LD_{50} of 618 mg/kg; the animal for which this value was derived was not specified, but it was probably the rat. The acute oral toxicity value for the diazinon formulation diazinon 4E in rats is 1,230 mg/kg. Acute inhalation LD_{50}s for technical diazinon and diazinon 4E are 3.5 mg/kg and >2 mg/kg, respectively. A 10 mg/kg injection of an unspecified concentration of diazinon has been found to cause no effect on brain, liver, and blood chemistry in rats; however, doses of 20 and 40 mg/kg caused significant alterations in these parameters. The acute dermal LD_{50} for technical diazinon and diazinon 4E in rabbits are >2,000 mg/L and 3,610 mg/L, respectively. The inhalation LD_{50} for an unspecified concentration of diazinon exposed to rabbits is 27.2 mg/L. Technical diazinon has been found to have an acute oral toxicity value of 2,750 mg/kg in mice. Exposure of 17.3 mg/kg of an unspecified formulation of diazinon to the white-footed mouse resulted in a 69% depression in brain acetylcholinesterase. The acute oral LD_{50}s for unspecified formulations of diazinon in guinea pigs, dogs, pigs, and sheep are 450 mg/kg, >500 mg/kg, 400 mg/kg, and >1,000 mg/kg respectively. Dogs experienced 50% reduction in serum cholinesterase within 3.5 hours following a single dose exposure to 4 mg/kg of an unspecified formulation of diazinon. Acute pancreatitis was exhibited by dogs following single doses of 75 mg/kg of this substance. In acute exposure, technical diazinon is not considered to be a dermal or eye irritant (EPA, 1988a). Studies with rabbits have demonstrated eye irritation with redness or swelling of the eyelids indicating this material is moderately irritating on contact (Ciba-Geigy, 1982).

Available data on manufacturing use formulations of diazinon (89-92%) indicate this substance is moderately toxic via acute oral exposure and mildly toxic on acute dermal and inhalation bases (EPA, 1988a).

Diazinon exposures calculated in this analysis did not reach any acute values in the "realistic" assessment. The "worst case" exposure values for deer did exceed the LD_{50} value extrapolated as 1/10 the value for the laboratory rat (Table B3-45).

2.3.2.2 Subchronic and Chronic Toxicity Effects

Subchronic exposures of an unspecified formulation of diazinon for an unspecified length of time resulted in a loss of body weight in rats at doses of 80 mg/kg/day. Some mortality occurred in this previous study at doses of 160 mg/kg/day. A five week dietary investigation in rats resulted in no observed effects at exposures of 0.1 mg/kg of an unspecified formulation of diazinon and depressed plasma cholinesterase levels at doses of 0.5 mg/kg of the test substance. Hepatic injury occurred in rats exposed to 0.5 mg/kg of technical diazinon twice weekly for 28 weeks . Dietary exposure to approximately 40 mg/kg/day of technical diazinon for 103 weeks resulted in no evidence of carcinogenicity in rats. No effect on reproduction and no malformations in the young were observed in a three generation study of rats exposed to an unspecified formulation of diazinon via the diet; however, reduced growth occurred in a two year dietary investigation of the effects of an unspecified concentration of diazinon on rats. Female mice exposed to an unspecified formulation of diazinon in a subchronic study of an unspecified time experienced weight loss at a dose of 120 mg/kg/day, and mortality occurred in both sexes at doses of 240 mg/kg/day. Dietary exposure of technical diazinon to mice for 108 weeks resulted in no evidence of oncogenicity. Developmental and behavioral dysfunctions have been observed in maturing mice subjected to prenatal exposures of 0.18 mg/kg/day; brain pathology occurred in mice at doses of 9 mg/kg/day. All pregnant mice fed 9 mg/kg of diazinon during gestation survived, and no mortality was observed in young at weaning with doses of 0.18 mg/kg/day; however, 12% of the pups died prior to weaning at doses of 9 mg/kg/day (Barnett et al., 1980). Doses of 100 mg/kg/day of an unspecified formulation of diazinon caused significant maternal toxicity in pregnant rabbits but resulted in no developmental toxicity in the young. A variety of subchronic studies have been conducted in which dogs were exposed to formulations of diazinon for varying lengths of time at various concentrations. Results of these studies range from cholinesterase inhibition at 4.3 mg/kg/day (43 week exposure) to complete mortality at 20 mg/kg/day (30 day exposure). Chronic oral toxicity studies indicate that death was probable if daily doses of diazinon exceed 5 mg/kg for swine.

2.3.3 BIRDS

2.3.3.1 Acute Toxicity Effects

Acute oral LD_{50}s for northern bobwhite quail range from 10 to 25 mg/kg. This value for the European quail is 4.22 mg/kg. Mallard ducks have acute oral LD_{50}s of 3.54 mg/kg for exposure to technical diazinon and 14 mg/kg for exposure to an unspecified formulation of this chemical in ducklings. Technical diazinon has an acute oral LD_{50} of 4.33 mg/kg in pheasant. Acute oral toxicity values for unspecified formulations of diazinon exposed to turkey are 2.5 and 3.5 mg/kg. Goslings exhibit an oral LD_{50} of 2.7 mg/kg for an unspecified concentration of diazinon. Acute oral LD_{50}s for passerine birds ranged from 2.0 mg/kg (red-wing blackbird) to 316 mg/kg (starling); however, most of these values were below 8.0 mg/kg.

In birds, granular diazinon is generally similar in toxicity to its technical form (Balcomb et al., 1984; Hill and Camardese, 1984). Using bobwhite quail, Hill and Camardese (1984) predicted that 1 to 5 granules of 14% granular Diazinon should be lethal to 15 to 35 gram birds, particularly to juveniles of seed eaters.

Manufacturing use formulations of diazinon are considered to be very highly toxic to waterfowl on an acute oral basis and highly toxic to waterfowl and upland game birds based on dietary studies (EPA, 1988c). Granular product formulations of diazinon are highly toxic or very highly toxic to waterfowl, upland game birds, and songbirds exposed to these substances via acute oral and dietary routes (EPA, 1988a). EPA (1988a) outlines the conclusion that use of diazinon on sod farms and golf courses may meet or exceed acceptable risk levels for birds, and the risk of exposure to diazinon by birds on other grassy sites is considered similar to these previously mentioned areas. Should application rates along road right-of-ways be similar to the grassy situations outlined in EPA (1988a), it would seem that road right-of-ways might also have a similar risk potential.

Diazinon was the only chemical evaluated in this report that produced a calculated exposure value exceeding the LD_{50} for Bobwhite quail. The "realistic" value was not met, but the "worst case" dose was exceeded. Birds are sensitive to diazinon and tend to readily eat it in its granular form. TxDOT applies diazinon as a liquid spray to wet (not drench) active fire ant mounts.

2.3.3.2 Subchronic and Chronic Toxicity Effects

Five-day feeding trials in which Japanese quail were exposed to technical grade diazinon and diazinon (AG500) yielded LC_{50}s of 167 and 101 ppm, respectively, indicating that these concentrations were very toxic to these animals (Hill and Camardese, 1986). No deaths occurred in this study at a dose level of 85 ppm, but 53% of the animals died at 170 ppm and 87% at 240 ppm. The dietary LC_{50} for technical diazinon exposure in bobwhite quail is 245 ppm. Food consumption and reproduction have been found to be negatively effected above concentrations of 35 ppm diazinon (Stromborg, 1981). Diazinon has been found to be teratogenic in chickens (Wyttenbach and Hwang, 1984) and bobwhite quail (Meneely and Wyttenbach, 1989). Bobwhite quail embryos displayed malformations of the axial skeletons similar to those seen in other birds; however, these defects were less pronounced in the bobwhite (Wyttenbach and Hwang, 1984). Dietary LC_{50}s of <47 and 191 ppm for technical diazinon have been reported in mallard ducks. All ducks exposed to the 47 ppm doses died. The subchronic LC_{50} value for technical diazinon, exposed via diet, in juvenile pheasant is 244 ppm. Doses of 1.02 to 2.10 mg/day have been found to affect food consumption and egg production in adult pheasant.

Based on dietary LC_{50}s of 245 ppm in bobwhite quail and <47 ppm in mallard ducks, EPA (1988a) considers diazinon to be highly toxic to upland game birds and very highly toxic to waterfowl.

The NOEL for diazinon was not met in this analysis for the "realistic" case, but the "worst case" exposure exceeded the rate.

2.3.3.3 Ecological Effects

Brehmer and Anderson (1992) conducted a study to determine if nesting success would be affected by diazinon sprayed on trees at levels of 598 ppm. Survival of young birds was monitored for up to 10 days post treatment. Sample sizes were small, but no significant differences in survival of young birds was found between sprayed and control nests. Consumption of prey contaminated with diazinon was not concluded to be the primary source of acquisition of this insecticide by hawks (Hooper et al., 1989).

2.3.4 Amphibians

2.3.4.1 Acute Toxicity Effects

The acute LD_{50} for technical diazinon exposed to the bullfrog is >2,000 mg/kg.

2.3.4.2 Subchronic and Chronic Toxicity Effects

No studies were found for this category.

2.3.5 Fish

2.3.5.1 Acute Toxicity Effects

Acute LD_{50}s for technical diazinon range from 2.1 to 6.9 mg/L for fathead minnows. Technical diazinon has an acute toxicity value of 168 ug/L in bluegills. Juvenile sheepshead minnows exhibited an acute LC_{50} of 1,400 ug/L for technical diazinon. Substantial variation occurs among values for acute LC_{50}s in various species of trout. These values range from 110 ug/L in rainbow trout to 1,700 ug/L in cutthroat trout. Tilapia have been reported to have an acute LC_{50} of 20 mg/L for an unspecified formulation of diazinon.

Toxicity values for fish exposed to manufacturing use and product formulations of diazinon ranged from moderately to very highly toxic; the majority of these tests characterized this chemical as highly toxic (EPA, 1988a).

2.3.5.2 Subchronic and Chronic Toxicity Effects

The no observed effect level for a significant increase in development of deformities in larval fathead minnows exposed to technical diazinon is between 0.05 and 0.09 mg/L. At doses of $\geq$0.09 mg/L, a significant decrease in growth was observed in these fish. No toxicant related mortality was observed in parental sheepshead minnows exposed to 10.0 ug/L of technical diazinon; however, doses of this chemical $\geq$0.47 ug/L caused reduced fecundity in these fish. Tilapia exhibited microscopic alterations in skeletal muscle following exposure to an unspecified concentration of diazinon at doses of $\geq$10 mg/L.

2.3.5.3 Ecological Effects

Goodman et al. (1979) conducted a study of the effects of sublethal doses of diazinon (0.47 to 6.5 ug/L) on demographic attributes of sheepshead minnows. These authors found that although the number of eggs spawned was significantly reduced, no concentrations tested significantly affected parental survival or fertility of eggs, nor were survival and growth of the young affected. Kanazawa (1978) found that the bioconcentration ratio (partition coefficient between the organism and the water) was higher for the fish tested than for the crayfish and snails examined. Upon being placed in pesticide-free water, elimination of diazinon from fish was rapid (Kanazawa, 1978).

2.3.6 Aquatic Invertebrates

2.3.6.1 Acute Toxicity Effects

Technical diazinon has acute toxicity values in daphnia ranging from 0.522 ppb to 2.0 ug/L; the majority of these values range from 0.8 to 2.0 ug/L. Rotifers exhibit an acute toxicity value of 29.22 mg/L for technical diazinon. The acute LC_{50} for technical diazinon is 4.82 ug/L in mysid shrimp. The maximum acceptable toxicant level for these animals is between 1.15 and 3.25 ug/L; at concentrations of $\geq$3.25 ug/L, fecundity was reduced. Penaeid shrimp have an acute toxicity value for technical diazinon of 28 ug/L. Cladocerans, scuds, and stoneflies have acute LC_{50} or EC_{50} values ranging from 0.2 ug/L to 25 ug/L.

Manufacturing use and product formulations of diazinon are considered to be very highly toxic to all species of freshwater invertebrates tested (EPA, 1988a).

2.3.6.2 Subchronic and Chronic Toxicity Effects

Demographic characteristics of a laboratory-maintained colony of rotifers were reduced by 50% following exposure to concentrations of 5.20 to 12.33 ug/L of technical diazinon. In an investigation conducted in outdoor stream channels, elevated drift, particularly of snails and amphipods, occurred four weeks after dosing with 0.3 and 3.0 ug/L of technical diazinon. Additional details regarding these studies are given in the following section (Ecologic Effects).

2.3.6.3 Ecologic Effects

Fifty percent reductions in net reproductive rate, generation time, and life expectancy at hatching were observed in rotifers at exposure concentrations of 5.20, 8.49, and 12.33 mg/L of technical diazinon (Fernández-Casalderrey et al., 1992a). The medium amount of time required for a concentration of diazinon to reduce a population of rotifers by 50% decreased with increasing concentration; exposures of diazinon ranging from 5.84 to 19.48 mg/L had medium lethal times ranging from 6.96 to 2.49 days (Fernández-Casalderrey et al., 1992b). It was proposed by Fernández-Casalderrey et al., (1992a) that in natural waters, diazinon might be hazardous to rotifers at much lower concentrations than those determined by laboratory studies because, generally, phytoplankton densities in natural waters are low, and it appears that rotifers are weaker in situations of low food density. Authur et al. (1983) investigated the effects of various concentrations of technical diazinon on macroinvertebrate and insect community structure within outdoor stream channels. Macroinvertebrate benthic densities were not consistently reduced following treatment with diazinon; however, densities in the control channel were 5 and 25% higher than in low and high treatment channels, respectively. Elevated drift occurred four weeks after dosing with 0.3 and 3.0 ug/L of technical diazinon and following increases in dose concentration. Dominant drifting macroinvertebrates in decreasing order of density were: phsyid snails, amphipods, corixids, leechs, and chironomids. Less abundant drifting organisms were damselflies, beetles, and mayflies. Diazinon treatment did not change emergence of chronomids, but caddisfly emergence was reduced.

2.3.7 Threatened and Endangered Species

Because diazinon is toxic to many nontarget species, this chemical has been identified by the Division of Endangered Species and Habitat Conservation of the U.S. Fish and Wildlife Service as likely to jeopardize certain endangered species inhabiting range and pastureland, grain crops, soybeans, and sorghum (EPA, 1988). Should applications along road right-of-ways be similar to the situations outlined above, the use of diazinon should be avoided on sites that could be inhabited by endangered species.

Considerable information has been published on diazinon, most of which deals with the acute toxicity of diazinon to birds. There seems to be little threat to reptiles or amphibians when used as labelled. Hudson et al. (1984) reported an LD_{50} exceeding 2,000 for the bullfrog but less than 4 mg/kg for the mallard in the same study. Diazinon poses a moderate threat to mammals, particularly those with small home ranges that could be restricted to a roadside environment. The granular form of diazinon is known to be toxic to birds in small doses. The liquid form of diazinon is proposed for insect control in roadside rest areas and around facilities used by humans. This should greatly reduce the likelihood of ingestion over the granular form. Birds feeding on seeds on the ground appear to be the most susceptible.

Table B3-12.

DIAZINON
Diazinon

MAMMALS

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RAT			
		Acute Toxicity	
4E	Oral	LD_{50} 1,230 mg/kg	Ciba-Geigy, 82
Tech.	Oral	LD_{50}s 96 to 967 mg/kg (males) 66 to 635 mg/kg (females)	EPA, 86b
Tech.	Oral	LD_{50}s 200 to 900	Gaines, 69 (*in* Smith, 87)
Tech.	Inhalation	LC_{50} 3.5 mg/L	EPA, 86b
4E	Inhalation/ 4 hour exposure	LC_{50} >2 mg/L	Ciba-Geigy, 82
Not specified	Oral	LD_{50}s 150 to 220 mg/kg	Schafer, 72
Not specified	Intraperitoneal injection	NOEL 10 mg/kg--no effect on brain, liver & blood chemistry examined	Matin et al., 90
Not specified	"	20 mg/kg--slight but significant hyperglycaemia, glycogen depletion, reduced brain cholinesterase activity, & increased brain & blood lactate levels	Matin et al., 90
Not specified	"	40 mg/kg--pronounced hyperglycaemia, glycogen depletion, reduced brain cholinesterase activity, & increased brain & blood lactate levels	Matin et al., 90

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Table B3-12. Diazinon (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RAT (cont.)			
		Subchronic Toxicity	
Not specified	Not specified	80 mg/kg/day (1600 ppm)--body weight loss occurred	EPA, 88a
Not specified	Not specified	160 mg/kg/day (3200 ppm)--some deaths occurred	EPA, 88a
Not specified	Dietary/5 week exposure	0.1 mg/kg--no effect	Davies & Holub, 80a (*in* Eisler, 86)
Not specified	"	0.5 mg/kg--depressed plasma cholinesterase levels	Davies & Holub, 80a (*in* Eisler, 86)
Tech. 87%	Gavage/twice weekly for 28 weeks	0.5 mg/kg--caused a sustained form of hepatic injury characterized by cellular lipid accumulation	Anthony et al., 86
		Chronic Toxicity	
Tech. 98%	Dietary/103 week exposure followed by 2 week observation	$\leq$40 mg/kg/day (800 ppm)--no evidence of carcinogenicity	EPA, 88a
		Reproductive/Developmental Toxicity	
Not specified	Dietary/2 year exposure	1,000 mg/kg--reduced growth	Eisler, 86
Not specified	Dietary/3 generation exposure	1,000 mg/kg--no malformations, no effect on reproduction	Eisler, 86

Table B3-12. Diazinon (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
MOUSE			
		Acute Toxicity	
Tech.	Oral	LD_{50} 2,750 mg/kg	Skinner & Kilgore, 82
		Subchronic Toxicity	
Not specified	Not specified	120 mg/kg/day (800 ppm)--weight loss in females	EPA, 88a
Not specified	Not specified	240 mg/kg/day (1,600 ppm)--mortality in males and females	EPA, 88a
		Chronic Toxicity	
Tech 98%	Dietary/108 week exposure	≤30mg/kg/day (200 ppm)--no evidence of oncogenicity	EPA, 88a
		Reproductive/Developmental Toxicity	
Not specified	Dietary/exposure during gestation of young	0.18 mg/kg/day--no mortality of young at weaning	Barnett et al., 80 (in Eisler, 86)
Not specified	"	9 mg/kg/day--12% mortality of young prior to weaning, reduced growth & altered serum immunoglobulins of young	Barnett et al., 80 (*in* Eisler, 86)
Not specified	2.8 week exposure	0.18 mg/kg/day--altered behavior & delayed sexual maturity	Spyker & Avery, 77 (*in* Eisler, 86)

Table B3-12. Diazinon (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
MOUSE (cont.)			
		Reproductive/Developmental Toxicity (cont.)	
Not specified	14.4 week exposure/ juveniles	0.18 mg/kg/day--impaired endurance & coordination	Spyker & Avery, 77 (*in* Eisler, 86)
Not specified	"	9 mg/kg/day--brain pathology occurred	Spyker & Avery, 77 (*in* Eisler, 86)
WHITE-FOOTED MOUSE (*Peromyscus leucopus*)			
		Acute Toxicity	
Not specified	Single dose	2.3 mg/kg--9% depression in brain acetylcholinesterase in 24 hours	Montz, 83 (*in* Eisler, 86)
Not specified	Single dose	17.3 mg/kg--69% depression in brain acetylcholinesterase in 6 hours	Montz & Kirkpartick, 82 (*in* Eisler, 86)
RABBIT			
		Acute Toxicity	
Tech.	Oral	LD_{50} 130 mg/kg	Smith, 87
4E	Dermal	LD_{50} 3,610 mg/kg	Ciba-Geigy, 82
Not specified	Inhalation/4 hour exposure	LC_{50} 27.2 mg/L	Anon, 72(*in* Eisler, 86)

Table B3-12. Diazinon (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RABBIT (cont.)		Reproductive/Developmental Toxicity	
Not specified	Gavage/pregnant animals/days 6 to 18 of gestation	100 mg/kg/day--significant maternal toxicity	EPA, 88a
Not specified	"	100 mg/kg/day--no evidence of developmental toxicity in young	EPA, 88a
GUINEA PIG (*Cavia cobava*)		Acute Toxicity	
Not specified	Oral	LD_{50} 450 mg/kg	Machin et al., 75 (*in* Eisler, 86)
DOG (*Canis familiaris*)		Acute Toxicity	
Not specified	Oral	LD_{50} >500 mg/kg	Earl et al., 71 (*in* Eisler, 86)
Not specified	Oral/single dose	4 mg/kg--39%reduction in serum cholinesterase in 10 minutes; 50% reduction in 3.5 hours	Iverson et al., 75 (*in* Eisler, 86)
Not specified	Oral/single dose	75 mg/kg--acute pancreatitis	Dressel et al., 82 (*in* Eisler, 86)

Table B3-12. Diazinon (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
DOG (*Canis familiaris*) (cont.)			
		<u>Subchronic Toxicity</u>	
Not specified	Oral/$\leq$8 month exposure	10 mg/kg/day--no mortality in 8 months; however, testicular atrophy & cholinesterase inhibition occurred 20 mg/kg/day--complete mortality in 30 days 25 mg/kg/day--no mortality in 15 days 50 mg/kg/day--no mortality in 4 days	Earl et al., 71 (*in* Eisler, 86)
Not specified	43 week exposure	4.3 - 5.3 mg/kg/day--cholinesterase inhibition	Anon, 72 (*in* Eisler, 86)
PIG (*Sus scrofa*)			
		<u>Acute Toxicity</u>	
Not specified	Oral	LD_{50} 400 mg/kg	Machin et al., 75 (*in* Eisler, 86)
		<u>Subchronic Toxixity</u>	
Not specified	Oral/$\leq$8 month exposure	5 mg/kg/day--no mortality in 8 months; however, cholinesterase inhibition, duodenal ulcers, & liver pathology occurred 10 mg/kg/day--75% mortality in 30 days	Earl et al., 71 (*in* Eisler, 86)
SHEEP (*Ovis aries*)			
		<u>Acute Toxicity</u>	
Not specified	Oral	LD_{50} >1,000 mg/kg	Machin et al., 75 (*in* Eisler, 86)

Table B3-13.

DIAZINON
Diazinon

BIRDS

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
BOBWHITE QUAIL (*Colinus virginianus*)			
		Acute Toxicity	
Tech. 99%	Oral	LD_{50}s 13 to 17 mg/kg	Hill et al., 84 (*in* Hill & Camardese, 84)
Tech. 99%	Oral	LD_{50} 10 mg/kg	Hill & Camardese, 84
Tech. 99%	Oral	LD_{100} 25 mg/kg	Hill et al., 84 (*in* Eisler, 86)
		Subchronic Toxicity	
Tech. 92.1%	Dietary	>35 ppm--food consumption & egg production negatively related to dose above this level	Stromborg, 81 (*in* Smith, 87)
Tech. 92.1%	Dietary/juveniles	LC_{50} 245 ppm	Hill et al., 75 (*in* Smith, 87)
EUROPEAN QUAIL (*Conturnix conturnix*)			
		Acute Toxicity	
Not specified	Oral	LD_{50} 4.22 mg/kg	Schafer et al., 83

Table B3-13. Diazinon (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
JAPANESE QUAIL (*Conturnix japonica*)		Subchronic Toxicity	
Tech. 99%	Dietary/5 day exposure	LC_{50} 167 ppm	Hill & Camardese, 86
HOUSE SPARROW (*Passer domesticus*)		Acute Toxicity	
Not specified	Oral	LD_{50} 7.5 mg/kg	Schafer et al., 83
COMMON GRACKLE (*Quiscalus quiscula*)		Acute Toxicity	
Not specified	Oral	LD_{50} 7.5 mg/kg	Schafer et al., 83
COMMON PIGEON (*Columba livia*)		Acute Toxicity	
Not specified	Oral	LD_{50} 3.16 mg/kg	Schafer et al., 83
STARLING (*Sturnus vulgaris*)		Acute Toxicity	
Not specified	Oral	LD_{50} 110 mg/kg	Schafer, 72
Not specified	Oral	LD_{50}s 110 - 316 mg/kg	Schafer et al., 83

Table B3-13. Diazinon (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
REDWING BLACKBIRD (*Agelaius phoeniceus*)			
		Acute Toxicity	
Not specified	Oral	LD_{50}s 2 - 3.6 mg/kg	Schafer, 72
MALLARD DUCK (*Anas platyrhynchos*)			
		Acute Toxicity	
Tech. 91.9%	Oral	LD_{50} 3.54 mg/kg	Hudson et al., 84
Tech.	Oral	LD_{50} 6.38 mg/kg	EPA, 88a
Not specified	Oral/ducklings	LD_{50} 14.0 mg/kg	Egyed et al., 74 (*in* Eisler, 86)
		Subacute Toxicity	
Tech. 92.1%	Dietary	LC_{50} 191 ppm	Hill et al., 75 (*in* Smith, 87)
Tech.	Dietary	LC_{50} <47 ppm--all animals died at 47 ppm	EPA, 88a
PHEASANT (*Phasiasus colchieus*)			
		Acute Toxicity	
Tech.	Oral	LD_{50} 4.33 mg/kg	Hudson et al., 84

Table B3-13. Diazinon (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
PHEASANT (*Phasiasus colchieus*) (cont.)		Subacute Toxicity	
Tech. 92.1%	Dietary/juveniles	LC_{50} 244 ppm	Hill et al., 75 (*in* Smith, 87)
Tech. 96.6%	Dietary/adults	1.02 - 2.10 mg/day--affect food consumption & egg production	Stromborg, 77 (*in* Eisler, 86)
GOOSE (*Anser* sp.)		Acute Toxicity	
Not specified	Oral/goslings	LD_{50} 2.7 mg/kg	Egyed et al, 74 (*in* Eisler, 86)
TURKEY (*Meleagris gallopavo*)		Acute Toxicity	
Not specified	Oral	LD_{50} 2.5 mg/kg	Egyed et al., 74 (*in* Eisler, 86)
Not specified	Oral	LD_{50} 3.5 mg/kg	Machin et al., 84 (*in* Eisler, 86)
Not specified	Oral	LD_{100} 10.0 mg/kg	Egyed et al., 74 (*in* Eisler, 86)

Table B3-14.

DIAZINON
Diazinon

AMPHIBIANS

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
BULLFROG (*Rana catesbeiana*)			
		Acute Toxicity	
Tech. 92%	96 hour exposure	LD_{50} >2,000 mg/kg	Hudson et al., 84

Table B3-15.

DIAZINON
Diazinon

FISH

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
FATHEAD MINNOW (*Pimephales promelas*)			
		Acute Toxicity	
Tech. 87.1%	Static bioassay/ larvae/96 hour exposure	LC_{50}s 4.3 mg/L (fresh solution) 2.1 mg/L (aged solution)	Jarvinen & Tanner, 82
Tech. 87.1%	Continuous flow bioassay/96 hour exposure	LC_{50} 6.9 mg/L	Jarvinen & Tanner, 82
Not specified	96 hour exposure	LC_{50} 7.8 mg/L	Allison & Hermanutz, 77 (*in* Jarvinen & Tanner, 82)
		Reproductive/Developmental Toxicity	
Tech. 87.1%	Continuous flow bio-assay/embryo-larvae/ 32day exposure	0.090 mg/L--significant decrease in growth exhibited by developing young	Jarvinen & Tanner, 82
Tech. 87.1%	"	NOEL-->0.050 - <0.090 mg/L--no significant increase in deformities in developing young	Jarvinen & Tanner, 82
Not specified	5^{th} day through 24^{th} week post hatch exposure	3.2 ug/L--reduced hatching sussess of young	Allison & Hermanutz, 77 (*in* Jarvinen & Tanner, 82)

Table B3-15. Diazinon (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
BLUEGILL (*Lepomis macrochirus*)		Acute Toxicity	
Tech. 92%	96 hour exposure	LC_{50} 168 ug/L	Johnson & Finley, 80
Tech.	Not specified	LC_{50} 0.079 ppm	EPA, 86b
SHEEPSHEAD MINNOW (*Cyprinodon variegatus*)		Acute Toxicity	
Tech.	Continuous flow bioassay/juveniles/ 96 hour exposure	LC_{50} 1,400 ug/L	Goodman et al., 79
		Reproductive/Developmental Toxicity	
Tech.	Continuous flow bioassay/began with juveniles & followed them & progeny through a reproductive cycle/108 day exposure-32 day depuration	10.0 ug/L--no toxicant related mortality of parental fish	Goodman et al., 79
Tech.	"	<0.47 ug/L--maximum acceptable toxicant concentration based on fecundity-$\geq$ this level fecundity was reduced	Goodman et al., 79

Table B3-15. Diazinon (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RAINBOW TROUT (*Salmo gairdneri*)		Acute Toxicity	
Tech.	96 hour exposure	LC_{50} 110 ug/L	Meier et al., 76 (*in* Eisler, 86)
Tech.	Not specified	LC_{50} 0.635 ppm	EPA, 86b
CUTTHROAT TROUT (*Salmo clarki*)		Acute Toxicity	
Tech. 92%	96 hour exposure/ test conducted in hard water	LC_{50} 1,700 ug/L	Johnson & Finley, 80
BROOK TROUT (*Salvelinus fontinalis*)		Acute Toxicity	
Not specified	96 hour exposure	LC_{50} 770 ug/L	Allison & Hermanutz, 77 (*in* Eisler, 86)
		Reproductive/Developmental Toxicity	
Not specified	5^{th} day through 24^{th} week post hatch exposure	0.55 ug/L--reduced growth of young	Allison & Hermanutz, 77 (*in* Eisler, 86)

Table B3-15. Diazinon (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
LAKE TROUT (*Salvelinus namaycush*)			
		<u>Acute Toxicity</u>	
Tech. 92%	96 hour exposure/ test conducted in hard water	LC_{50} 602 ug/L	Johnson & Finley, 80
EUROPEAN EEL (*Anguilla anguilla*)			
		<u>Acute Toxicity</u>	
Tech. 95%	Static bioassay	LC_{50}s 24 hr 0.16 mg/L 48 hr 0.11 mg/L 72 hr 0.09 mg/L 96 hr 0.08 mg/L	Sancho et al., 93
		<u>Subchronic Toxicity</u>	
Tech. 95%	Static bioassay/96 hour exposure	800 bioconcentration ratio for liver 1,600 bioconcentration ratio for muscle	Sancho et al., 93
WALKING CATFISH (*Clarias batrachus*)			
		<u>Subchronic Toxicity</u>	
Not specified	40 day exposure	LC_{50} 2.4186 ppm	Tripathi, 92
TILAPIA (*Tilapia nilotica*)			
		<u>Acute Toxicity</u>	
Not specified	Not specified	LC_{50} 20 mg/L	El Elaimy et al., 90 (*in* Sakr & Gabr, 92)

Table B3-15. Diazinon (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
TILAPIA (*Tilapia nilotica*) (cont.)			
		Subchronic Toxicity	
Not specified	Exposures of multiple factors of the **LD_{50}** value	24 hr - 10 mg/L--swelling of sarcoplasmic reticulum appearance of cytoplasmic vacuoles 48 hr - 20 mg/L--fragmentation of myofibrils occurred 72 hr - 30 mg/L--severe splitting & fragmentation of myofibrils	Sakr & Gabr, 92

Table B3-16.

DIAZINON
Diazinon

AQUATIC INVERTEBRATES

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
DAPHNIA (*Daphnia* sp.)		<u>Acute Toxicity</u>	
Tech.	Not specified	LC_{50} 0.522 ppb	EPA, 86b
DAPHNIA (*Daphnia magna*)		<u>Acute Toxicity</u>	
Tech. 91.9%	96 hour exposure	LC_{50} 2.0 ug/L	Meier, et al., 76 (*in* Eisler, 86)
Tech. 89%	Not specified	LC_{50} 0.96 ug/L	EPA, 88a
DAPHNIA (*Daphnia pulex*)		<u>Acute Toxicity</u>	
Tech. 89%	48 hour exposure	EC_{50} 0.8 ug/L	Johnson & Finley, 80
CLADOCERAN (*Simocephalus serrulatus*)		<u>Acute Toxicity</u>	
Tech. 89%	48 hour exposure	EC_{50} 1.4 ug/L	Johnson & Finley, 80

Table B3-16. Diazinon (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
MYSID SHRIMP (*Mysidopsis bahia*)		Acute Toxicity	
Tech.	Continuous flow bioassay/juveniles/ 96 hour exposure	LC_{50} 4.82 ug/L	Nimmo et al., 81
Tech.	Continuous flow bioassay/juveniles through adults	>1.15 <3.25 ug/L--maximum acceptable toxicant level between these values-≥ 3.25 ug/L fecundity was reduced	Nimmo et al., 81
PENAEID SHRIMP (*Penaeus aztecus*)		Acute Toxicity	
Tech.	48 hour exposure	LC_{50} 28 ug/L	Nimmo et al., 81
ROTIFER (*Brachionus calyciflorus*)		Acute Toxicity	
Tech. 92%	24 hour exposure	LC_{50} 29.22 mg/L	Fernández-Casalderrey et al., 92b
		Subchronic Toxicity	
Tech. 92%	Sublethal exposure/ 5.84, 7.31, 14.61, 19.48 mg/L	LT_{50} 6.96 to 2.49 days--medium lethal time to 50% decrease in population size--decreased with increasing concentrations	Fernández-Casaldberry et al., 92b

Table B3-16. Diazinon (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
ROTIFER (*Brachionus calyciflorus*) (cont.)			
		Reproductive/Developmental Toxicity	
Tech. 92%	11 day exposure	EC_{50} 5.20 mg/L--50% reduction in net reproductive rate	Fernández-Casaldberrey et al., 92a
Tech. 92%	11 day exposure	EC_{50} 8.49 mg/L--50% reduction in generation time	Fernández-Casaldberrey et al., 92a
Tech. 92%	11 day exposure	EC_{50} 12.33 mg/L--50% reduction in life expectancy at hatching	Fernández-Casaldberrey et al., 92a
SCUD (*Gammarus fasciatus*)			
		Acute Toxicity	
Tech. 89%	96 hour exposure	LC_{50} 0.2 ug/L	Johnson & Finley, 80
STONEFLY (*Pteronarcys*)			
		Acute Toxicity	
Tech. 89%	96 hour hour exposure	LC_{50} 25 ug/L	Johnson & Finley, 80
AMPHIPOD (*Crangonyx* sp.)			
		Subchronic Toxicity	
Tech. 92.5%	Continuous flow/in outdoor experimental channels	0.3 ug/L--elevated drift occurred	Arthur et al., 83

Table B3-16. Diazinon (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
AMPHIPOD (*Crangonyx* sp.) (cont.)		Subchronic Toxicity (cont.)	
Tech. 92.5%	"	>0.5 ug/L--increased drift	Arthur et al., 83
Tech. 92.5%	"	22 ug/L--significantly reduced survival	Arthur et al., 83
AMPHIPOD (*Hyalella azteca*)		Subchronic Toxicity	
Tech. 92.5%	Continuous flow/in outdoor experimental channels	0.3 ug/L--caused drift	Arthur et al., 83
Tech. 92.5%	"	≥0.5 ug/L--sharply reduced survival	Arthur et al., 83
CHRONOMID (*Chironomus* sp.)		Subchronic Toxicity	
Tech. 92.5%	Continuous flow/in outdoor experimental channels	0.3 ug/L--lengthened developmental period (lowered emergence)	Arthur et al., 83
FRESHWATER SNAIL (*Gillia altilis*)		Acute Toxicity	
Tech. 88.6%	Static bioassay/4, 96 hour exposures	LC_{50}s 4 hr 93 ppm 96 hr 11 ppm	Robertson & Mazzella, 89

Table B3-16. Diazinon (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
FRESHWATER SNAIL (*Gillia altilis*) (cont.)			
		Subchronic Toxicity	
Tech. 92.5%	Continuous flow/in outdoor experimental channels	0.3 ug/L--caused drift	Arthur et al., 83

2.4 Fenoxycarb (Logic)

2.4.1 General Information--A review of information regarding fenoxycarb is given in EPA (1986c). Results of toxicity studies are presented in Tables B3-17 to B3-19.

2.4.2 Mammals

2.4.2.1 Acute Toxicity Effects

Technical fenoxycarb has acute oral and dermal toxicity values of >16,800 mg/kg and >5,000 mg/kg, respectively. In rats, Logic has an oral acute toxicity value of >5,000 mg/kg and an inhalation value of >3,48 mg/L. Dermal acute toxicity in the rabbit is >2,000 mg/kg. This product is listed as practically nontoxic to slightly toxic via various exposures to rats and rabbits (Ciba-Geigy, 1991). In the rabbit, Logic is considered to be nonirritating to the skin but slightly irritating to the eye; it is not a sensitizer to the skin of guinea pigs (Ciba-Geigy, 1991).

Fenoxycarb appears to provide extremely low toxicity to any animals evaluated in the analysis (Table 43), or elsewhere. All values for the "realistic" and "worst case" exposures were well below the reference values.

2.4.2.2 Subchronic and Chronic Toxicity Effects

No observed effect levels (NOEL) for technical fenoxycarb in various studies with rats are ≤300 mg/kg/day and 200 ppm. Lifetime feeding studies of technical fenoxycarb resulted in an increase in the occurrence of benign and malignant lung tumors in male mice at the highest dose tested. This effect did not occur in female mice and rats. This substance was not teratogenic in rats or rabbits, or mutagenic in the analyses conducted (Ciba-Geigy, 1991).

2.4.3 Birds

2.4.3.1 Acute Toxicity Effects

Toxicity values for mallard ducks and bobwhite quail exposed to fenoxycarb are >3,000 mg/kg and 11,574 ppm, respectively. These values indicate that this chemical is practically nontoxic to birds (EPA, 1986c).

2.4.3.2 Acute Toxicity Effects

Acute exposure toxicity values for fish range from 1.05 to 2.9 mg/L. This chemical is considered moderately toxic to fish (EPA, 1986c).

2.4.3.3 Ecological Effects

Fenoxycarb was not found toxic to young mosquitofish at the maximum field application rates tested for this chemical (Tietze et al., 1991). Fish exposed to fenoxycarb could bioaccumulate this chemical to concentrations 300X greater than the concentration in the water; however, these fish will release 99% of the residues within two weeks upon being placed in fenoxycarb-free water (EPA, 1986c). The expected concentrations of fenoxycarb in six inches of water are less than 1/20 the LC_{50} for fish.

2.4.4 Aquatic Invertebrates

No specific information regarding the effects of fenoxycarb on these organisms could be found. There was, however, a statement in EPA (1986c) that the expected concentration of this chemical in six inches of water is less than 1/20 of the LC_{50} for daphnia.

2.4.5 Threatened and Endangered Species

Very few results of animal testing with fenoxycarb have been reported but based on the testing done it appears to have a low environmental toxicity. In EPA (1986c), it was stated that it is unlikely that fenoxycarb would adversely affect endangered aquatic species because of its low acute toxicity to the aquatic species tested and because the concentrations of this chemical would be less than 1/20 the LC_{50} of fish and daphnia.

Table B3-17.

FENOXYCARB
Logic

MAMMALS

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RAT			
		Acute Toxicity	
Tech.	Oral	LD_{50} >16,800 mg/kg	EPA, 86c
Tech.	Dermal	LD_{50} >5,000 mg/kg--effects include dyspnea, curved body position, ruffled fur, sedation, and diarrhea; no deaths occurred	EPA, 86c
Logic	Oral	LD_{50} >5,000 mg/kg	Ciba-Geigy, 91
Logic	Inhalation/4 hours	LC_{50} >3.48 mg/L	Ciba-Geigy, 91
		Subchronic Toxicity	
Tech.	Dermal/21 days	NOEL 200 mg/kg/day	EPA, 86c
		Chronic Toxicity	
Tech.	Not specified/ 52 weeks	NOEL 200 ppm	EPA, 86c
		Developmental Toxicity	
Tech.	Not specified	≤300 mg/kg/day no observed effects to developing young	EPA, 86c

Table B3-17. Fenoxycarb (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RABBIT			
		Acute Toxicity	
Logic	Dermal	LD_{50} >2,000 mg/kg	Ciba-Geigy, 91

Table B3-18.

FENOXYCARB
Logic

BIRDS

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
MALLARD DUCK (*Anas platyrhynchus*)		Acute Toxicity	
Tech.	Oral	LD_{50} >3,000 mg/kg	EPA, 86
BOBWHITE QUAIL (*Colinus virginianus*)		Subchronic Toxicity	
Tech.	Dietary	LC_{50} 11,574 ppm	EPA, 86

Table B3-19.

FENOXYCARB
Logic

FISH

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
BLUEGILL (*Lepomis macrochirus*)		Acute Toxicity	
Tech.	Not specified	LC_{50} 1.86 ppm	EPA, 86c
Tech.	96 hour exposure	LC_{50} 2.9 mg/L	Maag, 85 (*in* Lee & Scott, 89)
CARP		Acute Toxicity	
Tech.	96 hour exposure	LC_{50} 10.2 mg/L	Maag, 85 (*in* Lee & Scott, 89)
MOSQUITOFISH (*Gambusia affinis*)		Acute Toxicity	
Tech.	3-5 day old young/ 24 hour exposure	LC_{50} 1.05 ppm	Tietze et al., 91

Table B3-19. Fenoxycarb (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
MUMMICHOG (*Fundulus heteroclitus*)			
		Acute Toxicity	
Tech.	Static renewal bioassay/adults 96 hour exposure	LC_{50} 2.14 mg/L	Lee & Scott, 89
Tech.	"	NOEL 1.41 mg/L	Lee & Scott, 89
RAINBOW TROUT (*Salmo gairdneri*)			
		Acute Toxicity	
Tech.	Not specified	LC_{50} 1.6 ppm	EPA, 86c

2.5 Glyphosate (Roundup, Rodeo)

2.5.1 General Information

Residue and metabolism investigations have shown that, in the species tested, glyphosate is incompletely absorbed across gastrointestinal membranes and that there is minimal retention by tissues and rapid elimination of residues (Monsanto, 1982). Glyphosate is considered to be slightly toxic in the environment (Sassman et al., 1984), but it has not been reported to have caused any problems to wildlife (Smith, 1987). In a literature review of the biological activity of glyphosate to plants and animals, it was stated that this chemical is practically nontoxic to mammals, birds, and fish; it shows no bioaccumulation in the food chain and biodegrades into natural products (Smith and Oehme, 1992). Additional reviews of this chemical and its formulations appear in EPA (1986d), EPA (1993), Sassman et al. (1984), and WSSA (1983). Results of toxicity studies are presented in Tables B3-20 to B3-23.

2.5.2 Mammals

2.5.2.1 Acute Toxicity Effects

Acute oral toxicity values for technical glyphosate and its product formulations Roundup and Rodeo range from 4,040 to 5,600 mg/kg. Acute inhalation toxicity values for rats exposed to Roundup were 3.18 mg/L and 12.2 ppm. Roundup has an acute oral toxicity value of >5,000 mg/kg in the mouse. Acute oral and dermal exposure toxicity values for rabbits exposed to glyphosate and its product formulations range from 3,800 to >7,940 mg/kg. The acute oral toxicity value of Roundup for the dog is 5.0 ml/kg. The goat has an acute oral toxicity value of 4,860 mg/kg for Roundup. Roundup is considered practically non-toxic to slightly toxic in various acute tests of rats, mice, and rabbits and is practically nontoxic to dogs and slightly toxic to goats (Monsanto, 89). Results of studies with rats and rabbits exposed to Rodeo indicated that this substance is practically nontoxic to these animals (Monsanto, 1985a). Rodeo and Roundup are considered to be nonirritating to slightly irritating to the eyes of rabbits and practically nonirritating to moderately irritating to their skin (Monsanto, 1985a, 1985b, 1989). Neither Rodeo or Roundup were considered to be dermal sensitizing agents in guinea pigs (Monsanto, 1985a, 1985b, 1989).

Glyphosate is generally considered of low toxicity to mammals, and the values calculated here for the "realistic" cases for rabbits and deer were well below their respective LD_{50}s. The "worst case" value for the deer exceeded the reference value, which was extrapolated from 1/10 the value for the goat. The "worst case" value calculated here was well below the LD_{50} for the goat, with which they share similar habits and habitats.

2.5.2.2 Subchronic and Chronic Toxicity Effects

Subchronic and chronic dietary exposure studies in rats, primarily for technical glyphosate, have no observed effect limit values of between 300 ppm (31 mg/kg/day) to 10,000 ppm (500 mg/kg/day). Chronic effects occurred at 20,000 ppm (940 mg/kg/day) and 30,000 ppm (1,500 mg/kg/day). Various studies of the effects of technical glyphosate on developing young yielded no observed effect levels (NOEL) of approximately 31 mg/kg/day to 10,000 mg/kg/day. Maternal toxicity in rats exposed to glyphosate was 3,500 mg/kg/day. No observed effect levels for mice exposed to technical glyphosate and Roundup are 500 mg/L and $\leq$300 ppm, respectively. An exposure of 2,500 mg/L of technical glyphosate was found to cause reductions in weight gains in mice. Rabbits exposed to an unspecified formulation of glyphosate had a no observed effect level of 1,000 mg/kg/day and slight swelling and redness of the skin at 5,000 mg/kg/day. The lowest dose tested to cause maternal effect in dietary studies of rabbits is 350 mg/kg/day. No effect has been observed in dogs exposed, via diet, to 300 ppm and $\geq$500 mg/kg/day of technical glyphosate and 2,000 ppm of Roundup. In brahman-cross heifers, no effect was observed for Roundup at 400 mg/kg/day, but loss of appetite, diarrhea, and death occurred in doses of $\geq$500 mg/kg/day of this product.

The exposure levels for NOEL were well below the reference values for the "realistic" case, and were exceeded in the "worst case" scenarios for both the deer and rabbit (Table B3-45). Both of the reference values were extrapolated values based on other data.

2.5.2.3 Ecological Effects

Sullivan (1985) reported that consumption of glyphosate-treated food caused no gross adverse effects in black-tailed deer; these deer exhibited no difference in preference between food treated or not treated with herbicide. Sullivan (1990) concluded that for populations of deer mice (*Peromyscus maniculatus*) and Oregon voles (*Microtus oregoni*) the demographic attributes of recruitment, growth, and survival were not affected by application of glyphosate to the habitat of these animals. The impact of glyphosate on populations of small mammals depends on the degree of habitat alteration and the requirements of the species involved. Santillo et al. (1989b) demonstrated a decrease in population levels of insectivores on herbicide treated plots; however, other measures of community structure, such as diversity and evenness, did not vary greatly. Little overall change in small mammal populations has been noted in other studies following application of glyphosate or Roundup (Anthony and Morrison, 1985; D'Anieri et al., 1987; Sullivan, 1985). In a study of a forest ecosystem, Newton et al. (1984) found that exposure to, and retention of, glyphosate generally varied with the food preference of the species tested; however, all taxa had visceral and body content levels of this substance at or below those in ground cover and litter, indicating that this herbicide did not accumulate in higher trophic levels.

2.5.3 Birds

2.5.3.1 Acute Toxicity Effects

The only bird for which an acute toxicity value could be found was the bobwhite quail. The LD_{50} for this species is 3,850 mg/kg.

The "worst case" and "realistic" exposure scenarios calculated here were well below the NOEL reference value for bobwhite.

2.5.3.2 Subchronic and Chronic Toxicity Effects

Studies of mallard ducks and bobwhite quail exposed, via diet, to technical glyphosate yielded subchronic toxicity values of >4,640 ppm. The no observed effect level for Japanese quail exposed to Roundup is 5,000 ppm. No reproductive impairment was observed in a study of bobwhite quail exposed to ≤1,000 ppm technical glyphosate. No effect levels of ≤30 and ≤1,000 have been obtained for studies of different concentration of technical glyphosate to mallard ducks. The domestic chicken has been found to exhibit no behavioral or microscopic effects when exposed to 15,000 mg/kg of technical glyphosate in a three day period.

Based on results of an acute oral study of bobwhite quail and dietary studies of quail and mallards ducks, this chemical is considered practically nontoxic to slightly toxic in these birds (EPA, 1993). No precautionary labeling for birds on products containing glyphosate was recommended (EPA, 1993).

Bobwhite exposure values for both the "realistic" and "worst case" situations were well below the toxicity reference value (Table 43).

2.5.3.3 Ecological Effects

The density of birds has been found to be reduced and their behavior altered by application of glyphosate to an area (Morrison and Meslow, 1984a; Santillo et al., 1989a). These changes were due to the decrease in vegetational complexity caused by the herbicide. Fewer birds are likely to use such an area because their preferred habitat has been reduced or eliminated and, for the similar reason, insects on which many birds prey will be less available.

2.5.4 Fish

2.5.4.1 Acute Toxicity Effects

With the exception of two studies having values of >24 mg/L and 50 ppm, the acute toxicity LC_{50} values for fish exposed to technical glyphosate range from 84.9 to 380 mg/L. Of these studies, those having values over approximately 150 mg/L were investigations conducted with juvenile trout and salmonids. Toxicity values for various fish ranged from slightly to moderately toxic (Monsanto, 1989). Technical glyphosate is considered to be practically nontoxic to freshwater fish (EPA, 1993). Acute LC_{50} values for fish exposed to Roundup range from 2.3 to 52 mg/L. Rodeo has acute toxicity values of between >1,000 to >10,000 mg/L.

2.5.4.2 Subchronic and Chronic Toxicity Effects

Results of only one chronic study conducted on fish could be found. Fathead minnows were considered to exhibit no effect at doses ≤25.7 mg/L in an investigation of these fish exposed for a full life cycle to technical glyphosate.

2.5.4.3 Ecological Effects

Carp in a static pond were unaffected following exposure via aerial application of Roundup at the normal use concentration (Monsanto, 1989). Avoidance-preference studies conducted under field conditions indicated that rainbow trout avoided lethal concentrations of Roundup (Hildebrand et al., 1982). Operational application of this product at even 100X field dose resulted in no mortality of rainbow trout in field streams and indicated that such application of this herbicide at recommended levels should not be detrimental to the fish tested (Hildebrand et al., 1982). Folmar et al. (1979) concluded that applications of Roundup at the recommended rate of 2.2 kg of active ingredient per hectare (0.02 mg/L) probably would not affect habitat suitability for rainbow trout because its avoidance level for this chemical was several orders of magnitude above the anticipated concentrations of this herbicide in the water.

2.5.4 Aquatic Invertebrates

2.5.4.1 Acute Toxicity Effects

Twelve out of fifteen investigations of the effects of glyphosate and its products conducted on daphnia, scuds, chironomids, and amphipods yielded acute toxicity values of between 3 to 62 mg/L. Three additional studies had acute toxicity values of 780, 869, and 930 mg/L for technical glyphosate, an unspecified formulation containing 62.4% glyphosate, and Rodeo, respectively. Crayfish have an acute toxicity exposure value of >1,000 mg/L for Roundup. Glyphosate, Roundup, and Rodeo are considered to range from practically nontoxic to moderately toxic for the freshwater invertebrates examined (EPA, 1993; Monsanto, 1985a; Monsanto, 1989). Technical glyphosate has acute LC_{50} values of 281 mg/L for grass shrimp, 934 mg/L for fiddler crab, and a no observed effect level of 10 mg/L for the Atlantic oyster. This substance is considered practically nontoxic to grass shrimp and fiddler crab and slightly toxic to Atlantic oyster (EPA, 1993).

2.5.4.2 Ecological Effects

In a study of the effects of administration of glyphosate to daphnia in field situations, it was found that these organisms experienced no significant decrease in survival even when treated with 100X the recommended field dose (Hildebrand et al, 1980). Folmar et al. (1979) concluded that applications of Roundup at the recommended rate of 2.2 kg of active ingredient per hectare (0.02 mg/L) probably would not affect habitat suitability for mayfly nymphs because the avoidance level for this chemical by these animals was several orders of magnitude above the anticipated concentrations of this herbicide in the water. These authors stated that applications of Roundup along irrigation canal ditch banks should have no unfavorable effects on resident aquatic fauna (fish & invertebrates); however, they stipulated that applications near lentic ecosystems may be hazardous if the pH exceeds 7.5.

2.5.5 Threatened and Endangered Species

Based on toxicity data and estimated exposure, glyphosate is not considered to affect endangered terrestrial or aquatic organisms; however, it was determined that the Houston toad (*Bufo houstoninsis*) might be at risk in areas where this chemical is used on alfalfa (EPA, 1993). Alfalfa is not grown in Texas in the area inhabited by the Houston toad.

The primary impact of this chemical on organisms is through habitat alteration. As with any of the herbicides, some of the protected species have fragile habitats. An example would be in and around the San Marcos River where some of the neotenic salamanders are restricted to small areas of aquatic weed beds. The impact from careless use of glyphosate would be to destroy species indirectly and not from aquatic toxicity, but TxDOT excludes habitats for threatened or endangered species from chemical treatment.

Table B3-20.

GLYPHOSATE
Roundup or Rodeo

MAMMALS

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RAT		Acute Toxicity	
Tech.	Oral	LD_{50} 5,600 mg/kg	WSSA, 83
Tech. ≥95%	Oral	LD_{50}s 4,040 to 5,600 mg/kg	USDA, 81; Monsanto, 82a&b (*in* Sassman et al., 84)
Roundup	Oral	LD_{50} >5,000 mg/kg	Monsanto, 89
Roundup	Oral	LD_{50} 5,400 mg/kg	WSSA, 83
Roundup	Inhalation	LC_{50} 3.18 mg/L	Monsanto, 89
Roundup	Inhalation/4 hour exposure	NOEL 12.2 ppm--no relevant gross pathology noted 10 days post exposure	USDA, 81; Monsanto, 82a&b (*in* Sassman et al., 84)
Rodeo	Oral	LD_{50} >5,000 mg/kg	Monsanto, 85a
		Subchronic Toxicity	
Roundup	Dietary/90 day exposure	NOEL ≤1,000 ppm--no systemic effects	EPA, 93

Table B3-20. Glyphosate (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
Rat (cont.)			
		Chronic Toxicity	
Tech. ≥95%	Dietary/26 month exposure	NOEL ≥300 ppm (31 mg/kg/day-males; 34 mg/kg/day - females)--no effects on food consumption, weight gains, hemotology, & urology	EPA, 93
Tech.	Deitary/2 year exposure	NOEL 8,000 ppm (362 mg/kg/day-males; 457 mg/kg/day - females)--no systemic effects	EPA, 93
Tech.	"	20,000 ppm (940 mg/kg/day-males; 1,183 mg/kg/day - females)--decreased body weight gain-females; increased eye abnormalities, increased relative liver wieght	EPA, 93
Tech.	Dietary/exposure for 2 generations	NOEL 10,000 ppm (500 mg/kg/day)--no systemic effects	EPA, 93
Tech.	"	30,000 ppm (1,500 mg/kg/day)--lowest dose tested to cause various sytemic effects	EPA, 93
		Reproductive/Developmental Toxicity	
Tech.	Dietary/exposure for 2 generations	NOEL 30,000 ppm (1,500 mg/kg/day)--no effects on reproduction	EPA, 93
Tech.	"	NOEL 10,000 ppm (500 mg/kg/day)--no effects on developing young	EPA, 93

Table B3-20. Glyphosate (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
Rat (cont.)		Reproductive/Developmental Toxicity (cont.)	
Tech.	Dietary/exposure for 2 generations	30,000 ppm (1,500 mg/kg/day)--lowest dose tested to cause effects in developing young	EPA, 93
Tech. $\geq$95%	Dietary/30, 100, 300 ppm for 3 generations	NOEL 300 ppm--no significant effects on viability, weaning weights, litter size or fertility	USDA, 81 (*in* Sassman et al., 84)
Tech. $\geq$95%	Gavage of pregnant animals/days 6 to 19 of gestation	NOEL 1,000 mg/kg/day--no maternal toxicity	EPA, 93
Tech. $\geq$95%	"	3,500 mg/kg/day--lowest dose tested to cause maternal toxicity	EPA, 93
Tech $\geq$95%	"	NOEL 1,000 mg/kg/day--no effect on developing young	EPA, 93
Tech. $\geq$95%	"	3,500 mg/kg/day--lowest dose tested to toxic to developing young	EPA, 93
MOUSE		Acute Toxicity	
Roundup	Oral	LD_{50} >5,000 mg/kg	Monsanto, 89

Table B3-20. Glyphosate (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
Mouse (cont.)			
	Subchronic Toxicity		
Tech.	Dietary/90 day exposure	NOEL 500 mg/L--no systemic effects	EPA, 93
Tech.	"	2,500 mg/L--reduction of body weight gains in males of 24% & in females of 18%	EPA, 93
	Chronic Toxicity		
Roundup	Dietary/18 month exposure	NOEL $\leq$300 ppm--no increase in incidence of cytoplasmic vacuolation or lipid content	USDA, 81 (*in* Sassman et al., 84)
Not specified	Dietary	NOEL 5,000 ppm--non-neoplastic changes included centilobular hypertrophy and necrosis of hepatocytes, chronic interstitial nephritis, and proximal tubule epithelial cell basophilia and hypertrophy in females	EPA, 86d
RABBIT			
		Acute Toxicity	
Tech. $\geq$95%	Oral	LD_{50} 3,800 mg/kg	USDE, 82 (*in* Sassman et al., 84)
Tech.	Dermal	LD_{50} >5,000 mg/kg	WSSA, 83
Roundup	Dermal	LD_{50} >5,000 mg/kg	Monsanto, 89

Table B3-20. Glyphosate (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RABBIT (cont.)			
		Acute Toxicity (cont.)	
Rodeo	Dermal	LD_{50} >5,000 mg/kg	Monsanto, 85a
Not specified	Dermal	LD_{50} >7,940 mg/kg	Worthing, 79 (*in* Smith, 87)
		Subchronic Toxicity	
Not specified	Dermal/21 day study/exposure for 6 hours/day, 5 days/week	NOEL 1,000 mg/kg/day	EPA, 86d
Not specified	"	5,000 mg/kg/day--slight edma erythma of skin	EPA, 86d
		Reproductive/Developmental Toxicity	
Tech. ≥95%	Pregnant animals dosed with 10 or 30 mg/kg during fetal organogenesis	30 mg/kg/day--no maternal toxicity, this was the highest dose tested	Sassman et al., 84
Tech. ≥95%	Gavage of pregnant animals/days 6 to 27 of gestation	175 mg/kg/day--no maternal toxicity	EPA, 93
Tech. ≥95%	"	350 mg/kg/day--lowest dose tested to cause diarrhea, nasal discharge, and death	EPA, 93

Table B3-20. Glyphosate (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RABBIT (cont.)			
		<u>Reproductive/Developmental Toxicity</u> (cont.)	
Tech. ≥95%	Gavage of pregnant animals/days 6 to 27 of gestation	NOEL ≥175 mg/kg/day--no developmental effects	EPA, 93
DOG (*Canis familiaris*)			
		<u>Acute Toxicity</u>	
Roundup	Oral	LD_{50} >5.0 ml/kg	Monsanto, 89
		<u>Subchronic Toxicity</u>	
Roundup	Dietary/90 day exposure	NOEL 2,000 ppm--no effects on body weight, food consumption, behavioral reactions, mortality, hematology, blood chemistry, or urinalyses	WSSA, 83
		<u>Chronic Toxicity</u>	
Tech. ≥95%	Dietary/2 year exposure	NOEL 300 ppm--no increase in incidence of cytoplasmic vacuolation or lipid content, no histopathologic changes in the liver	USDA, 81 (*in* Sassman et al., 84)
Tech.	Dietary/1 year	NOEL ≥500 mg/kg/day--no systemic effects	EPA, 93

Table B3-20. Glyphosate (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
GOAT		Acute Toxicity	
Roundup	Oral	LD_{50} 4,860 mg/kg	Monsanto, 89
BRAHMAN-CROSS CATTLE		Subchronic Toxicity	
Roundup	Gavage/7 day exposure	$\geq$500 mg/kg/day--loss of appetite, diarrhea & mortality	Monsanto, 89
Roundup	Gavage/7 day exposure	NOEL 400 mg/kg/day	Monsanto, 89

Table B3-21.

GLYPHOSATE
Roundup or Rodeo
BIRDS

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
BOBWHITE QUAIL (*Colinus virgianus*)			
		Acute Toxicity	
Tech.	Oral	LD_{50} 3,850 mg/kg	WSSA, 83
		Subchronic Toxicity	
Tech. 98%	Dietary/8 day exposure	LC_{50} >4,640 mg/kg	WSSA, 83; EPA, 93
		Reproductive/Developmental Toxicity	
Tech. 83%	Not specified	NOEL ≤1,000 ppm--no reproductive impairment	EPA, 93
JAPANESE QUAIL (*Coturnix japonica*)			
		Subchronic Toxicity	
Roundup	Dietary/5 day exposure	NOEL 5,000 ppm	Hill & Camardese, 86

Table B3-21. Glyphosate (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
MALLARD DUCK (*Anas platyrhynchos*)			
		Subchronic Toxicity	
Tech. 98.5%	Dietary/8 day	LC_{50} >4,640 ppm	WSSA, 83; EPA, 93
Tech. 90.4%	Not specified	NOEL ≤30 ppm--no reproductive impairment	EPA,93
		Reproductive/Developmental Toxicity	
Tech. 83%	Not specified	NOEL ≤1,000 ppm--no reproductive impairment	EPA, 93
DOMESTIC CHICKEN			
		Subchronic Toxicity	
Tech.	Oral/1,250 mg/kg/ twice daily for 3 days	15,000 mg/kg in 3 days--no behavioral or microscopic changes	Monsanto, 82a (*in* Sassman et al., 84)

Table B3-22.

GLYPHOSATE
Roundup or Rodeo

FISH

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
FATHEAD MINNOW (*Pimephales promelas*)		Acute Toxicity	
Tech. 87.3%	48 hour exposure	LC_{50} 84.9 mg/L	EPA, 93
Tech. 96.7%	48 hour exposure	LC_{50} 97 mg/L	EPA, 93
Tech.	Static bioassay/ 24, 96 hour exposure	LC_{50}s 97 ppm (both exposures)	Folmar et al., 79
Roundup	96 hour exposure	LC_{50} 9.4 mg/L	Monsanto, 89
Roundup	Static bioassay/ 24, 96 hour exposure	LC_{50}s 24 hr 2.4 ppm 96 hr 2.3 ppm	Folmar et al., 79
		Chronic Toxicity	
Tech. 87.3%	Full life cycle exposed	>25.7 mg/L--no effect at or below this level	EPA, 93
BLUEGILL (*Lepomis macrochirus*)		Acute Toxicity	
Tech. 96.5%	48 hour exposure	LC_{50} >24 mg/L	EPA, 93
Tech. 96.7%	48 hour exposure	LC_{50} 140 mg/L	EPA, 93

Table B3-22. Glyphosate (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
BLUEGILL (*Lepomis macrochirus*) (cont.)		Acute Toxicity (cont.)	
Tech. 83%	48 hour exposure	LC_{50} 120 mg/L	EPA, 93
Tech.	96 hour exposure	LC_{50} 120 mg/L	WSSA, 83
Tech.	Static bioassay/ 24, 96 hour exposure	LC_{50}s 24 hr 150 ppm 96 hr 140 ppm	Folmar et al., 79
Roundup	Static bioassay/ 96 hour exposure	LC_{50} 14 mg/L	Monsanto, 89
Roundup	Continuous flow bioassay/96 hour exposure	LC_{50} 5.8 mg/L	Monsanto, 89
Roundup	Static bioassay/ 24, 96 hour exposure	LC_{50}s 24 hr 6.4 ppm 96 hr 5.0 ppm	Folmar et al., 79
Rodeo	96 hour exposure	LC_{50} >1,000 mg/L	Monsanto, 85a
Form. 62.4%	96 hour exposure	LC_{50} >1,000 mg/L	EPA, 93
Form. 41%	96 hour exposure	LC_{50} 4.3 mg/L	EPA, 93
CHANNEL CATFISH (*Ictalurus punctatus*)		Acute Toxicity	
Tech. 96.7%	48 hour exposure	LC_{50} 130 mg/L	EPA, 93
Tech.	Static bioassay/ 24, 96 hour exposure	LC_{50}s 130 ppm (both exposures)	Folmar et al., 79

Table B3-22. Glyphosate (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
CHANNEL CATFISH (*Ictalurus punctatus*) (cont.)		Acute Toxicity (cont.)	
Roundup	96 hour exposure	LC_{50} 16 mg/L	Monsanto, 89
Roundup	Static bioassay/ 24, 96 hour exposure	LC_{50}s 13 ppm (both exposures)	Folmar et al., 79
CARP		Acute Toxicity	
Tech	96 hour exposure	LC_{50} 115 ppm	Monsanto, 82a (*in* Sassman et al., 84)
Roundup	96 hour exposure	TL_{50} 19.7 ppm	Monsanto, 89
Rodeo	96 hour exposure	TL_{50} >10,000 ppm	Monsanto, 85
GRASS CARP (*Ctenopharyngodon idella*)		Acute Toxicity	
Roundup	Continuous flow bioassay/24, 48, 96 hour exposure	LC_{50}s 24 hr 26 mg/L 48 hr 24 mg/L 96 hr 15 mg/L	Tooby et al., 80
TROUT (Species not specified)		Acute Toxicity	
Tech.	96 hour exposure	LC_{50} 86 mg/L	WSSA, 83
Roundup	96 hour exposure	LC_{50} 11 mg/L	WSSA, 83
Rodeo	96 hour exposure	LC_{50} >1,000 mg/L	Monsanto, 85a

Table B3-22. Glyphosate (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RAINBOW TROUT (*Salmo gairdneri*)		Acute Toxicity	
Tech. 83%	48 hour exposure	LC_{50} 86 mg/L	EPA, 93
Tech. 96.7%	48 hour exposure	LC_{50} 140 mg/L	EPA, 93
Tech.	Static bioassay/ 24, 96 hour exposure	LC_{50}s 140 ppm	Folmar et al., 79
Tech.	96 hour exposure	LC_{50} 50 ppm	Folmar, 76 (*in* Folmar et al., 79)
Tech.	Static bioassay/ juveniles/24, 48, 72, 96 hour exposure/ 5 water types	LC_{50}s 24 hr, 21 - 220 mg/L 48 hr, 11 - 220 mg/L 72 hr, 11 - 220 mg/L 96 hr, 10 - 197 mg/L	Wan et al., 89
Roundup	Static bioassay/ juveniles/24, 48, 72, 96 hour exposure/ 5 water types	LC_{50}s 24 hr, 17 - 33 mg/L 48 hr, 17 - 33 mg/L 72 hr, 15 - 33 mg/L 96 hr, 14 - 33 mg/L	Wan et al., 89
Roundup	Static bioassay/ 24, 96 hour exposure	LC_{50}s 8.3 ppm	Folmar et al., 79
Roundup	Static bioassay/ 96 hour exposure	LC_{50}s 15 - 26 mg/L	Monsanto, 89
Roundup	Static bioassay/ fry/96 hour exposure	LC_{50}s 25.5 & 28.0 mg/L	Servizi et al., 87
Roundup	Continuous flow bioassay/96 hour exposure	LC_{50} 8.2 mg/L	Monsanto, 89

Table B3-22. Glyphosate (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RAINBOW TROUT (*Salmo gairdneri*) (cont.)		Acute Toxicity (cont.)	
Form. 41%	96 hour exposure	LC_{50} 9.0 mg/L	EPA, 93
Form. 41%	96 hour exposure	LC_{50} 1.3 mg/L	EPA, 93
Form. 62.4%	96 hour exposure	LC_{50} >1,000 mg/L	EPA, 93
COHO SALMON (*Oncorhynchus kisutch*)		Acute Toxicity	
Tech.	Static bioassay/ juveniles/24, 48, 72, 96 hour exposure/ 5 water types	LC_{50}s 24 hr, 44 - 210 mg/L 48 hr, 27 - 205 mg/L 72 hr, 27 - 182 mg/L 96 hr, 27 - 174 mg/L	Wan et al., 89
Roundup	96 hour exposure	LC_{50} 22 mg/L	Monsanto, 89
Roundup	Static bioassay/ fry/96 hour exposure	LC_{50} 42 mg/L	Servizi et al., 87
Roundup	Static bioassay/ juveniles/24, 48, 72, 96 hour exposure/ 5 water types	LC_{50}s 24 hr, 14 - 52 mg/L 48 hr, 13 - 38 mg/L 72 hr, 13 - 35 mg/L 96 hr, 13 - 33 mg/L	Wan et al., 89

Table B3-22. Glyphosate (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
CHINOOK SALMON (*Oncorhynchus tshawytscha*)		Acute Toxicity	
Tech.	Static bioassay/ juveniles/24, 48, 72, 96 hour exposure/ 5 water types	LC_{50}s 24 hr, 24 - 220 mg/L 48 hr, 22 - 220 mg/L 72 hr, 22 - 211 mg/L 96 hr, 19 - 211 mg/L	Wan et al., 89
Roundup	Static bioassay/ juveniles/24, 48, 72, 96 hour exposure/ 5 water types	LC_{50}s 24 hr, 17 - 41 mg/L 48 hr, 17 - 33 mg/L 72 hr, 17 - 33 mg/L 96 hr, 17 - 33 mg/L	Wan et al., 89
Roundup	96 hour exposure	LC_{50} 20 mg/L	Monsanto, 89
CHUM SALMON (*Oncorhynchus keta*)		Acute Toxicity	
Tech.	Static bioassay/ juveniles/24, 48, 72, 96 hour exposure/ 5 water types	LC_{50}s 24 hr, 16 - 202 mg/L 48 hr, 13 - 178 mg/L 72 hr, 10 - 157 mg/L 96 hr, 10 - 148 mg/L	Wan et al., 89
Roundup	Static bioassay/ juveniles/24, 48, 72, 96 hour exposure/ 5 water types	LC_{50}s 24 hr, 17 - 31 mg/L 48 hr, 12 - 27 mg/L 72 hr, 11 - 25 mg/L 96 hr, 11 - 22 mg/L	Wan et al., 89

Table B3-22. Glyphosate (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
PINK SALMON (*Oncorhynchus gorbuscha*)		Acute Toxicity	
Tech.	Static bioassay/ juveniles/24, 48, 72, 96 hour exposure/ 5 water types	LC_{50}s 24 hr, 26 - 380 mg/L 48 hr, 14 - 245 mg/L 72 hr, 14 - 190 mg/L 96 hr, 14 - 190 mg/L	Wan et al., 89
Roundup	Static bioassay/ juveniles/24, 48, 72, 96 hour exposure/ 5 water types	LC_{50}s 24 hr, 17 - 35 mg/L 48 hr, 17 - 33 mg/L 72 hr, 17 - 33 mg/L 96 hr, 14 - 33 mg/L	Wan et al., 89
SOCKEYE SALMON (*Oncorhynchus nerka*)		Acute Toxicity	
Roundup	Static bioassay/ fingerlings & fry/ 96 hour exposure	LC_{50}s 26.7, 27.7, & 28.8 mg/L	Servizi et al., 87

Table B3-23.

GLYPHOSATE
Roundup or Rodeo

AQUATIC INVERTEBRATES

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
DAPHNIA (*Daphnia*)		Acute Toxicity	
Tech. 83%	48 hour exposure	EC_{50} 780 mg/L	WSSA, 83; EPA, 93
Roundup	48 hour exposure	EC_{50} 5.3 mg/L	WSSA, 83
Roundup	48 hour exposure/ with aeration	EC_{50} 37 mg/L	Monsanto, 89
Roundup	48 hour exposure/ without aeration	EC_{50} 24 mg/L	Monsanto, 89
Roundup	Static bioassay/ 48 hour exposure	EC_{50} 25.5 mg/L	Servizi et al., 87
Roundup	Static bioassay/ larvae/48 hour exposure	EC_{50} 3 ppm	Folmar et al., 79
Rodeo	48 hour exposure	EC_{50} 930 mg/L	Monsanto, 85a
Form. 62.4%	48 hour exposure	EC_{50} 869 mg/L	EPA, 93
		Chronic Toxicity	
Tech. 99.7%	Not specified	>50 - <96 mg/L--no effect at 50 mg/L, reduced reproductive capacity at 96 mg/L	EPA, 93

Table B3-23. Glyphosate (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
SCUD (*Gammarus pseudolimnaeus*)		<u>Acute Toxicity</u>	
Roundup	48 hour exposure	EC_{50} 42 mg/L	Monsanto, 89
Roundup	Static bioassay/ adults/48, 96 hour exposure	LC_{50}s 48 hr 62 mg/L 96 hr 43 mg/L	Folmar et al., 79
CHIRONOMID (*Chironomus plumosus*)		<u>Acute Toxicity</u>	
Tech.	Static bioassay/ larvae/48 hour exposure	EC_{50} 55 ppm	Folmar et al., 79
Roundup	"	EC_{50} 18 ppm	Folmar et al., 79
Form. 41%	Not specified	>2.0 mg/L--significant increases in stream drift of larvae	EPA, 93
Form. 41%	"	NOEL ≤0.2 mg/L--no increase in stream drift of larvae	EPA, 93
GRASS SHRIMP (*Palaemonetas vulgaris*)		<u>Acute Toxicity</u>	
Tech.	96 hour exposure	LC_{50} 281 ppm	EPA, 93
Tech.	"	NOEL 210 ppm	USDA, 81 (*in* Sassman et al., 84)

Table B3-23. Glyphosate (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
FIDDLER CRAB (*Uca pagilator*)		Acute Toxicity	
Tech.	96 hour exposure	LC_{50} 934 ppm	EPA, 93
Tech	"	NOEL 650 ppm	USDA, 81 (*in* Sassman et al., 84)
CRAYFISH		Acute Toxicity	
Roundup	96 hour exposure	LC_{50} >1,000 ppm	Monsanto, 89
ATLANTIC OYSTER (*Crassostrea virginica*)		Acute Toxicity	
Tech.	48 hour exposure	NOEL 10 ppm	USDA, 81 (*in* Sassman et al., 84)

2.6 Hexazinone (Velpar)

2.6.1 General Information

The active ingredient of Velpar is hexazinone. This chemical is considered to be of low hazard to wildlife (EPA, 1982). It is quickly metabolized and excreted in the urine and feces of animals and exhibits no appreciable bioaccumulation in their tissues (Sassman et al., 1984). Kennedy (1984) stated that hexazinone has a low order of acute toxicity in mammals, birds, and freshwater and marine biota. Additional reviews of this chemical and its formulations appear in EPA (1988b), EPA (1988d), Sassman et al. (1984), and WSSA (1983). Results of toxicity studies are presented in Tables B3-24 to B3-27.

2.6.2 Mammals

2.6.2.1 Acute Toxicity Effects

Acute oral LD_{50}s of technical hexazinone are 1,690 mg/kg in rats and 860 mg/kg in guinea pigs. Technical hexazinone is classified as slightly toxic to rats and guinea pigs (Kennedy, 1984). Kennedy (1984) stated that inhalation studies of this chemical indicate that it should probably be considered as slightly to moderately toxic but that since no mortality occurred in the animals tested, ranking is somewhat difficult. Dermal application of this substance to rabbits yielded an LD_{50} of >5,278 (no mortalities occurred at this level). Technical hexazinone is not classified as a primary dermal irritant but is considered to be a severe eye irritant in rabbits (DuPont, 1990b; EPA, 1988b). Ninty-three percent of the ^{14}C-labeled hexazinone administered to rats by intragastric intubation was found be to eliminated from these animals within 72 hours (Rhodes & Jewell, 1980). In rats, the acute oral LD_{50} values for Velpar are >5,000 and 6,887 mg/kg. Velpar yielded an acute dermal toxicity value of >7,500 mg/kg in rabbits. These values for Velpar indicate that this substance is of very low toxicity to slightly toxic in the animals tested (DuPont, 1990b).

Hexazinone exposure values for the "worst case" or "realistic" cases did no exceed the toxic reference value (Table B3-45) for deer or rabbits.

2.6.2.2 Subchronic and Chronic Toxicity Effects

Several subchronic and chronic toxicity studies have been conducted on the effects of hexazinone on rats. The no observed effect level for a two week exposure study was 300 mg/kg/day. The lowest dose tested in a three month study to cause effect was 250 mg/kg, while the no observed effect level for this study was 50 mg/kg. A two-year feeding study of the rat exposed to technical hexazinone yielded a no observable effect level of 10 mg/kg. In this same study, nutritional and body weight effects were observed for females at 50 mg/kg and at 125 mg/kg in both sexes. Biochemical effects were noted in both sexes at this latter dose. Exposure of technical hexazinone to pregnant rats during gestation of their litters resulted in no observed effect levels of 100 mg/kg/day in both the developing fetuses and the pregnant mothers. Doses of 400 mg/kg/day caused adverse effects in both the mothers and the developing young. Reproduction and lactation in rats was not noticeably impacted in a three-generation, three-litter study of technical material; however, slightly lower weaning weights occurred in second and third litters at 125 mg/kg/day. The lowest dose tested in this study to cause maternal effects was 250 mg/kg/day. A two-year feeding study of the effects of technical hexazinone in mice resulted in a no observed effect level of 200 ppm, but non-neoplastic liver effects occurred at 2,500 ppm in males and at 10,000 ppm in both sexes. A dose of 125 mg/kg/day was found to be the lowest dose tested to be teratogenic or embryo-fetal toxic in rabbits and to effect the pregnant mothers. A no observed effect level of 25 mg/kg was obtained for a 90-day feeding study of technical material to dogs and slight nutritional, body weight and biochemical effects occurred at 125 mg/kg.

The value for the "worst case" exposure for deer exceeded the NOEL reference value. The "realistic" value for the deer was not exceeded. The reference value for the deer was extrapolated from 1/10 the value for the laboratory rat.

2.6.3 Birds

2.6.3.1 Acute Toxicity Effects

The only acute toxicity value found for the exposure of technical hexazinone to birds is an LD_{50} of 2,258 mg/kg for bobwhite quail.

Neither the "worst case" nor "realistic" exposure scenarios exceeded the toxic reference value for the bobwhite.

2.6.3.2 Subchronic and Chronic Toxicity Effects

Subchronic dietary toxicities for the bobwhite quail and the mallard duck range from >5,000 to 10,000 ppm.

The NOEL reference values for bobwhite were well above the calculated "worst case" and "realistic" exposure levels. Toxicity to birds seems very low.

Hexazinone is considered to range from slightly toxic to nontoxic for the birds tested by Kennedy (1984). This chemical is not expected to pose an acute risk to birds (EPA, 1988b).

2.6.4 Fish

2.6.4.1 Acute Toxicity Effects

The acute LC_{50} values for fish exposed to technical hexazinone for 96 hours ranged from 274 to 505 mg/L. No observed effect levels for fathead minnows, bluegill sunfish, and rainbow trout are 160, 370, and 240 mg/kg, respectively. The lowest tested dose to cause effect in both bluegill sunfish and rainbow trout is 420 mg/kg.

Bluegill sunfish that had been exposed to 1.0 ppm of ^{14}C-labeled hexazinone for four weeks were found to have eliminated >90% of this substance by the end of one week in fresh water and to have no detectable ^{14}C levels after two weeks (Rhodes, 1980). Technical hexazinone is listed as being slightly toxic to bluegill sunfish, fathead minnows, and rainbow trout (Kennedy, 1984). This substance is considered practically non-toxic to fish and is not expected to pose an acute risk to these organisms (EPA, 1988b).

Velpar has acute toxicity values of >1,000 mg/L for bluegill sunfish and is classified as slightly toxic to this species (DuPont, 1990b). The acute toxicity value for rainbow trout is >100 mg/L.

2.6.4 Aquatic Invertebrates

2.6.4.1 Acute Toxicity Effects

Daphnia exposed to technical hexazinone exhibited acute toxicity values of 145.3 and 152 ppm. These values indicate that hexazinone is practically nontoxic or slightly toxic to these organisms (EPA, 1988d & Kennedy, 1984, respectively).

The dose of Velpar that caused 50% reduction in abundance in rotifers, cladocera, and copepods varied from 0.04 to 3.26 mg/L depending on the number of days of observation following exposure.

Experiments with marine invertebrates exposed to hexazinone yielded acute toxicity values of >56 to 241 ppm for grass shrimp, >1,000 ppm for the fiddler crab, and >320 ppm for the oyster. The grass shrimp was the most sensitive marine organism tested, and hexazinone is moderately toxic to these animals (Kennedy, 1984). Oyster embryos are considered to be quite resistant to hexazinone, and fiddler crabs are relatively insensitive to this chemical (Kennedy, 1984).

2.6.4.2 Ecological Effects

No major alterations in species composition or diversity were detected in a macroinvertebrate community of a second order intermittent stream that was exposed to intermittent concentrations of 6 to 44 ppb of hexazinone (Mayack et al., 1982). Hexazinone and its metabolites were generally not detected in the aquatic invertebrates of this previous study. No significant mortality occurred in 13 test species of aquatic insects exposed to 80 mg/L of hexazinone in laboratory flow-through bioassays (Kreutzweiser et al., 1992). Exposures of 80 mg/L of this chemical to aquatic insects in outdoor streams caused significant drift of *Isonychia* sp.; however, the survival of these organisms, including the *Isonychia* sp., was not affected (Kreutzweiser et al., 1992). These authors stated that "marked similarity in diversity and species composition between control and herbicide treated sections of stream indicate that no gross changes in the aquatic invertebrate community occurred as a result of the introduction of hexazinone into the aquatic environment." Thompson et al. (1993b), however, found hexazinone to cause concentration-dependent reductions of zooplankton abundance. These authors suggested that chronic exposure of concentrations approximating 1 mg/L or above may result in reduced primary productivity in lentic ecosystems, which might result in reductions in zooplankton abundance.

2.6.5 Threatened and Endangered Animals

Little toxicity data is available for the various vertebrate groups relative to hexazinone. There is no indication that the chemical poses any threat to protected species, other than through habitat alteration.

Table B3-24.

HEXAZINONE
Velpar

MAMMALS

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RAT			
		Acute Toxicity	
Tech. >98%	Oral	LD_{50} 1,690 mg/kg	Kennedy, 84
Tech. >98%	Intraperitoneal injection	LD_{50} 530 mg/kg	Kennedy, 84
Tech. >98%	Inhalation/1 hour exposure	LC_{50} >7.48 mg/L	Kennedy, 84
Velpar	Oral	LD_{50}s >5,000 and 6,887 mg/kg/day	DuPont, 90b
		Subchronic Toxicity	
Tech. 89.3%	Oral/5 days exposure or >98%	NOEL 300 mg/kg/day per week for 2 weeks	Kennedy, 84
Tech.	Dietary/3 month exposure	NOEL 50 mg/kg--no systemic effects	EPA, 88b
Tech.	"	250 mg/kg--lowest dose tested to cause effect - decreased body weights	EPA, 88b

Table B3-24. Hexazinone (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RAT (cont.)			
		Chronic Toxicity	
Tech.	Dietary/2 year exposure	NOEL 10 mg/kg--no systemic effects	EPA, 88b
Tech.	Dierary/2 year exposure	50 mg/kg--lowest dose tested to cause effects - 5% decrease in body weight & food efficiency in females	EPA, 88b
Tech.	Dietary/2 year exposure	125 mg/kg--significant toxic effects in both sexes - decrease in body weight, organ weight changes, etc.	EPA, 88b
		Reproductive/Developmental Toxicity	
Tech.	Gavage/pregnant animals/days 7 to 16 of gestation	NOEL 100 mg/kg/day--no maternal toxicity	EPA, 88b
Tech.	"	400 mg/kg/day--lowest dose tested to effect adults - decreased food consumption, increased relative liver weight, decreased body weight gain, etc.	EPA, 88b
Tech.	"	NOEL 100 mg/kg/day--no effect on fetal development	EPA, 88b
Tech.	"	400 mg/kg/day--lowest dose tested to effect developing young-decreased body weight, marginally increased kidney anomalies, & decreased ossification	EPA, 88b

Table B3-24. Hexazinone (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RAT (cont.)		Reproductive/Developmental Toxicity (cont.)	
Tech.	Gavage/pregnant animals/days 7 to 16 of gestation	900 mg/kg/day--developmental toxicity evident in both sexes-decresed body weight, increase in partial ossification, increased kidney anomalies	EPA, 88b
Tech.	Dietary/pregnant animals/days 6 to 15 of gestation	NOEL 50 mg/kg/day--no effect on adults	EPA, 88b
Tech.	Dietary/3 generations/ 1 litter per generation	250 mg/kg/day--lowest dosed tested to cause effect in adults-decreased body weight & increased incidence of partial reabsorption	EPA, 88b
Tech.	Dietary/3 generations/ 1 litter per generation	NOEL 50 mg/kg/day--no effect on reproduction	EPA, 88b
Tech.	"	125 mg/kg/day--lowest dose tested to cause effect in reproduction-decreased average weight of weanlings	EPA, 88b
MOUSE		Subchronic Toxicity	
Tech. >98%	Dietary/8 week exposure	NOEL 2,500 ppm	Kennedy & Kaplan, 84
Tech. >98%	"	10,000 ppm--increased absolute & relative liver weights, no other effects noted	Kennedy & Kaplan, 84

Table B3-24. Hexazinone (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
MOUSE (cont.)		Chronic Toxicity	
Tech. ≥95%	Dietary/2 year exposure	NOEL 200 ppm	Kennedy & Kaplan, 84
Tech. ≥95%	"	2,500 ppm--caused non-neoplastic liver effects in males	Kennedy & Kaplan, 84
Tech. ≥95%	Dietary/2 year exposure	10,000 ppm--caused non-neoplastic liver effects in both sexes	Kennedy & Kaplan, 84
RABBIT		Acute Toxicity	
Tech.	Dermal	LD_{50} >5,278 mg/kg--no mortality occurred at this dose	EPA, 88b
Velpar	Dermal	LD_{50} 7,500 mg/kg	DuPont, 90b
		Reproductive/Developmental Toxicity	
Tech. >98%	Gavage/pregnant animals/days 6 to 19 of gestation	NOEL 50 mg/kg/day--no effects to adults	Kennedy & Kaplan, 84
Tech. >98%	"	125 mg/kg/day--lowest dose tested to cause effect in adults-decreased body weight, increased reabsorptions	Kennedy & Kaplan, 84

Table B3-24. Hexazinone (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RABBIT (cont.)		Reproductive/Developmental Toxicity (cont.)	
Tech. >98%	"	NOEL 50 mg/kg/day--no effect on developing young	Kennedy & Kaplan, 84
Tech. >98%	"	125 mg/kg/day--lowest dose tested to effect developing young-decreased body weight, delayed ossification of skeletal extremities	Kennedy & Kaplan, 84
GUINEA PIG (*Cavia cobava*)		Acute Toxicity	
Tech. >98%	Oral	LD_{50} 860 mg/kg	Kennedy, 84
DOG (*Canis familiaris*)		Acute Toxicity	
Tech. >98%	Oral or intragastric intubation	LD_{50} >3,400 mg/kg	Kennedy, 84
		Subchronic Toxicity	
Tech. >98%	Dietary/3 month exposure	NOEL 25 mg/kg--no systemic effects	Kennedy & Kaplan, 84
Tech. >98%	"	125 mg/kg--lowest dose tested to cause effect - decreased body weight, decreased albumin/globulin values, and increased relative liver weight	Kennedy & Kaplan, 84

Table B3-25.

HEXAZINONE
Velpar

BIRDS

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
BOBWHITE QUAIL (*Colinus virginianus*)		Acute Toxicity	
Tech. >98%	Oral	LD_{50} 2,258 mg/kg	Kennedy, 84
		Subchronic Toxicity	
Tech. >98%	Dietary/5 day exposure/3 day recovery	LC_{50} >5,000 ppm	Kennedy, 84
Tech.	Dietary/5 day exposure/3 day recovery	LC_{50} >10,000 ppm	Ghassemi et al., 81 & 82 (*in* Sassman et al., 84)
MALLARD DUCK (*Anas platyrhynchos*)		Subchronic Toxicity	
Tech. >98%	Dietary/ducklings/ 5 day exposure/3 day recovery	LC_{50} >10,000 ppm	Kennedy, 84

Table B3-26.

HEXAZINONE
Velpar

FISH

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
FATHEAD MINNOW (*Pimephales promelas*)		Acute Toxicity	
Tech. >98%	Static bioassay/ 24, 48, 96 hour exposure	NOEL (96 hr) 160 mg/L	Kennedy, 84
Tech. >98%	"	LC_{50} 24 hr 453 mg/L 48 hr >370 mg/L 96 hr 274 mg/L	Kennedy, 84
BLUEGILL (*Lepomis macrochirus*)		Acute Toxicity	
Tech. >98%	Static bioassay/ 24, 48, 96 hour exposure	NOEL (96 hr) 370 mg/L	Kennedy, 84
Tech. >98%	"	LC_{50} 24 hr 425 mg/L 48 hr >370 mg/L 96 hr >370 mg/L	Kennedy, 84
Tech. >98%	"	420 mg/L--lowest tested dose to cause effect in 96 hr exposure	Kennedy, 84
Tech. 95%	96 hour exposure	LC_{50} 505 mg/L	EPA, 88b

Table B3-26. Hexazinone (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
BLUEGILL (*Lepomis macrochirus*) (cont.)		Acute Toxicity (cont.)	
Velpar	96 hour exposure	LC_{50} >1,000 mg/L	DuPont, 90b
RAINBOW TROUT (*Salmo gairdneri*)		Acute Toxicity	
Tech.	Static bioassay/ 96 hour exposure	LC_{50} 322 ppm	Schneider & Kaplan, 83 (*in* Sassman et al., 84)
Tech. >98%	Static bioassay/ 24, 48, 96 hour exposure	NOEL (96 hr) 240 mg/L	Kennedy, 84
Tech. >98%	"	LC_{50} 24 hr, 401 mg/L 48 hr, 388 mg/L 96 hr, >320 mg/L	Kennedy, 84
Tech. >98%	"	420 mg/L--lowest tested dose to cause effect in 96 hr exposure	Kennedy, 84
Velpar	Static bioassay/ 96 hour exposure	LC_{50} >100 ppm	Johnson & Finley, 80

Table B3-27.

HEXAZINONE
Velpar

AQUATIC INVERTEBRATES

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
DAPHNIA (*Daphnia magna*)		Acute Toxicity	
Tech. >98%	Static bioassay/ 48 hour exposure	EC_{50} 152 ppm	Kennedy, 84
Tech.	Not specified	EC_{50} 145.3 ppm	EPA, 88b
ROTIFER (*Keratella cochlearis*)		Subchronic/Chronic Toxicity	
Velpar	Enclosure in lake/ single application/ 21 day observation	EC_{50} 0.04 mg/L--50% reduction in abundance	Thompson et al., 93b
CLADOCERA (3 species)		Subchronic/Chronic Toxicity	
Velpar	Enclosure in lake/ adults/single application/7 day observation	EC_{50} 1.38 mg/L--50% reduction in abundance	Thompson et al., 93b

Table B3-27. Hexazinone (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
CLADOCERA (3 species)(cont.)		Subchronic/Chronic Toxicity (cont.)	
Velpar	Enclosure in lake/ adults/single application/42 day observation	EC_{50} 0.09 mg/L--50% reduction in abundance	Thompson et al., 93b
Velpar	Enclosure in lake/ nauplii/single application/14 day observation	EC_{50} 0.52 mg/L--50% reduction in abundance	Thompson et al., 93b
COPEPODS (3 species)		Subchronic/Chronic Toxicity	
Velpar	Enclosure in lake/ single application/ 7 day observation	EC_{50} 3.26 mg/L--50% reduction in abundance	Thompson et al., 93b
Velpar	Enclosure in lake/ single application/ 14 day observation	EC_{50} 0.51 mg/L--50% reduction in abundance	Thompson et al., 93b
Velpar	Enclosure in lake/ single application/ 42 day observation	EC_{50} 0.32 mg/L--50% reduction in abundance	Thompson et al., 93b
Velpar	Enclosure in lake/ single application/ 56 day observation	EC_{50} 0.88 mg/L--50% reduction in abundance	Thompson et al., 93b

Table B3-27. Hexazinone (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
SHRIMP (Species not specified)		Acute Toxicity	
Tech.	96 hour exposure	LC_{50} 78 ppm	EPA, 88b
GRASS SHRIMP (*Palaemonetes pugio*)		Acute Toxicity	
Tech. >98%	Static bioassay/ 24, 48, 96 hour exposure	LC_{50}s 24 hr, 241 ppm 48 hr, 94 ppm 96 hr, >56 ppm	Kennedy, 84
FIDDLER CRAB (*Uca pugilator*)		Acute Toxicity	
Tech.	Static bioassay/ 96 hour exposure	LC_{50} >1,000 ppm	EPA, 88b
OYSTER (*Crassostrea virginica*)		Acute Toxicity	
Tech. >98%	Static bioassay/ embryos/48 hour exposure	NOEL 320 ppm--no reduction in numbers of normally developed animals	Kennedy, 84
Tech. >98%	"	560 ppm--lowest dose tested that caused effect - no animals developed normally	Kennedy, 84
Tech. >98%	"	LC_{50} >320	Kennedy, 84

2.7 Imazapyr (Arsenal)

2.7.1 General Information

Additional information for imazapyr and Arsenal is presented in EPA (1985a). Results of toxicity studies are presented in Tables B3-28 to B3-31.

2.7.2 Mammals

2.7.2.1 Acute Toxicity Effects

Arsenal has an acute LD_{50} value for oral exposure in rats of >5,000 mg/kg and a dermal exposure value of >2,148 mg/kg in rabbits. These values indicate that Arsenal is no more than slightly toxic to these animals (Cyanamid, 1990). Technical imazapyr and its Arsenal formulation are irritating to the eyes of rabbits and mildly irritating to their skin but is considered nonsensitizing to guinea pigs (EPA, 1985a).

Imazapyr is considered of low toxicity to mammals and the reference values were not exceeded in the "worst case" or "realistic" cases for deer or rabbits (Table B3-45).

2.7.2.2 Subchronic and Chronic Toxicity Effects

A subchronic dermal exposure of Arsenal to the rabbit yielded a no observed effect level of 400 mg/kg/day. The no observed effect level for teratogenicity and fetotoxicity is 1,000 mg/kg/day in rats exposed to Arsenal and is 400 mg/kg/day in rabbits exposed to this product. No maternal toxicity was observed in these studies at doses of 300 mg/kg/day and 400 mg/kg/day for rats and rabbits, respectively. Technical imazapyr is considered to be nonmutagenic in all mammals tested (EPA, 1985a).

The "worst case" exposure for the deer exceeded the reference NOEL value extrapolated from 10% of the value for the laboratory rat. The values were not exceeded in the "realistic" case for the deer, nor in either the "worst case" or "realistic" cases for the rabbit.

2.7.3 Birds

2.7.3.1 Acute Toxicity Effects

The acute toxicity value for both bobwhite quail and mallard ducks exposed to Arsenal is >2,150 mg/kg. Ecological data referred to, but not elucidated, in EPA (1985a) indicate that the technical acid of imazapyr is practically nontoxic to the birds tested.

The toxicity values for the bobwhite computed for both "worst case" and "realistic" cases were well below the reference values (Table B3-45).

2.7.3.2 Subchronic and Chronic Toxicity Effects

Bobwhite quail and mallard ducks both have dietary subchronic toxicity values of >5,000 ppm.

The NOEL values were well above the toxicity levels computed for both the "realistic" and "worst case" levels in the bobwhite.

2.7.4 Fish

2.7.4.1 Acute Toxicity Effects

Bluegill, channel catfish, and rainbow trout have LC_{50} values for exposure to Arsenal of >100 mg/L. Ecological data referred to, but not elucidated, in EPA (1985a) indicate that the technical acid of imazapyr is practically nontoxic to the fish tested.

2.7.4.2 Subchronic and Chronic Toxicity Effects

No studies could be found for this category.

2.7.5 Aquatic Invertebrates

2.7.5.1 Acute Toxicity Effects

The only toxicity value found for aquatic invertebrates was an acute exposure value of >100 mg/l for daphnia exposed to Arsenal.

2.7.5.2 Subchronic and Chronic Toxicity Effects

No studies could be found for this category.

2.7.6 Threatened and Endangered Animals

Imazapyr appears to have a low toxicity to vertebrates, although studies concerning amphibians and reptiles are lacking. Caution should always be used when applying any chemical near an endangered species in the absence of test data.

Table B3-28.

IMAZAPYR
Arsenal

MAMMALS

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RAT			
		Acute Toxicity	
Arsenal	Oral	LD_{50} >5,000 mg/kg	Cyanamid, 90
Arsenal	Inhalation/nominal	LD_{50} >5.1 mg/L	EPA, 85a
Arsenal	Inhalation/gravimetric	LD_{50} >1.3 mg/L	EPA, 85a
		Reproductive/Developmental Toxicity	
Arsenal	Not specified	NOEL 300 mg/kg/day--no maternal toxicity	EPA, 85a
Arsenal	Not specified	NOEL 1,000 mg/kg/day--no developmental or fetotoxic effects on developing young	EPA, 85a
RABBIT			
		Acute Toxicity	
Arsenal	Dermal	LD_{50} >2,148 mg/kg	Cyanamid, 90
		Subchronic Toxicity	
Arsenal	Dermal/21 day	NOEL 400 mg/kg/day	EPA, 85a

Table B3-28. Imazapyr (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RABBIT (cont.)			
		Reproductive/Developmental Toxicity	
Arsenal	Not specified	NOEL 400 mg/kg/day--no maternal toxicity	EPA, 85a
Arsenal	Not specified	NOEL 400 mg/kg/day--no developmental or fetotoxic effect	EPA, 85a

Table B3-29.

IMAZAPYR
Arsenal

BIRDS

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
BOBWHITE QUAIL (*Colinus virginianus*)			
		Acute Toxicity	
Arsenal	Oral	LD_{50} >2,150 mg/kg	EPA, 85a
		Subchronic Toxicity	
Arsenal	Dietary	LC_{50} >5,000 ppm	EPA, 85a
MALLARD DUCK (*Anas platyrhynchos*)			
		Acute Toxicity	
Arsenal	Oral/adults	LD_{50} >2,150 mg/kg	EPA, 85a
		Subchronic Toxicity	
Arsenal	Dietary/ducklings	LC_{50} >5,000 ppm	EPA, 85a

Table B3-30.

IMAZAPYR
Arsenal

FISH

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
BLUEGILL (*Lepomis macrochirus*)		Acute Toxicity	
Arsenal	Surface absorption	LC_{50} >100 mg/L	EPA, 85a
CHANNEL CATFISH (*Ictalurus punctatus*)		Acute Toxicity	
Arsenal	Surface absorption	LC_{50} >100 mg/L	EPA, 85
RAINBOW TROUT (*Salmo gairdneri*)		Acute Toxicity	
Arsenal	Surface absorption	LC_{50} >100 mg/L	EPA, 85a

Table B3-31.

IMAZAPYR
Arsenal

AQUATIC INVERTEBRATES

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
DAPHNIA		Acute Toxicity	
Arsenal	Static bioassay	EC_{50} >100 mg/L	EPA, 85a

2.8 Metsulfuron Methyl (Escort)

2.8.1 General Information

Additional information on metsulfuron methyl is presented in EPA (1986e). Results of toxicity studies are presented in Tables B3-32 to B3-35.

2.8.2 Mammals

2.8.2.1 Acute Toxicity Effects

Both technical metsulfuron methyl and Escort have acute oral LD_{50}s of >5,000 mg/kg in rats, and an acute dermal LD_{50}s of >2,000 mg/kg in rabbits. Metsulfuron methyl is considered to be of low toxicity based on acute tests (EPA, 1986e). Escort is classified as having a very low acute oral toxicity to rats and as slightly to moderately toxic to rabbits via dermal exposure (DuPont, 1990a). This material is not considered to be a primary skin irritant in rabbits or a skin sensitizer in guinea pigs (DuPont, 1990a). Escort caused mild to moderate corneal irritation in the unwashed eyes of rabbits and mild conjunctival irritation in washed eyes of these animals, but all effects were reversed within seven days (Du Pont, 1990a).

Metsulfuron methyl indicated no values approaching environmental toxicity when applied at the labelled rate. Both the "worst case" and "realistic" values for deer and rabbits were well below the reference, even when extrapolated from the rat (Table B3-45).

2.8.2.2 Subchronic and Chronic Effects

A feeding study in which rats were exposed to technical metsulfuron methyl for two years revealed no observed systemic effects at 500 ppm and had a lowest dose to cause effect of 5,000 ppm. Even at this higher dose, no ontogenetic effects occurred. A two generation exposure of this chemical to rats had a maternal no observed effect level of 500 ppm; the lowest tested dose to cause a parental effect (slightly decreased body weight) was 5,000 ppm. No reproductive or fetotoxic effects were observed in this previous study at the highest dose tested of 5,000 ppm. In another developmental study with rats, the maternal no effect level was <40 mg/kg/day, the fetotoxic no effect level was <1,000 mg/kg/day, and no developmental effects in newborns were observed at 1,000 mg/kg/day. The systemic and oncogenic no observed effect level was 5,000 ppm for an 18 month exposure study in the mouse. No teratogenic or embryo-fetal toxic effects were caused by 700 mg/kg/day (highest dose tested) in rabbits exposed to technical metsulfuron methyl. The maternal no effect dose in this study was 25 mg/kg/day, and the lowest dose to cause a maternal effect was 100 mg/kg/day. The lowest dose to cause an effect in a feeding study in which dogs were exposed for one year to technical metsulfuron methyl was 500 ppm; the no observed effect level for this study was 50 ppm. Technical metsulfuron methyl has been found to be mutagenic in only one of five such assays.

The "worst case" and "realistic" case scenarios computed in this study produced values well below the NOEL values extrapolated for deer and rabbits (Table B3-45).

2.8.3 Birds

2.8.3.1 Acute Toxicity Effects

The only acute toxicity value found for birds was LD_{50} of >2,150 mg/kg for mallard ducks.

Both the "worst case" and "realistic" cases considered in this analysis were well below the toxic reference value for bobwhite.

2.8.3.2 Subchronic and Chronic Toxicity Effects

Both bobwhite quail and mallard ducks have subchronic toxicity values of >5,620 ppm.

The NOEL reference value for bobwhite was well above the exposure values at both the "realistic" and "worst case" values.

Metsulfuron methyl is practically nontoxic to birds (EPA, 1986e).

2.8.4 Fish

2.8.4.1 Acute Toxicity Effects

The acute toxicity value for bluegill and rainbow trout exposed to technical metsulfuron methyl is >150 ppm.

2.8.4.2 Subchronic and Chronic Toxicity Effects

No studies were found for this category.

Metsulfuron methyl is considered to be practically nontoxic to fish (EPA, 1986e).

2.8.5 Aquatic Invertebrates

2.8.5.1 Acute Toxicity Effects

The acute toxicity value for daphnia exposed to technical metsulfuron methyl is >150 ppm.

2.8.5.2 Subchronic and Chronic Toxicity Effects

The subchronic toxicity value for daphnia exposed to metsulfuron methyl is >5,620 ppm. Chronic exposure of a boreal forest lake with Escort generated only marginal effects on the zooplankton communities in experimental enclosures within the lake

(Thompson et al., 1993b). This response was similar to that of the phytoplankton community concomitantly exposed to Escort (Thompson et al., 1993a).

Metsulfuron methyl is practically nontoxic to aquatic invertebrates (EPA, 1986e).

2.8.6 Threatened and Endangered Animals

No information was found considering toxicity to reptiles and amphibians, but based on values for mammals, birds, and aquatic invertebrates, metsulfuron methyl and its formulated product Escort should pose low ecotoxicity. The chemical should be tested on amphibians, which have very permeable skin prior to using in the vicinity of any endangered species of amphibians.

Table B3-32.

METSULFURON METHYL
Escort

MAMMALS

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RAT			
		Acute Toxicity	
Tech.	Oral	LD_{50} >5,000 mg/kg	EPA, 85e
Escort	Oral	LD_{50} >5,000 mg/kg	DuPont, 90a
		Chronic Toxicity	
Tech.	Dietary/2 year exposure	NOEL 500 ppm--no observed systemic effect	EPA, 85e
Tech.	"	5,000 ppm--lowest dose tested to cause systematic effect	EPA, 85e
		Reproductive/Developmental Toxicity	
Tech.	Gavage	NOEL <40 mg/kg/day--no significant effect on maternal animals	EPA, 85e
Tech.	"	NOEL <1,000 mg/kg/day--no significant effect on fetal animals	EPA, 85e
Tech.	"	1,000 mg/kg/day--no significant effect on developing young	EPA, 85e

Table B3-32. Metsulfuron methyl (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RAT (cont.)			
		Reproductive/Developmental Toxicity (cont.)	
Tech.	2 generation exposure	NOEL 500 ppm--no significant effect on maternal animals	EPA, 85e
Tech.	2 generation exposure	5,000 ppm--lowest dose tested to cause effect on maternal animals	EPA, 85e
Tech.	"	5,000 ppm--no significant effect on reproduction	EPA, 85e
Tech.	"	NOEL >5,000 ppm--no significant effect on fetal animals	EPA, 85e
MOUSE			
		Subchronic Toxicity	
Tech.	18 month exposure	NOEL 5,000 ppm--no systemic nor oncogenic effect	EPA, 85e
RABBIT			
		Acute Toxicity	
Tech.	Dermal	LD_{50} >2,000 mg/kg	EPA, 85e
Escort	Dermal	LD_{50} >2,000 mg/kg	DuPont, 90a

Table B3-32. Metsulfuron methyl (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RABBIT (cont.)			
		Reproductive/Developmental Toxicity	
Tech.	Gavage	NOEL 25 mg/kg/day--no significant effect on maternal animals	EPA, 85e
Tech.	"	100 mg/kg/day--lowest dose tested to cause effect on maternal animals	EPA, 85e
Tech.	Gavage	NOEL >700 mg/kg/day--no significant effect on fetal animals	EPA, 85e
Tech.	Gavage	700 mg/kg/day--no significant effect on developing animals	EPA, 85e
DOG (*Canis familiaris*)			
		Subchronic Toxicity	
Tech.	Dietary/1 year exposure	NOEL 50 ppm	EPA, 85e
Tech.	"	500 ppm--lowest dose tested to cause effect	EPA, 85e

Table B3-33.

METSULFURON METHYL
Escort

BIRDS

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
BOBWHITE QUAIL (*Colinus virginianus*)			
		Subchronic Toxicity	
Tech.	Dietary/8 day exposure	LC_{50} >5,620 ppm	EPA, 85e
MALLARD DUCK (*Anas platyrhynchoss*)			
		Acute Toxicity	
Tech.	Oral	LD_{50} >2,150 mg/kg	EPA, 85e
		Subchronic Toxicity	
Tech.	Dietary/8 day exposure	LC_{50} >5,620 ppm	EPA, 85e

Table B3-34.

METSULFURON METHYL
Escort

FISH

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
BLUEGILL (*Lepomis macrochirus*)		Acute Toxicity	
Tech.	96 hour exposure	LC_{50} >150 ppm	EPA, 85e
RAINBOW TROUT (*Salmo gairdneri*)		Acute Toxicity	
Tech.	96 hour exposure	LC_{50} >150 ppm	EPA, 85e

Table B3-35.

METSULFURON METHYL
Escort

AQUATIC INVERTEBRATES

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
DAPHNIA (*Daphnia magna*)			
		Acute Toxicity	
Tech.	48 hour exposure	EC_{50} >150 ppm	EPA, 85e
		Subchronic Toxicity	
Tech.	Dietary/8 day exposure	LC_{50} >5,620 ppm	EPA, 85e

2.9 Sulfometuron Methyl (Oust)

2.9.1 General Information

Additional information on sulfometuron methyl is presented in Sczerzenie et al. (1987). Results of toxicity studies are presented in Tables B3-36 to B3-39.

2.9.2 Mammals

2.9.2.1 Acute Toxicity Effects

The acute oral LD_{50} of 75% sulfometuron methyl exposed to rats is >5,000 mg/kg, indicating that it is of very low toxicity to these animals (DuPont, 1991). The acute dermal LD_{50}s for rabbits exposed to Oust were >8,000 mg/kg for males and >2,000 mg/kg for females, indicating a slight to moderate toxicity (DuPont, 1991). The LC_{50} value for a four hour inhalation study using an unspecified formulation of sulfometuron methyl is 5 mg/L for the rat. Sulfometuron methyl (75%) is nonsensitizing to guinea pigs but is slightly irritating to rabbit eyes and skin (Sczerzenie, 1987).

The acute toxicity reference levels for sulfometuron methyl were well above the levels computed for deer and rabbits and both the "worst case" and "realistic" exposures (Table B3-45).

2.9.2.2 Subchronic and Chronic Toxicity Effects

Fertility and reproduction were not effected at a dose level of 500 ppm in a two-generation study of reproduction in rats; however, maternal toxicity and reduced pup production were observed at 5,000 ppm. No teratogenic effects have been observed for rats and rabbits exposed to this substance. Decreased body weight gain, liver changes, and red blood cell hemolysis occurred following repeated exposures to high doses of sulfometuron methyl, and long term exposure caused mild hemolytic anemia, decreased body weight, changes in the bile duct, and altered clinical chemical parameters. Sulfometuron methyl has been found to be rapidly metabolized and excreted by goats; following seven days of dosing at levels of 25 or 60 ppm, greater than 93% of this material was excreted in the urine (Koeppe and Mucha, 1922).

The NOEL value computed in the "worst case" for the deer exceeded the reference value. The value for the deer was extrapolated from a value for the laboratory rat where the upper limits were not determined. The "realistic" value for the deer and the "worst case" and "realistic" values for the rabbit were well below the reference value.

2.9.3 Birds

2.9.3.1 Acute Toxicity Effects

The acute oral LD_{50} for mallard ducks is >5,000 mg/kg. Sulfometuron methyl is slightly toxic to the species of birds tested (Sczerzenie et al., 1987).

Calculated values for the bobwhite used in this assessment were well below the toxicity reference value.

2.9.3.2 Subchronic and Chronic Toxicity Effects

Oral LC_{50}s of an eight-day dietary study of mallard ducks and bobwhite quail >5,000 ppm and >5,620 ppm, respectively.

The Noel reference value for bobwhite quail greatly exceeded the calculated exposure values for both the "realistic" and "worst case" levels (Table B3-45).

2.9.4 Fish

2.9.4.1 Acute Toxicity Effects

No significant bioaccumulation of [^{14}C]sulfometuron methyl occurred in bluegill sunfish (*Lepomis macrochirus*) maintained at nominal levels of 0.01 ppm to 1.0 ppm of this chemical for 28 days (Harvey et al., 1985).

2.9.5 Aquatic Invertebrates

2.9.5.1 Acute Toxicity Effects

Oust was found to be very mildly toxic to juvenile crayfish and practically nontoxic to adult crayfish (Naqvi et al., 1987). The previous authors stated that it is unlikely that concentrations of Oust lethal to crayfish would exist in field conditions unless a massive contamination occurred.

2.9.5.2 Subchronic and Chronic Toxicity Effects

No studies were found for this category.

2.9.6 Threatened and Endangered Animals

Sulfometuron methyl appears to have low ecotoxicity to vertebrates and does not appear to be a threat to any protected animal species. There is, however, no test data for amphibians or reptiles. Chemical applications should be avoided in areas of endangered species until test data are available on a related species.

Table B3-36.

SULFOMETURON METHYL
Oust

MAMMALS

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RAT			
		Acute Toxicity	
Oust	Oral	LD_{50}s >5,000 mg/kg	DuPont, 91
		Subchronic Toxicity	
Tech.	Gavage/10 doses over 2 week period	NOEL 3,400 mg/kg/day--no deaths resulted	EPA, 84 (*in* Sezerzenie et al., 87)
Tech.	Dietary/90 day exposure	NOEL 50 mg/kg/day (1,000 ppm)--no effect	EPA, 84 (*in* Sezerzenie et al., 87)
Tech.	"	250 mg/kg/day (5,000 ppm)--lowest dose tested to cause effect-elevated white blood cell counts	EPA, 84 (*in* Sezerzenie et al., 87)
		Reproductive/Developmental Toxicity	
Not specified	Dietary/2 year, 2 generation, 4 litter exposure	NOEL 2.5 mg/kg/day (50 ppm)--no systemic effect	DuPont, 86b (*in* Sezerzenie et al., 87)
Not specified	"	25 mg/kg/day (500 ppm)--lowest dose tested to cause systemic effects in adults-liver toxicity, decreased brain weight to body weight ratio	Dupont, 86b (*in* Sezerzenie et al., 87)

Table B3-36. Sulfometuron methyl (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RAT (cont.)		Reproductive/Developmental Toxicity (cont.)	
Not specified	Dietary/2 year, 2 generation, 4 letter exposure	NOEL 25 mg/kg/day (500 ppm)--no effect on reproduction	DuPont, 86c (*in* Sezerzenie et al., 87)
Not specified	1 generation	NOEL 250 mg/kg (5,000 ppm)--no effect on reproduction (highest dose tested)	EPA, 84 (*in* Sezerzenie et al., 87)
Not specified	Exposure duration not specified	NOEL 50 mg/kg/day (1,000 ppm)--no maternal effect	EPA, 84 (*in* Sezerzenie et al., 87)
Not specified	"	250 mg/kg/day (5,000 ppm)--lowest dose tested to cause maternal effect-reduced weight gain	EPA, 84 (*in* Sezerzenie et al., 87)
Not specified	"	NOEL 50 mg/kg/day (1,000 ppm)--no effect on fetal development	EPA, 84 (*in* Sezerzenie et al., 87)
Not specified	"	250 mg/kg/day (5,000 ppm)--lowest dose tested to cause fetal effect-reduced weight gain	EPA, 84 (*in* Sezerzenie et al., 87)
Not specified	"	NOEL >250 mg/kg/day (>5,000 ppm)--no effect on developing young (highest dose tested)	EPA, 84 (*in* Sezerzenie et al., 87)
RABBIT		Acute Toxicity	
Tech.	Dermal	LD50 >2,000 mg/kg	EPA, 84 (*in* Sezerzenie et al., 87)

Table B3-36. Sulfometuron methyl (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RABBIT (cont.)			
		Acute Toxicity (cont.)	
Form. 75%	Dermal	LD50s >2,000 mg/kg (females) >8,000 mg/kg (males)	EPA, 84 (*in* Sezerzenie et al., 87)
		Subchronic Toxicity	
Oust	Dermal/21 day exposure	2,000 mg/kg/day--no observed effects (highest dose tested)	EPA, 84 (*in* Sezerzenie et al., 87)
		Reproductive/Developmental Toxicity	
Not specified	Exposure duration not specified	300 mg/kg--no maternal or fetal effects, no effect on developing young (highest dose tested)	EPA, 84 (*in* Sezerzenie et al., 87)
DOG (*Canis familiaris*)			
		Chronic Toxicity	
Not specified	Dietary/1 year exposure	NOEL 5 mg/kg/day (200 ppm)--no systemic effect	EPA, 84 (*in* Sezerzenie et al., 87)
Not specified	"	25 mg/kg/day (1,000 ppm)--lowest dose tested to cause systemic effect-decreased red blood cell, hemoglobin & hematocrit levels, increased liver weights	EPA, 84 (*in* Sezerzenie et al., 87)

Table B3-37.

SULFOMETURON METHYL
Oust

BIRDS

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
BOBWHITE QUAIL (*Colinus virginianus*)		Subchronic Toxicity	
Oust	Dietary/8 day exposure	LC_{50} >5,620 ppm	DuPont, 91
MALLARD DUCK (*Anas playrhynchos*)		Subchronic Toxicity	
Not specified	Dietary/8 day exposure	LC_{50} >5,000 ppm	DuPont, 83 (*in* Sezerzenie et al., 87)

Table B3-38.

SULFOMETURON METHYL
Oust

FISH

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
BLUEGILL (*Lepomis macrochirus*)		Acute Toxicity	
Tech.	96 hour exposure	LC_{50} >12.5 ppm	DuPont, 83 (*in* Sezerzenie et al., 87)
RAINBOW TROUT (*Salmo gairdneri*)		Acute Toxicity	
Tech.	96 hour exposure	LC_{50} >12.5 ppm	DuPont, 83 (*in* Sezerzenie et al., 87)

Table B3-39.

SULFOMETURON METHYL
Oust

ACQUATIC INVERTEBRATES

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
DAPHNIA (*Daphnia magna*)		Acute Toxicity	
Tech.	48 hour exposure	LC_{50} >12.5 ppm	DuPont, 83 (*in* Sezerzenie et al., 87)
MICROCRUSTACEAN (*Diaptomus* sp.)		Acute Toxicity	
Oust	Static bioassay/ 48 hour exposure	LC_{50} 1,315 mg/L	Naqvi & Hawkins, 89
MICROCRUSTACEAN (*Eucyclops* sp.)		Acute Toxicity	
Oust	Static bioassay/ 48 hour exposure	LC_{50} 1,320 mg/L	Naqvi & Hawkins, 89
MICROCRUSTACEAN (*Alonella* sp.)		Acute Toxicity	
Oust	Static bioassay/ 48 hour exposure	LC_{50} 802 mg/L	Naqvi & Hawkins, 89

Table B3-39. Sulfometuron methyl (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
MICROCRUSTACEAN (*Cypria* sp.)			
		Acute Toxicity	
Oust	Static bioassay/ 48 hour exposure	LC_{50} 2,241 mg/L	Naqvi & Hawkins, 89
CRAYFISH (*Procambarus clarkii*)			
		Acute Toxicity	
Oust	Static bioassay/ juveniles/96 hour exposure	LC_{50} 12,174 ppm	Naqvi & Hawkins, 89
Oust	Static bioassay/ adults/96 hour exposure	LC_{50} >60,000 ppm	Naqvi & Hawkins, 89

2.10 Triclopyr (Pathfinder II)

2.10.1 General Information

Additional information on triclopyr is presented in Sassman (1984) and WSSA (1983). Results of toxicity studies are presented in Tables B3-40 to B3-42.

2.10.2 Mammals

2.10.2.1 Acute Toxicity

The acute oral LD_{50}s for technical triclopyr exposed to rats ranges from 630 to 729 mg/kg. This chemical was not carcinogenic in rats at exposures of $\leq$30 mg/kg/day. The acute oral toxicity value for technical triclopyr exposed to the mouse, guinea pig, and rabbit are 471, 310, 550 mg/kg, respectively. The dermal LD_{50} for this chemical in rabbits is >2,000 mg/kg. Technical triclopyr is considered to be a slight eye irritant in the rabbit. The acute LD_{50}s for Pathfinder II in rats is 630 and 729 mg/kg. No mortality or other exposure related effects occurred in rats exposed via inhalation to 4.7 mg/L of Pathfinder II for four hours; the LC_{50} for this formulation in rats is greater than this value. The acute dermal toxicity value for Pathfinder II in rabbits is >2,000 mg/kg. This formulation does not cause allergic skin reactions in guinea pigs (DowElanco, 1994).

In mammals, technical triclopyr and its formulations exhibit low to moderate acute toxicity, mild subchronic toxicity, and no chronic toxicity (Sassman et al., 1984).

Triclopyr is considered moderately toxic to mammals, and the "worst case" exposure calculated (Table B3-45) for deer greatly exceeded the value for deer as extrapolated from the laboratory rat. Neither the "realistic" value for the deer, nor the "realistic" or "worst case" values for the rabbit, exceeded the acute toxicity reference value.

2.10.2.2 Subchronic and Chronic Effects

In a 90 day study in which technical triclopyr was fed to rats, the no observed effect levels were $\leq$30 mg/kg/day and $\leq$100 mg/kg/day for males and females, respectively. Decreased body and liver weight and increased kidney weight was observed in males at 100 mg/kg/day in this previous study. An approximate two year chronic study of dietary exposure of technical triclopyr in rats yielded no toxic effect at $\leq$30 mg/kg/day. No developmental or reproductive toxicity was observed in rats at exposure levels up to those causing maternal toxicity (100 mg/kg/day). A three generation study of rats in which they were exposed to $\leq$30 mg/kg/day found no effects on reproduction, growth, maturation, or development of the young. No reproductive, developmental, or reproductive toxicity was observed in rabbits at exposure levels causing maternal toxicity (25 mg/kg/day). In male mice, the lowest dose of technical triclopyr tested that caused an effect (reduced liver weight) was 60 mg/kg/day. A no observed effect level of $\leq$60 mg/kg/day was obtained for female mice in this previous study. Dogs exposed to 2.5 mg/kg/day of technical triclopyr for 183 days exhibited a slightly reduced excretion of the test substance, and dogs exposed to 5 to 20 mg/kg/day of this chemical exhibited decreased weight gain, decreased food consumption, and liver and kidney effect due to increased urinary retention of the triclopyr. Monkeys exposed to as much as 30 mg/kg/day for an unspecified time exhibited no toxic effects, and no effect on renal excretion was observed. Ponies had no adverse effects to doses of 60 mg/kg/day for four days; however, a similar exposure schedule with 300 mg/kg/day resulted in depression, recumbency, decreased gastrointestinal activity, and respiratory and muscular distress (Osweiler, 1983). This material is rapidly excreted through the kidneys (Sassman et al., 1984). No triclopyr was detectable in the urine of a cow later than 24 hours after a four-day dosing period, and 86.4% of this substance was excreted intact (Eckerlin et al., 1987).

The NOEL reference values were exceeded in both the deer and rabbit in the "worst case" exposure scenarios. The values were less than the NOEL in the "realistic" cases for the rabbit and deer.

2.10.3 Birds

2.10.3.1 Acute Toxicity Effects

The acute LD_{50} for technical triclopyr in mallard ducks is 1,698 mg/kg. Triclopyr has low acute toxicity to this bird (Sassman et al., 1984).

2.10.3.2 Subchronic and Chronic Toxicity Effects

The subchronic toxicity values for technical triclopyr in mallard ducks, bobwhite quail, and Japanese quail are >5,000, 2,935, 3,278 ppm, respectively. Triclopyr has low subchronic dietary toxicities for mallard ducks, bobwhite, and Japanese quail (Sassman et al., 1984).

Little animal test data is available for birds. The acute toxicity reference value for bobwhite, computed from the mallard duck study, exceeded the calculated exposure cases of both "realistic" and "worst case" (Table B3-45). The NOEL value was exceeded, however, in the "worst case" exposure situation. The "realistic" value was well below the reference NOEL.

2.10.4 Fish

2.10.4.1 Acute Toxicity Effects

Technical triclopyr has acute LC_{50}s of 148 ppm in the bluegill and 117 ppm in the rainbow trout. Based on these values, the chemical is considered to be only slightly toxic to those fish (Sassman et al., 1984). The acute toxicity values found for technical triclopyr exposed for 24 to 96 hours to six species of juvenile salmonids ranged from 5.3 to 13.3 mg/L. The acute toxicity values for technical triclopyr exposed for 24 to 96 hours to six species of juvenile salmonids ranged from 1.2 to 4.2 mg/L. Neither triclopyr or its metabolites appear to bioaccumulate in catfish or mosquito fish (Sassman et al., 1984). DowElanco (1994) states that the Pathfinder II formulation of triclopyr is considered to be toxic to fish; however, no specific toxicity values are given.

2.10.5 Aquatic Invertebrates

2.10.5.1 Acute Toxicity Effects

No studies were found for this category.

2.10.5.2 Subchronic and Chronic Toxicity Effects

In a study of crayfish exposed to potential field concentrations of $_{14}C$ triclopyr, it was determined that there was low potential for bioaccumulation of this substance and its metabolites in these organisms (Barron et al., 1991).

2.10.6 Threatened and Endangered Animals

There is little test data for any animals for triclopyr, and inferences are difficult to make. The limited data on laboraory rats and ducks indicates that the chemical should have restricted use in the immediate vicinity of protected species until further testing is done on related species.

Table B3-40.

TRICLOPYR
Pathfinder II

MAMMALS

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RAT			
		Acute Toxicity	
Tech.	Oral	LD_{50}s 630 & 729 mg/kg	Dow Chemical, date unknown
Tech.	Oral	LD_{50} 713 mg/kg	WSSA, 83
Tech.	Not specified	NOEL $\leq$30 mg/kg/day--not carcinogenic	Dow Chemical, 83 (*in* Sassman et al., 84)
Pathfinder II	Oral	LD_{50}s 4,183 & 4,464 mg/kg	DowElanco, 94
Pathfinder II	Inhalation/ 4 hour exposure	LC_{50} >4.7 mglL--no mortality or other treatment related effects occurred	DowElanco, 94
		Subacute Toxicity	
Tech.	Dietary/males/ 90 day exposure	100 mg/kg/day--decreased body & liver weight, increased kidney weight	Humiston et al., 75 (*in* Hanley et al., 84)
Tech.	"	NOEL $\leq$30 mg/kg/day--no effect on adult males	Humiston et al., 75 (*in* Hanley et al., 84)
Tech.	Dietary/females/ 90 day exposure	NOEL $\leq$100 mg/kg/day--no effect on adult females	Humiston et al., 75 (*in* Hanley et al., 84)

Table B3-40. Triclopyr (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RAT (Cont.)			
		Chronic Toxicity	
Tech.	Dietary/approximate 2 year exposure	NOEL $\leq$30 mg/kg/day--no toxic effect	Dow Chemical, 83 (*in* Sassman et al, 84)
		Reproductive/Developmental Toxicity	
Tech.	Gavage/pregnant animals/days 6-15 of gestation	50 mg/kg/day--transient abdominal distress in pregnant animals	Hanley et al., 84
Tech.	"	100 mg/kg/day--suppressed food consumption by pregnant animals	Hanley et al., 84
Tech.	"	200 mg/kg/day--suppressed body weight gain in pregnant animals	Hanley et al., 84
Tech.	"	LD_{100} 400 mg/kg/day--all adults died	Hanley et al., 84
Tech.	"	NOEL 100 mg/kg/day--no effect on embryological or fetal development	Hanley et al., 84
Tech.	"	200 mg/kg/day--mild effect on fetal development, possibly secondary to maternal toxicity in the adults	Hanley et al., 84
Tech.	Dietary/3 generation exposure	NOEL $\leq$30 mg/kg/day--no effects on reproduction, growth, maturation, or development of young	Hanley et al., 84

Table B3-40. Triclopyr (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
MOUSE		Acute Toxicity	
Tech.	Oral	LD_{50} 471 mg/kg	EPA, 85b (*in* Sassman et al., 84)
		Subacute Toxicity	
Tech.	Dietary/males/ 90 day exposure	NOEL 6 & 20 mg/kg/day--no effect	Dow Chemical, 83 (*in* Sassman et al., 84)
Tech.	"	60 mg/kg/day--reduced liver weight	Dow Chemical, 83 (*in* Sassman et al., 84)
Tech.	Dietary/females/ 90 day exposure	NOEL $\leq$60 mg/kg/day--no effects	Dow Chemical, 83 (*in* Sassman et al., 84)
		Chronic Toxicity	
Tech.	Dietary/approximate 2 year exposure	3, 10, & 30 mg/kg/day--no toxic effect; not carcinogenic	Dow Chemical, 83 (*in* Sassman et al., 84)
GUINEA PIG (*Cavia cobava*)		Acute Toxicity	
Tech.	Oral	LD_{50} 310 mg/kg	WSSA, 83

Table B3-40. Triclopyr (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
RABBIT			
		Acute Toxicity	
Tech.	Oral	LD_{50} 550 mg/kg	WSSA, 83
Tech.	Dermal	LD_{50} >2,000 mg/kg	Dow Chemical, 83 (*in* Sassman et al., 84)
Tech.	Primary eye irritation	slight irritant	Dow Chemical, 83 (*in* Sassman et al., 84)
Pathfinder II	Dermal	LD_{50} >2,000 mg/kg	DowElanco, 94
		Reproductive/Developmemtal Toxicity	
Tech.	Gavage/pregnant animals/days 6-18 of gestation	0, 10, 25, mg/kg/day--transient dose-related decrease in maternal body weight; maternal death occurred at all dose levels, including controls, and may have been due to gavage procedure	Hanley et al., 84
Tech.	"	NOEL ≤25 mg/kg/day--not teratogenic, not fetotoxic to developing young	Hanley et al., 84
MONKEY			
		Subchronic Toxicity	
Tech.	Dietary/period not specified	20 & 30 mg/kg/day--no toxic effect; no effect on renal excretion	Dow Chemical, 83 (*in* Sassman et al., 84)

Table B3-40. Triclopyr (cont.)

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
DOG (*Canis familiaris*)			
		Subchronic Toxicity	
Tech.	Dietary/183 day exposure	2.5 mg/kg/day--slightly reduced kidney excretion of test substance	Dow Chemical, 83 (*in* Sassman et al., 84)
Tech.	Dietary/228 day exposure	5, 10, & 20 mg/kg/day--decreased weight gain & food consumption; liver & kidney effects considered due to increased urinary retention of test substance	Dow Chemical, 83 (*in* Sassman et al., 84)

Table B3-41.

TRICLOPYR
Pathfinder II

BIRDS

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
MALLARD DUCK (*Anas platyrhynchos*)			
		Acute Toxicity	
Tech.	Oral	LD_{50} 1,698 mg/kg	WSSA, 83
		Subchronic Toxicity	
Tech.	Dietary/8 day exposure	LC_{50} >5,000 ppm	WSSA, 83
BOBWHITE QUAIL (*Colinus virginianus*)			
		Subchronic Toxicity	
Tech.	Dietary/8 day exposure	LC_{50} 2,935 ppm	WSSA, 83
JAPANESE QUAIL (*Conturnix japonica*)			
		Subchronic Toxicity	
Tech.	Dietary/8 day exposure	LC_{50} 3,278 ppm	WSSA, 83

Table B3-42.

TRICLOPYR
Pathfinder II

FISH

ANIMAL/ FORMULATION	EXPOSURE	EFFECTS	SOURCE
BLUEGILL (*Lepomis macrochirus*)		Acute Toxicity	
Tech.	Static bioassay/ 96 hour exposure	LC_{50} 148 ppm	Dow Chemical, 83a (*in* Sassman et al., 84)
RAINBOW TROUT (*Salmo gairdneri*)		Acute Toxicity	
Tech.	Static bioassay/ 96 hour exposure	LC_{50} 117 ppm	Dow Chemical, 83a (*in* Sassman et al., 84)
SALMONIDS (6 species)		Acute Toxicity	
Tech.	Static bioassay/ juveniles/24, 48, 72, 96 hour exposures	LC_{50}s-24 hrs, 7.8 to 13.3 mg/L 48 hrs, 7.5 to 9.6 mg/L 72 hrs, 6.1 to 9.7 mg/L 96 hrs, 5.3 to 9.7 mg/L	Wan et al., 87

Table B3-43. Biological Parameters of Target Species Used in the Analysis.

TARGET SPECIES	HOME RANGE hectares	WEIGHT INGESTED grams	DAILY FORAGE INGESTED grams	DAILY WATER RATE liters	BREATHING AREA l/min	BODY SURFACE VEGETATION cm^2	DAILY CONTACTING GROOMING %	SELF %
Bobwhite Quail	29.3	184	37	0.1	0.08	324	74	39
Eastern Cottontail Rabbit	1.0	1200	132	0.25	0.44	1132	62	23
White-tailed Deer	62.0	50000	1838	1.5	8.67	13621	39	7

Table B3-44. EPA Clasifications of Chemicals Toxicities.

	VERY HIGHLY TOXIC	HIGHLY TOXIC	MODERATELY TOXIC	SLIGHTLY TOXIC	PRACTICALLY NON-TOXIC
MAMMAL					
LD_{50} (mg/kg)	<10	10 - 50	51 - 500	501 - 2000	>2000
LC_{50} (ppm)	<50	51 - 500	501 - 1000	1001 - 5000	>5000
BIRD					
LD_{50} (mg/kg)	<10	10 - 50	51 - 500	501 - 2000	>2000
LC_{50} (ppm)	<50	51 - 500	501 - 1000	1001 - 5000	>5000
AQUATIC					
LC_{50} (ppm)	<0.1	0.1 - 1.0	>1 - 10	>10 - 100	>100

3.0 Risk Assessment and Conclusions

3.1 Terrestrial and Aquatic Wildlife

The ten chemicals considered in this analysis appear to have low toxicity to wildlife on roadsides. None of the chemicals used at their maximum labeled application rate reached even an observable effect level, considering a "realistic" exposure scenario for bobwhite quail, eastern cottontail rabbit, and white-tailed deer. Even though aquatic species were sensitive to several of the chemicals, very little exposure to toxic levels is foreseen. Using the concentrations in the water from Kenega (1972), none of the chemicals reach toxic levels through incidental exposure through drift or pass-by spray trucks. Figures B3-1 through B3-4 display the relative toxicities of the various chemicals to representatives of major animal groups. When "worst-case" exposures were considered, several chemicals were identified that could impact wildlife. Chlorpyrifos (dursban), diazinon, and triclopyr emerged with toxic values in "worst-case." When the methods of usage along roadsides are considered, the impacts are reduced. Triclopyr, for instance, is used as a basal spray on woody species; dursban and diazinon are used around roadside rest areas, electrical outlets, and facilities for human accomodation. In some cases, so little is known about wildlife responses to the chemicals (fenoxycarb) that caution has to be used, even when the chemical appears practically innocuous. The chemicals which exceed NOEL levels in the "worst-case" should not be used in critical habitat for rare and endangered species.

Care should be taken in assessing toxicity. Assessments given for the basic compound may vary considerably from those for the formulation in use, which can be related directly to the use scenario of a material.

TxDOT is very conservative in selecting pesticides which offer a minimum risk to humans and to wildlife and their habitat. Risk also considers the responsible use of the specified materials. Responsibility is promoted in TxDOT through the licensing procedure and by periodic training exercises for applicators and vegetation managers.

Risk can be mitigated by the manner in which the materials are used. Workers can minimize skin contact by wearing clothing which will intercept spray materials, as well as restricting the area to be treated and the amount of material being dispensed. Seasonal applications may avoid the presence of desirable fauna and yet achieve the desirable results. Localized applications to the basal portion of woody stems leaves the uncontaminated foliage available as browse.

Merging the management requirements for the facility and mitigating impacts to various components of the environment becomes a priority. Where evidence is available on which to base a decision, the management is perhaps more straightforward. Where risk data are lacking, as with many aquatic and terrestrial organisms, suggestions often can be gleaned from other test organisms. Otherwise, the manager should seek and consider alternative treatments.

Table B3-45. Animal Toxicity Limits and Values.

CHEMICAL TARGET SPECIES	ACUTE DOSE LD^{50} (mg/kg)	NO OBSERVABLE EFFECT NOEL (mg/kg)	EXPOSURE LEVEL WORST CASE (mg/kg)	 REALISTIC (mg/kg)	MAXIMUM APPLICATION RATE ($kg^{a.i.}/ha$)
CHLORPYRIFOS Dursban					4.648
Bobwhite quail	32.0	15.00	1.8663	0.0007	
Eastern cottontail	15.1 [1]	0.15 [4]	*4.3947*	0.0143	
White-tailed deer	47.3 [2]	0.47 [4]	**341.4260**	0.0717	
CLOPYRALID Transline					0.565
Bobwhite quail	146.5 [3]	1.47 [4]	0.2269	0.0001	
Eastern cottontail	430.0 [1]	250.00	0.5342	0.0017	
White-tailed deer	430.0 [1]	25.00 [5]	*41.5030*	0.0087	
DIAZINON Diazinon					4.380
Bobwhite quail	10.0	0.12 [4]	*1.7587*	0.0007	
Eastern cottontail	130.0	1.30	4.1414	0.0135	
White-tailed deer	6.6 [1]	0.07 [4]	**321.7397**	*0.0676*	

Table B3-45. (Continued). Animal Toxicity Limits and Values.

CHEMICAL / TARGET SPECIES	ACUTE DOSE LD^{50} (mg/kg)	NO OBSERVABLE EFFECT NOEL (mg/kg)	EXPOSURE LEVEL WORST CASE (mg/kg)	EXPOSURE LEVEL REALISTIC (mg/kg)	MAXIMUM APPLICATION RATE ($kg^{a.i.}$/ha)
FENOXYCARB Logic					0.01411
Bobwhite quail	>300.0 [3]	>3.00 [4]	0.0057	<0.0001	
Eastern cottontail	>1680.0 [1]	>20.00 [6]	0.0133	<0.001	
White-tailed deer	>1680.0 [1]	>20.00 [6]	1.0365	0.0002	
GLYPHOSATE Roundup or Rodeo					4.629
Bobwhite quail	3850.0	1000.00	1.8586	0.0008	
Eastern cottontail	3800.0	175.00 -	4.3768	0.0143	
White-tailed deer	199.3 [2]	36.20 [6]	**340.0304**	0.0714	
HEXAZINONE Velpar					2.258
Bobwhite quail	2258.0	22.58 [4]	0.9066	0.0003	
Eastern cottontail	169.0 [1]	50.00	2.1349	0.0069	
White-tailed deer	169.0 [1]	30.00 [6]	*165.8649*	0.0348	

Table B3-45. (Continued). Animal Toxicity Limits and Values.

CHEMICAL TARGET SPECIES	ACUTE DOSE LD_{50} (mg/kg)	NO OBSERVABLE EFFECT NOEL (mg/kg)	EXPOSURE LEVEL WORST CASE (mg/kg)	 REALISTIC (mg/kg)	MAXIMUM APPLICATION RATE ($kg^{a.i.}$/ha)
IMAZAPYR Arsenal					1.870
Bobwhite quail	59.3	0.59 [4]	*0.7508*	0.0003	
Eastern cottontail	138.0 [1]	110.00	1.7681	0.0058	
White-tailed deer	138.0 [1]	1.38 [4]	*137.3637*	0.0288	
METSULFURON METHYL Escort					0.0847
Bobwhite quail	>215.0 [3]	>2.15 [4]	0.0340	0.0001	
Eastern cottontail	>500.0 [1]	>5.00 [4]	0.0801	0.0003	
White-tailed deer	>500.0 [1]	>5.00 [4]	*6.2203*	0.0013	
SULFOMETURON METHYL Oust					0.635
Bobwhite quail	>375.0 [3]	>3.75 [4]	0.2550	0.0001	
Eastern cottontail	>375.0 [1]	>3.75 [4]	0.6004	0.0020	
White-tailed deer	>375.0 [1]	>3.75 [4]	*46.6449*	0.0097	

Table B3-45. (Continued). Animal Toxicity Limits and Values.

CHEMICAL TARGET SPECIES	ACUTE DOSE LD^{50} (mg/kg)	NO OBSERVABLE EFFECT NOEL (mg/kg)	EXPOSURE LEVEL WORST CASE (mg/kg)	 REALISTIC (mg/kg)	MAXIMUM APPLICATION RATE ($kg^{a.i.}$/ha)
TRICLOPYR Pathfinder II					11.128
Bobwhite quail	169.8 [3]	1.70 [4]	*4.4681*	0.0018	
Eastern cottontail	550.0	≤3.00 [6]	*10.5217*	0.0344	
White-tailed deer	63.0 [1]	<3.00 [6]	**817.4245**	0.1716	

[1] = 10% of the LD_{50} for the rat

[2] = 10% of the LD_{50} for the goat

[3] = 10% of the LD_{50} for the duck

[4] = extrapolated from the LD_{50}

[5] = 10% of the NOEL for the rabbit

[6] = 10% of the NOEL for the rat

Calculated values:

Bold Values - exceed LD_{50} values

Italic Values - exceed NOEL values

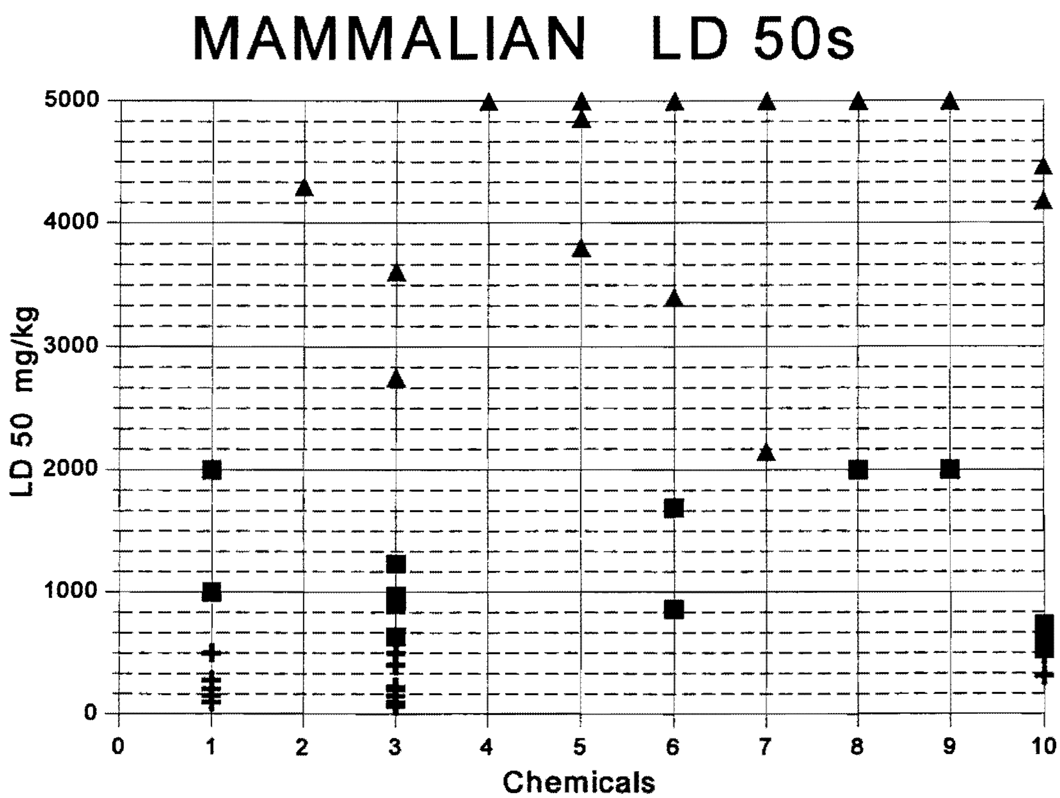

Figure B3-1. Combined LD_{50}s of mammalian species from toxicity tables (mg/kg). Chemical: 1) Chlorpyrifos, 2) Clopyralid, 3) Diazinon, 4) Fenoxycarb, 5) Glyphosate, 6) Hexazinone, 7) Imazapyr, 8) Metsulfuron methyl, 9) Sulfometuron methyl, 10) Triclopyr. Symbols: Cross = moderately toxic; Square = slightly toxic; Triangle = practically non-toxic.

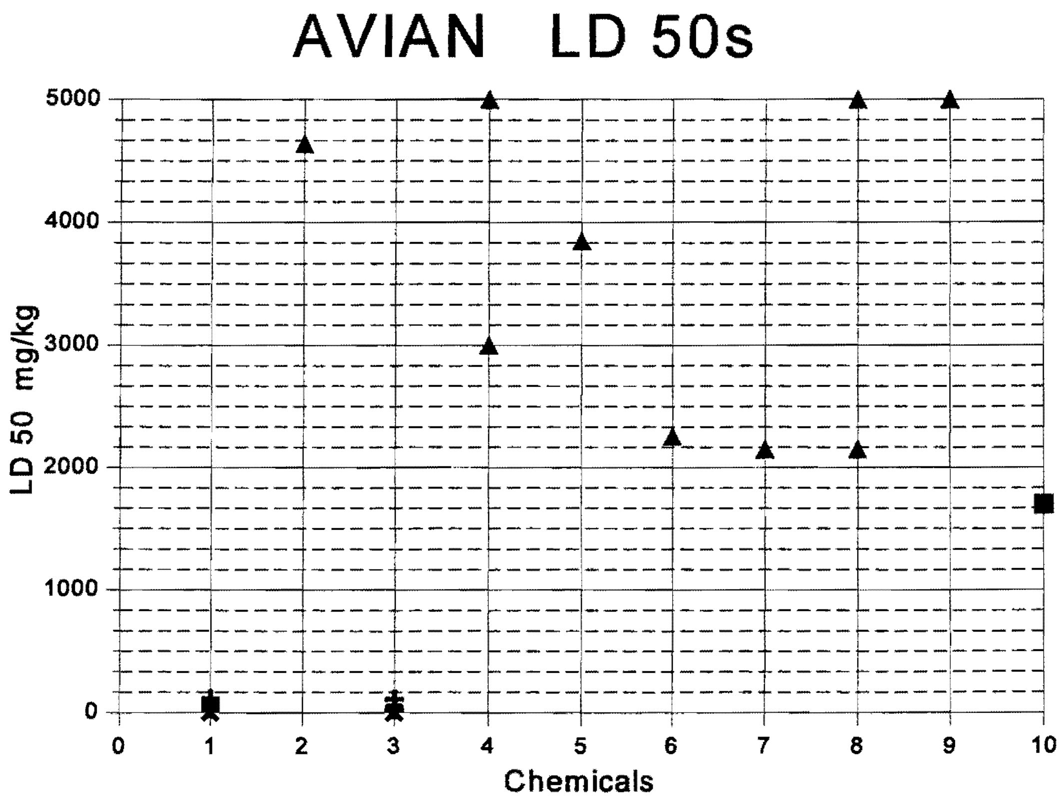

Figure B3-2. Combined LD_{50}s of avian species from toxicity tables (mg\kg). Chemical: 1) Chlorpyrifos, 2) Clopyralid, 3) Diazinon, 4) Fenoxycarb, 5) Glyphosate, 6) Hexazinone, 7) Imazapyr, 8) Metsulfuron methyl, 9) Sulfometuron methyl, 10) Triclopyr. Symbols: X=very highly toxic; * =highly toxic; + = moderately toxic; Square = slightly toxic; Triangle = practically non-toxic.

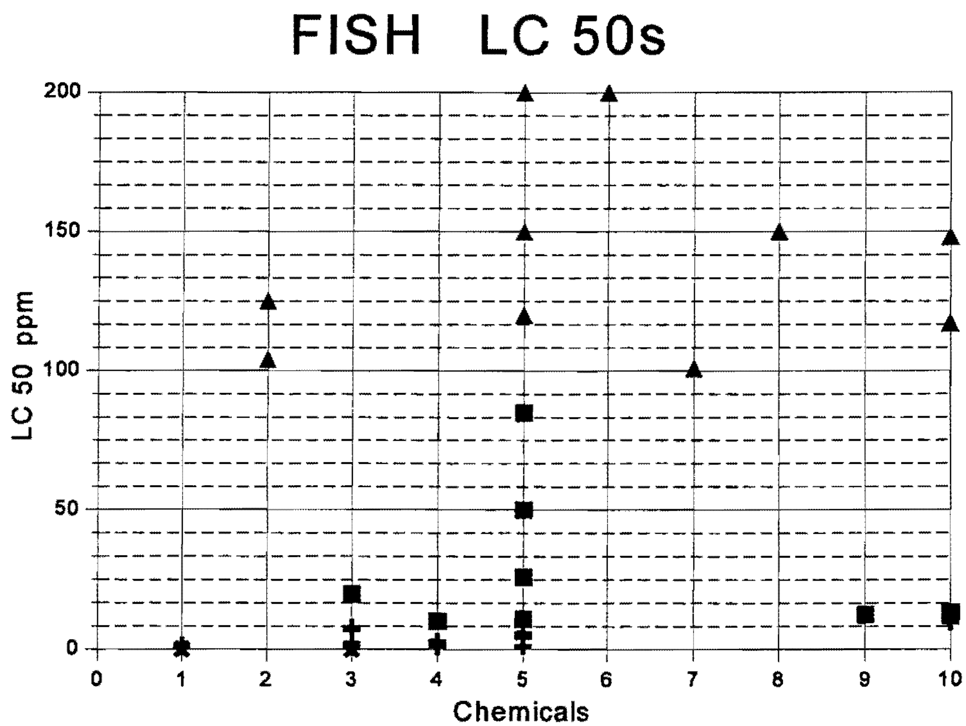

Figure B3-3. Combined LC_{50}s of fish species from toxicity tables (ppm). Chemical: 1) Chlorpyrifos, 2) Clopyralid, 3) Diazinon, 4) Fenoxycarb, 5) Glyphosate, 6) Hexazinone, 7) Imazapyr, 8) Metsulfuron methyl, 9) Sulfometuron methyl, 10) Triclopyr. Symbols: X=very highly toxic; * =highly toxic; + = moderately toxic; Square = slightly toxic; Triangle = practically non-toxic.

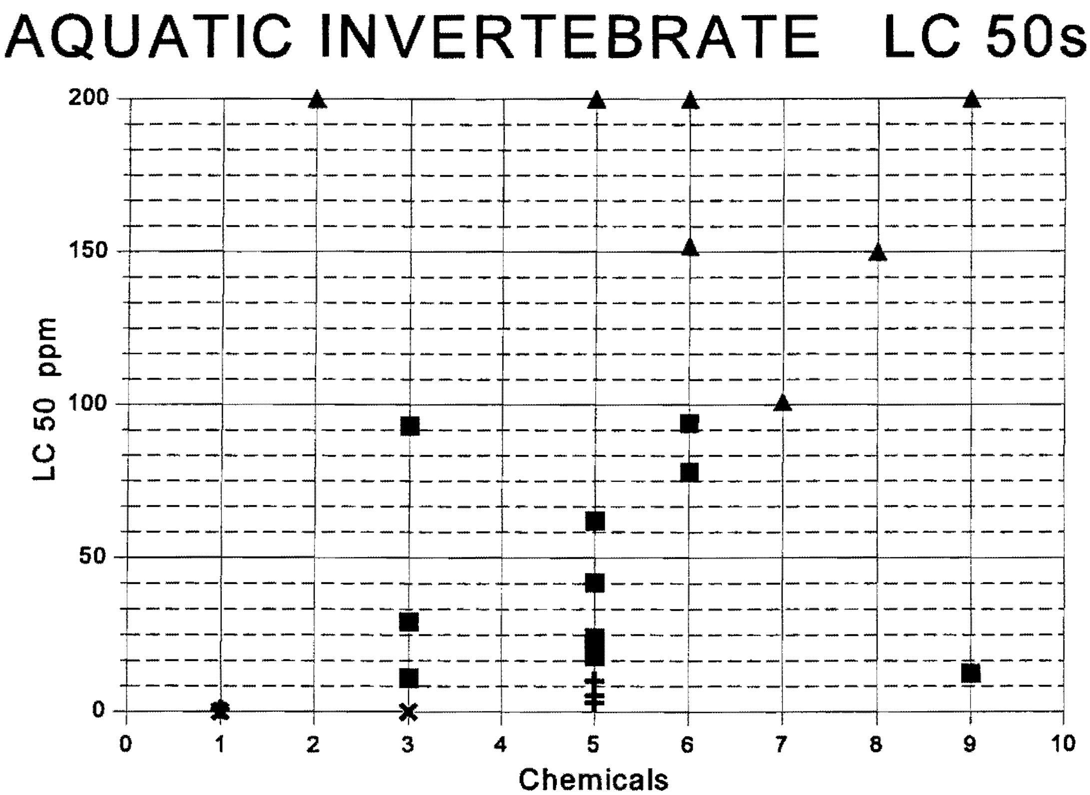

Figure B3-4. Combined LC_{50}s of aquatic invertebrates from toxicity tables (ppm). Chemical: 1) Chlorpyrifos, 2) Clopyralid, 3) Diazinon, 4) Fenoxycarb, 5) Glyphosate, 6) Hexazinone, 7) Imazapyr, 8) Metsulfuron methyl, 9) Sulfometuron methyl, 10) Triclopyr. Symbols: X=very highly toxic; * =highly toxic; + = moderately toxic; Square = slightly toxic; Triangle = practically non-toxic.

3.2 Rare, Threatened and Endangered Species

The Texas landscape and climate is diverse and cannot be defined with any "typical" description that fits throughout the state. The animals of the state are equally diverse with species composition varying widely throughout the state. Most animals are tied closely to particular habitats, and habitats are the result of a complex of characteristics including the soils, topography, climate, and other factors which support particular plant and animal communities.

With nearly 100 different plant communities identified in Texas, it is no surprise that nearly 150 animals have been identified in the state to be of special concern. Approximately 100 of these animals in Texas have been identified by the Federal government to be endangered or threatened with extinction, or are being reviewed for threatened or endangered status. The State has identified an additional 50 species that are of concern and warrant protection. The state list tends to be more inclusive with protection afforded to the species that are rare or exploited in the state, even though the species may be thriving in other states or adjacent Mexico.

In most cases, the rarity of the species of concern can be related back to habitat alterations due to land use changes. Prairies and grasslands converted to cropland, forests managed for timber production, or converted to grazing or cropland, intensive land management, urbanization and other human needs have altered the habitats. In some cases, habitats have disappeared, other habitats have expanded, and, in some cases, new habitats have been formed since modern man began controlling more of the environment.

The list of State and Federally protected species presented in Table B3-46 have been identified after extensive review and evaluation. These lists are dynamic, and as species recover they are removed from the list, just as additional species facing extinction will be added to the list. The Texas Natural Heritage Program of the Texas Parks and Wildlife Department maintains up-to-date lists of the protected species and specific areas of past and present distribution. It is impossible to know exactly everywhere a protected species occurs, but suitable habitat in the general vicinity of the known distribution of the protected animal should always be suspect.

The use of chemicals without good ecotoxicity data relative to the endangered or threatened species should be restricted in areas of special concern that harbor protected animal species. The endangered species usually inhabit very small and localized habitats that can be avoided. If chemical vegetation or insect control is needed, efforts should be made to support research on closely related, non-protected, species to allow prudent decisions concerning chemicals in the areas of endangered species.

Table B3-46. TEXAS THREATENED AND ENDANGERED ANIMALS

SCIENTIFIC NAME	COMMON NAME	**STATUS** STATE	FEDERAL	OCCURRENCE IN TEXAS
	*** MAMMALS ***			
Bats				
Euderma maculatum	Spotted bat	T	C2	Trans-Pecos region
Lasiurus ega	Southern yellow bat	T		Extreme south Texas
Leptonycteris nivalis	Mexican long-nosed bat	E	LE	Brewster and Presidio Counties
Plecotus rafinesquii	Eastern big-eared bat	T	C2	Eastern Texas
Rodents				
Dipodomys elator	Texas kangaroo rat	T	C2	Extreme north-central Texas
Oryzomys couesi	Coue's rice rat	T	C2	Lower Rio Grande Valley
Peromyscus truei comanche	Palo Duro mouse	T	C2	Armstrong, Briscoe and Randall Cos.
Marine Mammals				
Balaenoptera musculus	Blue whale	E	LE	Gulf Coast marine waters
Balaenoptera physalus	Finback whale	E	LE	Gulf Coast marine waters
Eubalaena glacialis	Black right whale	E	LE	Gulf Coast marine waters
Feresa attenuata	Pygmy killer whale	T		Gulf Coast marine waters
Globicephala macrorhyncyhus	Short-finned pilot whale	T		Gulf Coast marine waters
Kogia breviceps	Pygmy sperm whale	T		Gulf Coast marine waters
Kogia simus	Dwarf sperm whale	T		Gulf Coast marine waters
Mesoplodon europaeus	Gervais' beaked whale	T		Gulf Coast marine waters
Orcinus orca	Killer whale	T		Gulf Coast marine waters
Physeter catodon	Sperm whale	E	LE	Gulf Coast marine waters
Pseudorca crassidens	False killer whale	T		Gulf Coast marine waters
Stenella plagiodon	Atlantic spotted dolphin	T		Gulf Coast marine waters
Steno bredanensis	Rough-toothed dolphin	T		Gulf Coast marine waters
Trichechus manatus	Manatee	E	LE	Coastal marshes and marine waters
Ziphius cavirostris	Goose-beaked whale	T		Gulf Coast marine waters
Carnivores				
Canis lupus	Gray wolf	E	LE	Extirpated, statewide
Canis lupus baileyi	Mexican wolf	E	LE	Occasional migrant, Big Bend area
Canis rufus	Red wolf	E	LE	Extirpated, possibly deep SE Texas
Felis pardalis	Ocelot	E	LE	South Texas
Felis wiedii	Margay	E		Extirpated, south Texas
Felis yagouaroundi	Jaguarundi	E	LE	Extreme South Texas
Mustela nigripes	Black-footed ferret	E	LE	Extirpated from Texas
Nasua nasua	Coati	E		South, southwest & Trans-Pecos
Panthera onca	Jaguar	E		Extirpated from Texas
Ursus americanus	Black bear	E	LT	Occasional south & west Texas migrants
Ursus americanus luteolus	Louisiana black bear	E	LT	Extirpated, deep east Texas

Table B3-46. TEXAS THREATENED AND ENDANGERED ANIMALS (continued)

SCIENTIFIC NAME	COMMON NAME	**STATUS** STATE	**STATUS** FEDERAL	OCCURRENCE IN TEXAS
	*** BIRDS ***			
Waterbirds				
Egretta rufescens	Reddish egret	T	C2	Coastal, occasionally far inland
Grus americana	Whooping crane	E	LE	Aransas & Matagorda Cos., migrant north
Mycteria americana	Wood stork	T		Coastal, eastern, central, Rio Grande
Pelecanus occidentalis	Brown pelican	E	LE	Coastal counties
Plegadis chihi	White-faced ibis	T	C2	Coastal, central and western Texas
Raptors				
Buteo albicaudatus	White-tailed hawk	T		Coastal prairies, occasional westward
Buteo albonotatus	Zone-tailed hawk	T		Trans Pecos, Edwards Plateau, Rio Grande
Buteo nitidus maximus	Northern gray hawk	T	C2	Lower Rio Grande Valley to Trans Pecos
Buteogallus anthracinus	Common black-hawk	T		Davis Mts to Rio Grande Valley
Elanoides forficatus	American swallow-tailed kite	T	3C	Migrant statewide except Panhandle
Falco femoralis septentrionalis	Northern aplomado falcon		LE	Migrant west, southern, & lower coastal
Falco peregrinus anatum	American peregrine falcon	E	LE	Chisos & Guadalupe Mountains
Falco peregrinus tundrius	Arctic peregrine falcon	T	LT	Migrant across state
Glaucidium brasilianum	Ferruginous pygmy-owl	T		Rio Grande Valley, N. to Kennedy Co.
Glaucidium brasilianum cactorum	Cactus ferruginous pygmy-owl	T	C1	Rio Grange Valley
Haliaeetus leucocephalus	Bald eagle	E	LE	Migrant & resident throughout state
Strix occidentalis lucida	Mexican spotted owl		LE	Extreme West Texas; Wooded Canyons
Shorebirds				
Charadrius melodus	Piping plover	T	LT	Migrant in eastern half of state
Numenius borealis	Eskimo curlew	E	LE	Galveston Co, possibly extinct
Sterna antillarum	Least tern		LE	Gulf Coast and extreme NE Texas
Sterna antillarum athalassos	Interior least tern	E	LE	Panhandle & eastern 2/3 state
Sterna dougallii	Roseate tern		LT	Cameron, Calhoun, Galveston & Nueces
Sterna fuscata	Sooty tern	T		Coastal areas, occasional to cental
Upland Birds				
Tympanuchus cupido attwateri	Attwater's prairie-chicken	E	LE	Coastal, Galveston to Refugio Cos.
Woodpeckers				
Campephilus principalis	Ivory-billed woodpecker	E	LE	Extirpated, eastern third of state
Picoides borealis	Red-cockaded woodpecker	E	LE	East Texas Piney-woods

Table B3-46. TEXAS THREATENED AND ENDANGERED ANIMALS (continued)

SCIENTIFIC NAME	COMMON NAME	**STATUS** STATE	FEDERAL	OCCURRENCE IN TEXAS
	* * * BIRDS (cont) * * *			
Songbirds				
Aimophila aestivalis	Bachman's sparrow	T	C2	East Texas Piney-woods
Aimophila botterii texana	Texas botteri's sparrow	T	C2	Rio Grande Valley & lower coastal
Campstostoma imberbe	Northern beardless tyrannulet	T		Rio Grande Valley & lower coastal
Dendroica chrysoparia	Golden-cheeked warbler	E	LE	Ashe Juniper areas of central Texas
Pachyramphus aglaiae	Rose-throated becard	T		Rio Grande Valley below Falcon Dam
Parula pitiayumi nigrilora	Tropical parula	T	C2	Rio Grande Valley & lower coastal
Vermivora bachmanii	Bachman's warbler		LE	Extirpated, possibly Big Thcket area
Vireo atricapillus	Black-capped vireo	E	LE	Edwards Plateau, west and north
	* * * REPTILES * * *			
Turtles				
Caretta caretta	Loggerhead sea turtle	E	LT	Gulf coast marine waters
Chelonia mydas	Green turtle	T	LT	Gulf coast marine waters
Dermochelys coriacea	Leatherback sea turtle	E	LE	Gulf coast marine waters
Eretmochelys imbracata imbricata	Atlantic Hawksbill Sea Turtle	E	LE	Gulf coast marine waters
Eretmochelys imbricata	Hawksbill Sea Turtle		LE	Gulf coast marine waters
Gopherus berlandieri	Texas Tortoise	T		Southern Texas
Kinosternon hirtipes murrayi	Chihuahuan mud turtle	E	C2	Presido County
Lepidochelys kempii	Kemp's ridley sea turtle	E	LE	Gulf coast marine waters
Macroclemys temminckii	Alligator snapping turtle	T	C2	Eastern Texas
Snakes				
Cemophora coccinea copei	Northern scarlet snake	T		East Texas
Cemophora coccinea lineri	Texas scarlet snake	T		South Texas,coastal counties
Coniophanes imperialis	Black-striped snake	T		Cameron, Hidalgo and Willacy Cos.
Crotalus horridus	Timber rattlesnake	T		Eastern third of Texas
Drymarchon corais	Indigo snake	T		South Texas
Drymobius margaritiferus	Speckled racer	E		Cameron County
Leptodeira s. septentrionalis	Northern cat-eyed snake	E		Valley of south Texas
Nerodia harteri harteri	Brazos water snake	T	C2	Upper Brazos River
Nerodia harteri paucimaculata	Concho water snake	E	LT	Upper Colorado River
Opheodrys vernalis	Smooth green snake	E		Extreme southeast Texas
Pituophis melanoleucus ruthveni	Louisiana pine snake	E	C2	Far East Texas
Tantilla rubra	Big Bend blackhead snake	T		Southern Trans Pecos
Trimorphodon biscutatus vilkinsoni	Texas lyre snake	T		El Paso, Hudspeth, Presido, Brewster

Table B3-46. TEXAS THREATENED AND ENDANGERED ANIMALS (continued)

SCIENTIFIC NAME	COMMON NAME	**STATUS** STATE	FEDERAL	OCCURRENCE IN TEXAS
	*** REPTILES (cont) ***			
Lizards				
Coleonyx reticulatus	Reticulated gecko	T	3C	Brewster and Presidio Cos.
Crotaphytus reticulatus	Reticulate collared lizard	T	C2	South Texas, scattered localities
Phrynosoma cornutum	Texas horned lizard	T	C2	Statewide
Phrynosoma douglassii hernandesi	Mountain short-horned lizard	T		Extreme west Texas
	*** AMPHIBIANS ***			
Salamanders				
Eurycea nana	San Marcos salamander	T	LT	Upper San Marcos River
Eurycea tridentifera	Comal blind salamander	T	C2	Comal and Bexar Counties
Notophthalmus meridionalis	Black-spotted newt	E	C2	Southern Texas coastal counties
Siren intermedia texana	Rio Grande lesser siren	E	C2	Southern Texas
Typhlomolge rathbuni	Texas blind salamander	E	LE	Hays County
Typhlomolge robusta	Blanco blind salamander	E	C2	Hays County
Frogs				
Bufo houstonensis	Houston toad	E	LE	Bastrop, Burleson, Colorado, Harris Cos.
Hypopachus variolosus	Sheep frog	T		Southern Texas
Leptodactylus fragilis	White-lipped frog	E		Cameron, Hidalgo and Starr Cos.
Rhinophrynus dorsalis	Mexican burrowing toad	T		Starr and Zapata Counties
Smilisca baudinii	Mexican treefrog	T		Cameron and Hidalgo Counties
	*** FISHES ***			
Large River Fish				
Polyodon spathula	Paddlefish	E	C2	Reintroduced, Trinity Basin eastward
Scaphirhynchus platorynchus	Shovelnose sturgeon	E		Red River below Dennison Dam
Minnows				
Campostoma ornatum	Mexican stoneroller	T	C2	Rio Grande in Brewester & Presido Cos.
Cyprinella proserpina	Proserpine shiner	T	C2	Devil's & lower Pecos R., nearby creeks
Dionda diaboli	Devil's River minnow	T	C1	Val Verde County creeks
Gila pandora	Rio Grande chub	T		Davis Mountains
Notropis chihuahua	Chihuahua shiner	T	C2	Big Bend region
Notropis hubbsi	Bluehead shiner	T		Caddo Lake
Notropis orca	Phantom shiner	E	3A	Extinct, Rio Grande mouth to El Paso
Notropis simus	Bluntnose shiner	E		Extirpated, upper Rio Grande & Pecos
Suckers				
Cycleptus elongatus	Blue sucker	T	C2	Large rivers statewide
Erimyzon oblongatus	Creek chubsucker	T		Red River south to San Jacinto drainage

Table B3-46. TEXAS THREATENED AND ENDANGERED ANIMALS (continued)

SCIENTIFIC NAME		COMMON NAME	**STATUS** STATE	FEDERAL	OCCURRENCE IN TEXAS
		*** FISHES (cont) ***			
	Catfish				
Satan eurystomus		Widemouth blindcat	T	C2	San Antonio pool of the Edwards Aquifer
Trogloglanis pattersoni		Toothless blindcat	T	C2	San Antonio pool of the Edwards Aquifer
	Killifishes				
Cyprinodon bovinus		Leon Springs pupfish	E	LE	Leon Creek, Pecos County
Cyprinodon elegans		Comanche Springs pupfish	E	LE	Jeff Davis and Reeves Counties
Cyprinodon eximius		Conchos pupfish	T	C2	Devil's R & Rio Grande to Conchos R.
Cyprinodon pecosensis		Pecos pupfish	T	C1	Pecos River tributaries
	Livebearers				
Gambusia gaigei		Big Bend gambusia	E	LE	Big Bend National Park
Gambusia georgei		San Marcos gambusia	E	LE	Extinct, upper San Marcos River
Gambusia heterochir		Clear Creek gambusia	E	LE	Menard Co., headwaters Clear Creek
Gambusia nobilis		Pecos gambusia	E	LE	Jeff Davis, Pecos and Reeves Cos.
Gambusia senilis		Blotched gambusia	E	C2	Devil's River, believed extirpated
	Perches				
Etheostoma fonticola		Fountain darter	E	LE	Upper San Marcos and Comal Rivers
Etheostoma grahami		Rio Grande darter	T	C2	Rio Grande & Pecos R. above Devil's R.
Percina maculata		Blackside darter	E		Red River Basin, northeastern Texas
	Coastal Fishes				
Awaous tajasica		River goby	T		Rio Grande, Hidalgo and Willacy Cos.
Gobionellus atripinnis		Blackfin goby	E		South Texas, lower Rio Grande, estuarine
Microphis brachyurus		Opposum pipefish	T		Rio Grande in Cameron County

Table B3-46. TEXAS THREATENED AND ENDANGERED ANIMALS (continued)

SCIENTIFIC NAME	COMMON NAME	**STATUS** STATE	FEDERAL	OCCURRENCE IN TEXAS
*** INVERTEBRATES ***				
Spiders				
Tartarocreagris texana	Tooth Cave pseudoscorpion		LE	Edwards Plateau
Neoleptoneta myopica	Tooth Cave spider		LE	Edwards Plateau
Texella reddelli	Bee Creek Cave harvestman		LE	Edwards Plateau
Texella reyesi	Bone Cave Harvestman		LE	Edwards Plateau
Insects				
Rhadine persephone	Tooth Cave ground beetle		LE	Edwards Plateau
Texamaurops reddelli	Kretschmarr Cave mold beetle		LE	Edwards Plateau
Batrisodes texanus	Coffin Cave mold beetle		LE	Edwards Plateau

KEY

STATE STATUS:
E = Endangered
T = Threatened

FEDERAL STATUS:
LE = Listed Endangered, LT = Listed Threatened
PT = Proposed Threatened
C1 = Candidate Species (category 1 - awaiting listing)
C2 = Candidate Species (category 2 - awaiting more information)
3A = Removed from list due to extinction
3C = Removed from list due to abundance

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Appendix B - Chapter 4

Draft EIS

Pest Management Program

Appendix B - Chapter Four

Assessment of Surface and Leaching Loss Risks From Chemical Use

1.0 Introduction

The purpose of this project was to assess the potential for off-site movement to occur from application of the ten pesticides used most commonly by the Texas Department of Transportation (TxDOT). Pesticides are effective, useful, and economical chemicals utilized in management of plant and insect disease pest problems. TxDOT field operations require use of herbicides for controlling herbaceous and woody vegetation along roadsides, ditch-banks, right-of-ways, medians, etc., and insecticides for managing nuisance pests encountered near roadside parks, picnic areas, work sites, and TxDOT field operations facilities.

Because of their chemical nature, pesticides may contribute to either point or nonpoint source pollution problems if improperly applied. The cause and effect relationship between pesticide use at a given locale and subsequent detection away from the target site often can be attributed to improper handling or application techniques. Pollution from pesticides may arise from a combination of factors including weather, soils, pesticide characteristics, site characteristics, and management practices employed.

2.0 Pesticide Fate

The fate of a given pesticide in the soil environment must consider all the processes that could potentially affect the chemical's fate and all the factors influencing the various processes in a specific site. Because the processes and their interactions are complex and difficult to characterize experimentally, the use of computer simulation models has proven to be an invaluable tool to simulate the processes occurring under a certain set of chemical, soil, and climatic circumstances.

Pesticides are a highly variable group of chemical compounds. Characteristics which describe their potential to cause pollution of surface or groundwater include solubility, volatility, persistence, toxicity, and the degree to which they are attracted to soil particles and acted on by degradation processes within the soil. Soil properties such as organic matter content, pH, clay content, and cation exchange capacity influence the degradation and ultimate fate of applied pesticides. Pesticides applied to terrestrial environments are degraded by soil microorganisms, temperature, moisture, photolysis, hydrolysis, and biochemical processes within plants and other organisms.

Chemicals which are highly soluble in water are more subject to leaching losses or being carried away in runoff. Those with long persistence or that are less subject to degradation provide a longer time interval for undesirable movement to occur. Pesticides that are strongly adsorbed to soil particles have low leaching potential but may present a greater risk of losses if soil erosion occurs.

3.0 Soils Criteria

Soils are highly variable from one part of the State to another and may vary greatly within a relatively short distance. In some locations, comparisons of soils only a few feet apart reveals major differences. Primary soil characteristics which affect the potential for surface or groundwater pollution to occur when a pesticide is applied are infiltration rate, permeability, cation/anion exchange properties, erodibility, slope of the land, soil texture and thickness, and location or proximity to surface- and groundwater.

For example, coarse-textured, sandy soils offer little filtration or adsorptive capacity for applied chemicals. Where such soils directly overlie shallow aquifers, chemicals must be carefully used. However, when the same soils do not overlie an aquifer, little potential exists for pollution to occur from chemical use. Another example is where fine-textured, clayey soils occur on relatively steep slopes. Such soils have low infiltration rates and applied chemicals may be moved readily in solution or adsorbed to sediment carried into nearby water bodies causing potential pollution problems.

Representative soils were selected for each of the Major Land Resource Areas (MLRAs) in Texas (Figure 1). The most extensive soils (based on acreage extent in the MLRA) and selected contrasting soils were used. A minimum of three soils were selected from each MLRA.

The soils series were selected from the Texas portion of STATSGO (State Soil Geographic Database) which was developed and is maintained by the USDA-Soil Conservation Service in Temple, Texas. It is a part of the most complete soils database for the U.S. The soil series names have been correlated to current series concepts. These may differ slightly from the soil names used in published county soil survey reports, particularly if they are several years old.

4.0 Gleams Computer Simulation Model

The soil/pesticide interaction outcomes presented herein were generated utilizing the GLEAMS (Groundwater Loading Effects of Agricultural Management Systems) computer simulation model. GLEAMS is a state-of-the-art mathematical computer model developed by the USDA-Agricultural Research Service to evaluate the impact of land and agricultural management systems on the potential movement of pesticides and nutrients in surface runoff, sediment, and percolation water (Leonard et al., 1987). GLEAMS consists of a single computer program that integrates soil, hydrology, pesticide, climate, and management characteristics and their interactions to assess potential edge-of-field and bottom-of-the-profile chemical movement.

In the model, pesticide application rates, methods, and timing can be altered to account for management systems to evaluate potential off-site movement. The model accounts for varying soils and climate in determining leaching and surface loss potential. The model traces movement of pesticides present in percolated water, surface runoff, and sediment. Vertical movement of pesticides and plant uptake are simulated with evaporation and transpiration processes. Erosion in overland flow is estimated using a Modified Universal Soil Loss Equation.

A full and complete discussion of GLEAMS and the model components is provided by Leonard et al., 1987. However, for clarification purposes the major model components are listed below:

1) Hydrology
2) Erosion
3) Soil
4) Pesticide
5) Pesticide degradation
6) Pesticide extraction into runoff
7) Pesticide movement within soil profile
8) Pesticide transport with sediment
9) Pesticide evaporation and uptake

5.0 Gleams Application

To insure broadscale adaptability and applicability, the GLEAMS model provides the user with opportunities to customize the simulation with regard to various soil and pesticide input parameters. This enables the user to evaluate simulatenously the influence of several different management systems on the fate of applied pesticides.

5.1 Soils Components

Information regarding soil series characteristics were obtained from the GLM soils data base and listed in Appendix 2. The specific surface area values for the clay in the soil series were based on the mineralogy of the soil series. The following values were utilized:

Mineralogy	Specific Surface Area (m^2/g)
Montmorillonitic	600
Mixed	300
Carbonatic	150
Kaolinitic	50
Siliceous	30

The erosion parameter in GLEAMS uses the modified soil loss equation, A=RxKxLSxVM, where:

A	= rate of soil loss in tons per acre per year
R	= rainfall erosion factor
K	= soil erodibility factor
LS	= length/slope factor
VM	= erosion control factor (vegetative and mechanical measures)

This equation would be used to estimate soil loss on highway construction sites.

The hydrology parameter in GLEAMS requires the Soil Conservation Service Curve Number for antecedent moisture condition number two (SCS CNII). The typical right-of-way section was assumed to resemble the land use of range or pasture land, not contoured, and in good condition. Therefore, using the hydrologic soil group provided by GLM soil, the curve number was determined as follows:

Hydrologic Soil Group	Curve Number
A	39
B	61
C	74
D	80

5.2 Pesticide Component

Pesticides used by TxDOT are applied postemergence, with the largest fraction of the spray intercepted by the foliage of the target species and the remaining fraction encountering the soil surface. A listing of the characteristics of the pesticides most commonly used by TxDOT are shown in Table 1.

Field application procedures followed by TxDOT were mimicked as closely as possible in order to insure model applicability. Labeled use rates for each compound as dictated by the primary target species (as provided by TxDOT - Vegetation Management Operations) were used in the model.

The major use application for the ten pesticides utilized by TxDOT is through spot-spray treatments, which result in less than 5% of the total landscape being treated at a given time. Broadcast methods of application were used to develop the initial outcomes and the spot-spray outcomes were expressed as a broadcast equivalent.

Broadcast applications were structured such that 75% of the application was intercepted by foliage, and 25% intercepted by the soil surface. Spot-spray outcomes were determined on a broadcast equivalent basis, assuming that only 5% of the total area was treated. Both are presented to provide an assessment of the reduction in the potential off-site movement of the spot-spraying technique as compared to broadcast application methods.

5.3 Interpretation

The information and outcomes presented in Appendix 1 involve utilization of important soil characteristics of the selected soils and characteristics of the ten pesticides selected for the study to generate the soil/pesticide/climate interactions for surface runoff, sediment, and leaching loss potentials.

Outcomes from GLEAMS are presented for the selected soils within each individual MLRA. Tables include a 30 year storm summary and the annual average pesticide losses separated into the three components of surface runoff, sediment, and percolation. The total loss (surface runoff + sediment + percolation) is also presented. Within each category, the fate of the pesticide is expressed in units of g/ha and as a percentage of the initially applied pesticide. Outcomes are presented for both broadcast and spot-spray methods, thus providing an alternative comparison.

Maintenance personnel will need to evaluate additional site specific data prior to pesticide application, such as proximity to surface water bodies, depth to aquifers, location of natural areas, potential presence of endangered plant or animal species, and other appropriate considerations which would affect judicious use of a pesticide.

The information provided herein will facilitate selection of application techniques where alternatives are available. Techniques utilizing wicks, rollers, or wipers may provide adequate chemical application for vegetation control, while minimizing soil contact and potential off-site pesticide movement. These precision techniques generally are considered to be greater than 95% efficient in placing the pesticide on the target species. Such adjustments may be necessary to allow usage of a pesticide under certain conditions. In general, the data developed could aid in chemical selection and in recognizing potential pollution problems.

GLEAMS and other computer simulation models, regardless of the level of sophistication, do not provide absolute predictions of pesticide loading rates. The strength of GLEAMS is in its ability to provide comparative analysis of different pesticides and management practices as influenced by soil and climate. When interpreting model applications, decisions should be based on relative comparisons rather than absolute data outputs. For example, does one practice reduce pesticide loss compared to another, or is one pesticide more susceptible to leaching or runoff than another.

Figure 1. Major Land Resource Areas

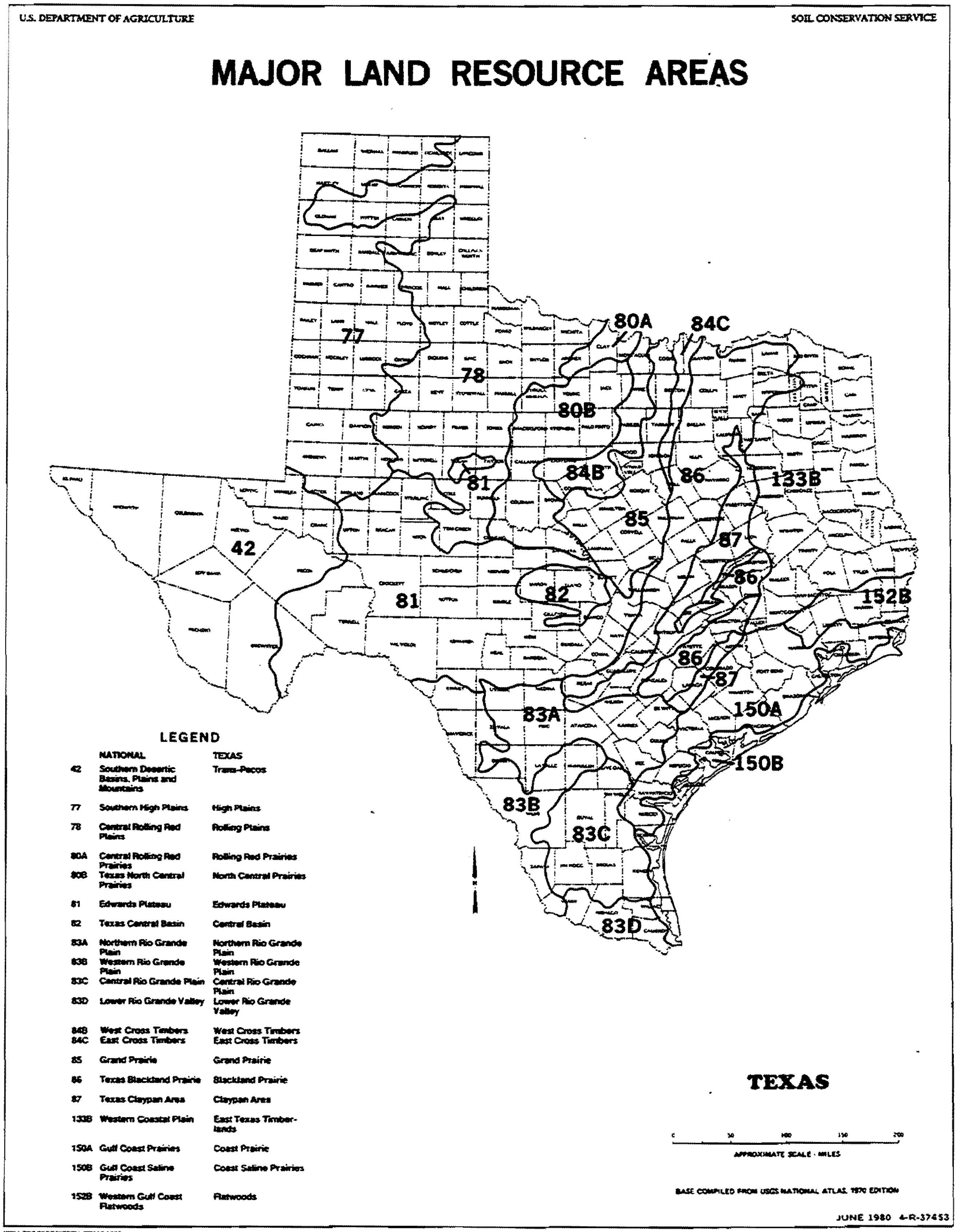

Table 1. Major Land Resource Areas Comprising the Vegetational Areas of Texas

Vegetational Region	Major Land Resource Areas
Pineywoods (1)	133B: East Texas Timberlands 152B: Flatwoods
Gulf Prairies (2) and Marshes	150A: Coast Prairie 150B: Coast Sabine Prairies 83C: Central Rio Grande Plain
Post Oak Savannah (3)	86A: Northern Blackland Prairie 87A: Southern Claypan Area 87B: Northern Claypan Area 133B: East Texas Timberlands
Blackland Prairies (4)	86B: Southern Blackland Prairie 87A: Southern Claypan Area
Cross Timbers (5) and Prairies	80A: Rolling Red Prairie 80B: North Central Prairie 84B: West Cross Timbers 84C: East Cross Timbers 85: Grand Prairie
South Texas Plains (6)	83A: Northern Rio Grand Plain 83B: Western Rio Grande Plain 83C: Central Rio Grand Plain 83D: Lower Rio Grand Valley
Edwards Plateau (7)	81A: Western Edwards Plateau 81B: Central Edwards Plateau 81C: Eastern Edwards Plateau 82: Central Basin
Rolling Plains (8)	78A: Rolling Plains, Northern Part 78B: Rolling Plains, Western Part 78C: Rolling Plains, Eastern Part 78D: Rolling Limestone Prairie
High Plains (9)	77A: High Plains, Northern Part 77B: High Plains, Northwestern Part 77C: High Plains, Southern Part 77D: High Plains, Southwestern Part
Trans-Pecos (10)	42: Trans-Pecos 81A: Western Edwards Plateau

Table 2. Pesticide Characteristics

Pesticide		Soil Half-life[1] (days)	Foliar Residue Half-life[1] (days)	Solubility[2] (ppm)	Vapor Pressure[3] (mm Hg)	Organic Carbon Partition Coefficient[4] - K_{oc}
Common name	Trade name					
Herbicides						
Clopyralid	Transline	40	2.0	300,000	1.3×10^{-5}	6
Glyphosate	Roundup	47	2.5	900,000	1.9×10^{-7}	24,000
Hexazinone	Velpar	90	30.0	3,300	2.0×10^{-7}	54
Imazapyr acid	Arsenal	90	30.0	11,000	2.0×10^{-7}	100
Metsulfuron methyl	Escort	30	30.0	9,500 @ pH 7.0	5.8×10^{-6}	35
Sulfometuron methyl	Oust	28	10.0	70 @ pH 7.0	5.5×10^{-16}	78
Triclopyr amine	Garlon-3	46	15.0	2,100,000	1.3×10^{-6}	20
Triclopyr ester	Garlon-4	46	15.0	23	---	780
Insecticides						
Chlorpyrifos	Dursban	30	3.3	0.4	1.9×10^{-5}	6070
Diazinon	Diazinon	40	4.0	60	4.1×10^{-4}	1000
Fenoxycarb	Logic	1	0.1	6	1.7×10^{-7}	1000

[1] Half-life is a measure of the degradation rate in days.

[2] Solubility is a measure of the extent to which a chemical will dissolve in water, usually expressed as the maximum amount of chemical which will dissolve in a specific volume at a specified temperature and pH. Highly soluble chemicals may be rapidly leached from soils and surfaces and are generally mobile in groundwater. The pH of water can dramatically affect the solubility of a weak acid or weak

base, or the salt of a weak acid or weak base. Organic chemicals have characteristic water solubility, which will change only slightly with temperature. The solubility of an inorganic compound, on the other hand, is highly dependent on the valence state of the element and on the chemistry of the surrounding medium.

[3] Volatilization is the process by which a compound evaporates from a condensed (solid or liquid) phase. Volatilization may occur from surface waters, aqueous spray solutions, shallow soils, and plant surfaces. The tendency of a chemical to volatilize from a spill of the pure material or water can be estimated from the chemical's vapor pressure and its Henry's law constant. Volatilization from spills and surface waters is affected by turbulence, wind speed and temperature. The extent to which a chemical will volatilize from soils depends on the moisture content of the soil and the relative partitioning of the chemical among the soil-water, gas and solid phases.

[4] A reflection of the propensity of an organic chemical to adsorb to the organic matter found in soil or sediment. By extension, the K_{oc} can be used to determine whether a chemical is likely to migrate through the soil and sediment. The K_{oc} may be calculated from an experimentally determined soil-water distribution coefficient or may be estimated from the chemical's water solubility or K_{ow}. The normal range of K_{oc} values for all organic chemicals is from 1 to 10^7 (log K_{oc} = 0 to 7) with higher values indicating greater adsorption potential and lower values indicating a tendency to migrate with any infiltrating groundwater.

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MLRA 42

Soil Series: Brewster

30 Year Storm Summary

1464	storms produced	885.87	cm. of rainfall
63	storms produced	26.40	cm. of runoff
39	storms produced	48.14	cm. of percolation
63	storms produced	75.00	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0003	0.00	0.0000	0.0000	0.00	0.0000	2.8356	0.00	0.1418	2.8360	0.00	0.1418
Glyphosate	0.4650	0.02	0.0233	3.7360	0.14	0.1868	0.0000	0.00	0.0000	4.2010	0.16	0.2101
Hexazinone	0.7223	0.02	0.0361	0.0138	0.00	0.0007	52.6611	1.14	2.6331	53.3972	1.16	2.6699
Imazapyr Acid	1.4242	0.06	0.0712	0.0491	0.00	0.0025	11.1646	0.48	0.5582	12.6379	0.54	0.6319
Metsulfuron-Meth	0.0027	0.00	0.0001	0.0000	0.00	0.0000	0.2312	0.28	0.0116	0.2340	0.28	0.0117
Sulfometuron-Met	0.0125	0.01	0.0006	0.0003	0.00	0.0000	0.0240	0.02	0.0012	0.0368	0.03	0.0018
Triclopyr Amine	0.0138	0.00	0.0007	0.0001	0.00	0.0000	13.0269	1.13	0.6513	13.0408	1.13	0.6520
Clorpyrifos	0.4400	0.04	0.0220	0.8986	0.08	0.0449	0.0000	0.00	0.0000	1.3386	0.12	0.0669
Diazinon	0.8485	0.15	0.0424	0.2858	0.05	0.0143	0.0009	0.00	0.0000	1.1351	0.20	0.0568
Fenoxycarb	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000

MLRA 42

Soil Series: Delnorte

30 Year Storm Summary

1464	storms produced	885.87	cm. of rainfall
33	storms produced	10.18	cm. of runoff
0	storms produced	0.00	cm. of percolation
33	storms produced	28.62	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0000	0.00	0.0000	0.00	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Glyphosate	0.4030	0.02	0.0201	1.2093	0.05	0.0605	0.00	0.00	0.0000	1.6123	0.07	0.0806
Hexazinone	0.0059	0.00	0.0003	7.00E-05	0.00	0.0000	0.0000	0.00	0.0000	0.0060	0.00	0.0003
Imazapyr Acid	0.0183	0.00	0.0009	3.57E-04	0.00	0.0000	0.0000	0.00	0.0000	0.0186	0.00	0.0009
Metsulfuron-Meth	0.0000	0.00	0.0000	0.00E+00	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Sulfometuron-Met	0.0001	0.00	0.0000	3.33E-06	0.00	0.0000	0.0000	0.00	0.0000	0.0001	0.00	0.0000
Triclopyr Amine	0.0001	0.00	0.0000	0.00E+00	0.00	0.0000	0.0000	0.00	0.0000	0.0001	0.00	0.0000
Clorpyrifos	0.2952	0.03	0.0148	0.2267	0.02	0.0113	0.0000	0.00	0.0000	0.5218	0.05	0.0261
Diazinon	0.1744	0.03	0.0087	0.0226	0.00	0.0011	0.0000	0.00	0.0000	0.1971	0.03	0.0099
Fenoxycarb	0.0000	0.00	0.0000	0.00	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000

MLRA 42

Soil Series: Reagan

30 Year Storm Summary

1464	storms produced	885.87	cm. of rainfall
12	storms produced	1.02	cm. of runoff
2	storms produced	1.11	cm. of percolation
12	storms produced	0.17	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0001	0.00	0.0000	0.0001	0.00	0.0000
Glyphosate	0.0255	0.06	0.0013	0.0108	0.06	0.0005	0.0000	0.00	0.0000	0.0363	0.11	0.0018
Hexazinone	0.0002	0.05	0.0000	0.0000	0.00	0.0000	0.0181	1.86	0.0009	0.0183	1.90	0.0009
Imazapyr Acid	0.0011	0.17	0.0001	0.0000	0.00	0.0000	0.0029	0.83	0.0001	0.0040	1.00	0.0002
Metsulfuron-Meth	0.0000	0.01	0.0000	0.0000	0.00	0.0000	0.0000	0.42	0.0000	0.0000	0.43	0.0000
Sulfometuron-Met	0.0000	0.07	0.0000	0.0000	0.00	0.0000	0.0000	0.06	0.0000	0.0000	0.12	0.0000
Triclopyr Amine	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0022	1.41	0.0001	0.0022	1.41	0.0001
Clorpyrifos	0.0190	0.15	0.0010	0.0021	0.04	0.0001	0.0000	0.00	0.0000	0.0211	0.19	0.0011
Diazinon	0.0168	0.43	0.0008	0.0003	0.02	0.0000	0.0000	0.00	0.0000	0.0171	0.45	0.0009
Fenoxycarb	0.0000	0.01	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.01	0.0000

MLRA 42

Soil Series: Reakor

30 Year Storm Summary

1464	storms produced	885.87	cm. of rainfall
13	storms produced	1.43	cm. of runoff
3	storms produced	2.24	cm. of percolation
13	storms produced	0.44	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0002	0.00	0.0000	0.0002	0.00	0.0000
Glyphosate	0.0512	0.00	0.0026	0.0201	0.00	0.0010	0.0000	0.00	0.0000	0.0713	0.00	0.0036
Hexazinone	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0627	0.00	0.0031	0.0628	0.00	0.0031
Imazapyr Acid	0.0002	0.00	0.0000	0.0000	0.00	0.0000	0.0126	0.00	0.0006	0.0127	0.00	0.0006
Metsulfuron-Meth	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Sulfometuron-Met	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Triclopyr Amine	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0093	0.00	0.0005	0.0093	0.00	0.0005
Clorpyrifos	0.0304	0.00	0.0015	0.0031	0.00	0.0002	0.0000	0.00	0.0000	0.0336	0.00	0.0017
Diazinon	0.0112	0.00	0.0006	0.0002	0.00	0.0000	0.0000	0.00	0.0000	0.0114	0.00	0.0006
Fenoxycarb	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000

MLRA 77A

Soil Series: Darrouzett

30 Year Storm Summary

2098	storms produced	1332.10	cm. of rainfall
55	storms produced	18.80	cm. of runoff
0	storms produced	0.00	cm. of percolation
55	storms produced	2.88	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0004	0.00	0.0000	0.00	0.00	0.0000	0.0000	0.00	0.0000	0.0004	0.00	0.0000
Glyphosate	0.5733	0.02	0.0287	0.2989	0.01	0.0149	0.0000	0.00	0.0000	0.8721	0.03	0.0436
Hexazinone	0.9065	0.02	0.0453	0.0016	0.00	0.0001	0.0000	0.00	0.0000	0.9080	0.02	0.0454
Imazapyr Acid	1.5851	0.07	0.0793	0.0046	0.00	0.0002	0.0000	0.00	0.0000	1.5897	0.07	0.0795
Metsulfuron-Meth	0.0041	0.00	0.0002	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0041	0.00	0.0002
Sulfometuron-Met	0.0196	0.02	0.0010	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0197	0.02	0.0010
Triclopyr Amine	0.0168	0.00	0.0008	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0168	0.00	0.0008
Clorpyrifos	0.7726	0.07	0.0386	0.1000	0.01	0.0050	0.0000	0.00	0.0000	0.8726	0.08	0.0436
Diazinon	1.2580	0.22	0.0629	0.0275	0.00	0.0014	0.0000	0.00	0.0000	1.2855	0.22	0.0643
Fenoxycarb	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000

MLRA 77A

Soil Series: Sherm

30 Year Storm Summary

2098	storms produced	1332.10	cm. of rainfall
106	storms produced	33.43	cm. of runoff
6	storms produced	2.41	cm. of percolation
106	storms produced	2.33	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0020	0.00	0.0001	0.00	0.00	0.0000	0.0004	0.00	0.0000	0.0024	0.00	0.0001
Glyphosate	1.1718	0.05	0.0586	0.2313	0.01	0.0116	0.0000	0.00	0.0000	1.4031	0.06	0.0702
Hexazinone	1.9304	0.04	0.0965	0.0011	0.00	0.0001	0.0073	0.00	0.0004	1.9388	0.04	0.0969
Imazapyr Acid	3.2882	0.14	0.1644	0.0034	0.00	0.0002	0.0008	0.00	0.0000	3.2924	0.14	0.1646
Metsulfuron-Meth	0.0099	0.01	0.0005	0.0000	0.00	0.0000	0.0001	0.00	0.0000	0.0099	0.01	0.0005
Sulfometuron-Met	0.0443	0.04	0.0022	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0443	0.04	0.0022
Triclopyr Amine	0.0483	0.00	0.0024	0.0000	0.00	0.0000	0.0025	0.00	0.0001	0.0507	0.00	0.0025
Clorpyrifos	1.5091	0.13	0.0755	0.0742	0.01	0.0037	0.0000	0.00	0.0000	1.5833	0.14	0.0792
Diazinon	2.1794	0.38	0.1090	0.0181	0.00	0.0009	0.0000	0.00	0.0000	2.1975	0.38	0.1099
Fenoxycarb	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0001	0.00	0.0000

MLRA 77A

Soil Series: Conlen

30 Year Storm Summary

2098	storms produced	1332.10	cm. of rainfall
10	storms produced	1.91	cm. of runoff
1	storms produced	4.17	cm. of percolation
10	storms produced	0.52	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0000	0.00	0.0000	0.00	0.00	0.0000	0.0174	0.00	0.0009	0.0174	0.00	0.0009
Glyphosate	0.0806	0.00	0.0040	0.0689	0.00	0.0034	0.0000	0.00	0.0000	0.1495	0.00	0.0075
Hexazinone	0.0034	0.00	0.0002	0.0000	0.00	0.0000	0.1632	0.00	0.0082	0.1666	0.00	0.0083
Imazapyr Acid	0.0258	0.00	0.0013	0.0001	0.00	0.0000	0.0157	0.00	0.0008	0.0415	0.00	0.0021
Metsulfuron-Meth	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0015	0.00	0.0001	0.0015	0.00	0.0001
Sulfometuron-Met	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0001	0.00	0.0000	0.0002	0.00	0.0000
Triclopyr Amine	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0912	0.01	0.0046	0.0912	0.01	0.0046
Clorpyrifos	0.1131	0.01	0.0057	0.0239	0.00	0.0012	0.0000	0.00	0.0000	0.1369	0.01	0.0068
Diazinon	0.1449	0.03	0.0072	0.0052	0.00	0.0003	0.0000	0.00	0.0000	0.1500	0.03	0.0075
Fenoxycarb	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000

MLRA 77B

Soil Series: Dallam

30 Year Storm Summary

2098	storms produced	1332.10	cm. of rainfall
10	storms produced	1.70	cm. of runoff
1	storms produced	5.00	cm. of percolation
10	storms produced	0.55	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0000	0.00	0.0000	0.00	0.00	0.0000	0.0271	0.00	0.0014	0.0271	0.00	0.0014
Glyphosate	0.1337	0.01	0.0067	0.0747	0.00	0.0037	0.0000	0.00	0.0000	0.2084	0.01	0.0104
Hexazinone	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.6833	0.01	0.0342	0.6834	0.01	0.0342
Imazapyr Acid	0.0010	0.00	0.0000	0.0000	0.00	0.0000	0.1546	0.01	0.0077	0.1556	0.01	0.0078
Metsulfuron-Meth	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0052	0.01	0.0003	0.0052	0.01	0.0003
Sulfometuron-Met	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0009	0.00	0.0000	0.0009	0.00	0.0000
Triclopyr Amine	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.1959	0.02	0.0098	0.1959	0.02	0.0098
Clorpyrifos	0.1550	0.01	0.0078	0.0214	0.00	0.0011	0.0000	0.00	0.0000	0.1764	0.01	0.0088
Diazinon	0.0760	0.01	0.0038	0.0018	0.00	0.0001	0.0000	0.00	0.0000	0.0778	0.01	0.0039
Fenoxycarb	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000

MLRA 77B

Soil Series: Lincoln

30 Year Storm Summary

2098	storms produced	1332.10	cm. of rainfall
0	storms produced	0.00	cm. of runoff
0	storms produced	0.00	cm. of percolation
0	storms produced	0.00	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Glyphosate	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Hexazinone	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Imazapyr Acid	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Metsulfuron-Meth	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Sulfometuron-Met	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Triclopyr Amine	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Clorpyrifos	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Diazinon	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Fenoxycarb	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000

MLRA 77B

Soil Series: Vingo

30 Year Storm Summary

2098	storms produced	1332.10	cm. of rainfall
12	storms produced	2.09	cm. of runoff
1	storms produced	1.58	cm. of percolation
12	storms produced	1.09	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0176	0.00	0.0009	0.0176	0.00	0.0009
Glyphosate	0.1513	0.01	0.0076	0.1195	0.00	0.0060	0.0000	0.00	0.0000	0.2708	0.01	0.0135
Hexazinone	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.1221	0.00	0.0061	0.1223	0.00	0.0061
Imazapyr Acid	0.0016	0.00	0.0001	0.0000	0.00	0.0000	0.0113	0.00	0.0006	0.0129	0.00	0.0006
Metsulfuron-Meth	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0014	0.00	0.0001	0.0014	0.00	0.0001
Sulfometuron-Met	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0001	0.00	0.0000	0.0001	0.00	0.0000
Triclopyr Amine	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0824	0.01	0.0041	0.0824	0.01	0.0041
Clorpyrifos	0.1798	0.02	0.0090	0.0352	0.00	0.0018	0.0000	0.00	0.0000	0.2150	0.02	0.0107
Diazinon	0.1030	0.02	0.0052	0.0035	0.00	0.0002	0.0000	0.00	0.0000	0.1065	0.02	0.0053
Fenoxycarb	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000

MLRA 77C

Soil Series: Amarillo

30 Year Storm Summary

2853	storms produced	1459.48	cm. of rainfall
10	storms produced	6.20	cm. of runoff
3	storms produced	4.18	cm. of percolation
10	storms produced	1.37	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0342	0.00	0.0017	0.0342	0.00	0.0017
Glyphosate	0.3428	0.01	0.0171	0.0807	0.01	0.0040	0.0000	0.00	0.0000	0.4235	0.02	0.0212
Hexazinone	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.6044	0.01	0.0302	0.6045	0.01	0.0302
Imazapyr Acid	0.0008	0.00	0.0000	0.0000	0.00	0.0000	0.1538	0.01	0.0077	0.1546	0.01	0.0077
Metsulfuron-Meth	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0059	0.01	0.0003	0.0059	0.01	0.0003
Sulfometuron-Met	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0023	0.00	0.0001	0.0023	0.00	0.0001
Triclopyr Amine	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.1536	0.01	0.0077	0.1536	0.01	0.0077
Clorpyrifos	0.3236	0.03	0.0162	0.0195	0.01	0.0010	0.0000	0.00	0.0000	0.3432	0.04	0.0172
Diazinon	0.0650	0.01	0.0033	0.0008	0.00	0.0000	0.0000	0.00	0.0000	0.0659	0.01	0.0033
Fenoxycarb	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000

MLRA 77C

Soil Series: Pullman

30 Year Storm Summary

2853	storms produced	1459.48	cm. of rainfall
109	storms produced	49.17	cm. of runoff
0	storms produced	0.00	cm. of percolation
109	storms produced	3.62	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0021	0.00	0.0001	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0021	0.00	0.0001
Glyphosate	1.3206	0.05	0.0660	0.2894	0.01	0.0145	0.0000	0.00	0.0000	1.6100	0.06	0.0805
Hexazinone	2.3019	0.05	0.1151	0.0015	0.00	0.0001	0.0000	0.00	0.0000	2.3034	0.05	0.1152
Imazapyr Acid	3.8129	0.16	0.1906	0.0043	0.00	0.0002	0.0000	0.00	0.0000	3.8172	0.16	0.1909
Metsulfuron-Meth	0.0120	0.01	0.0006	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0120	0.01	0.0006
Sulfometuron-Met	0.0615	0.06	0.0031	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0615	0.06	0.0031
Triclopyr Amine	0.0565	0.00	0.0028	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0566	0.00	0.0028
Clorpyrifos	1.6371	0.14	0.0819	0.0899	0.01	0.0045	0.0000	0.00	0.0000	1.7270	0.15	0.0863
Diazinon	2.3735	0.41	0.1187	0.0223	0.00	0.0011	0.0000	0.00	0.0000	2.3958	0.41	0.1198
Fenoxycarb	0.0011	0.01	0.0001	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0011	0.01	0.0001

MLRA 77C

Soil Series: Springer

30 Year Storm Summary

2853	storms produced	1459.48	cm. of rainfall
10	storms produced	6.52	cm. of runoff
0	storms produced	0.00	cm. of percolation
10	storms produced	2.32	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Glyphosate	0.0226	0.00	0.0011	0.0004	0.00	0.0000	0.0000	0.00	0.0000	0.0230	0.00	0.0012
Hexazinone	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Imazapyr Acid	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Metsulfuron-Meth	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Sulfometuron-Met	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Triclopyr Amine	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Clorpyrifos	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0001	0.00	0.0000
Diazinon	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Fenoxycarb	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000

MLRA 77D

Soil Series: Jalmar

30 Year Storm Summary

2292	storms produced	1379.38	cm. of rainfall
0	storms produced	0.00	cm. of runoff
7	storms produced	10.90	cm. of percolation
0	storms produced	0.00	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.3404	0.00	0.0170	0.3404	0.00	0.0170
Glyphosate	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Hexazinone	0.0000	0.00	0.0000	0.0000	0.00	0.0000	2.9866	0.06	0.1493	2.9866	0.06	0.1493
Imazapyr Acid	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.4368	0.02	0.0218	0.4368	0.02	0.0218
Metsulfuron-Meth	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0372	0.04	0.0019	0.0372	0.04	0.0019
Sulfometuron-Met	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0025	0.00	0.0001	0.0025	0.00	0.0001
Triclopyr Amine	0.0000	0.00	0.0000	0.0000	0.00	0.0000	1.2619	0.11	0.0631	1.2619	0.11	0.0631
Clorpyrifos	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Diazinon	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Fenoxycarb	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000

MLRA 77D

Soil Series: Penwell

30 Year Storm Summary

2292	storms produced	1379.38	cm. of rainfall
0	storms produced	0.00	cm. of runoff
4	storms produced	4.15	cm. of percolation
0	storms produced	0.00	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.4393	0.00	0.0220	0.4393	0.00	0.0220
Glyphosate	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Hexazinone	0.0000	0.00	0.0000	0.0000	0.00	0.0000	6.6190	0.14	0.3309	6.6190	0.14	0.3309
Imazapyr Acid	0.0000	0.00	0.0000	0.0000	0.00	0.0000	1.5058	0.07	0.0753	1.5058	0.07	0.0753
Metsulfuron-Meth	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0657	0.08	0.0033	0.0657	0.08	0.0033
Sulfometuron-Met	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0101	0.01	0.0005	0.0101	0.01	0.0005
Triclopyr Amine	0.0000	0.00	0.0000	0.0000	0.00	0.0000	1.9279	0.17	0.0964	1.9279	0.17	0.0964
Clorpyrifos	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Diazinon	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Fenoxycarb	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000

MLRA 77D

Soil Series: Triomas

30 Year Storm Summary

2292	storms produced	1379.38	cm. of rainfall
18	storms produced	2.08	cm. of runoff
15	storms produced	16.15	cm. of percolation
18	storms produced	0.67	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.2677	0.00	0.0134	0.2677	0.00	0.0134
Glyphosate	0.1656	0.01	0.0083	0.1255	0.00	0.0063	0.0000	0.00	0.0000	0.2911	0.01	0.0146
Hexazinone	0.0003	0.00	0.0000	0.0000	0.00	0.0000	1.4404	0.03	0.0720	1.4407	0.03	0.0720
Imazapyr Acid	0.0029	0.00	0.0001	0.0000	0.00	0.0000	0.1487	0.01	0.0074	0.1516	0.01	0.0076
Metsulfuron-Meth	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0120	0.01	0.0006	0.0120	0.01	0.0006
Sulfometuron-Met	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0004	0.00	0.0000	0.0004	0.00	0.0000
Triclopyr Amine	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.8411	0.07	0.0421	0.8411	0.07	0.0421
Clorpyrifos	0.1913	0.02	0.0096	0.0351	0.00	0.0018	0.0000	0.00	0.0000	0.2264	0.02	0.0113
Diazinon	0.1202	0.02	0.0060	0.0037	0.00	0.0002	0.0000	0.00	0.0000	0.1239	0.02	0.0062
Fenoxycarb	0.0004	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0004	0.00	0.0000

MLRA 77E

Soil Series: Berda

30 Year Storm Summary

2098	storms produced	1332.10	cm. of rainfall
12	storms produced	2.32	cm. of runoff
1	storms produced	4.43	cm. of percolation
12	storms produced	8.26	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0229	0.00	0.0011	0.0229	0.00	0.0011
Glyphosate	0.1783	0.01	0.0089	0.8742	0.03	0.0437	0.0000	0.00	0.0000	1.0525	0.04	0.0526
Hexazinone	0.0002	0.00	0.0000	0.0000	0.00	0.0000	0.3477	0.01	0.0174	0.3479	0.01	0.0174
Imazapyr Acid	0.0017	0.00	0.0001	0.0000	0.00	0.0000	0.0482	0.00	0.0024	0.0500	0.00	0.0025
Metsulfuron-Meth	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0032	0.00	0.0002	0.0032	0.00	0.0002
Sulfometuron-Met	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0003	0.00	0.0000	0.0003	0.00	0.0000
Triclopyr Amine	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.1430	0.01	0.0071	0.1430	0.01	0.0071
Clorpyrifos	0.2079	0.02	0.0104	0.2560	0.02	0.0128	0.0000	0.00	0.0000	0.4639	0.04	0.0232
Diazinon	0.1082	0.02	0.0054	0.0222	0.00	0.0011	0.0000	0.00	0.0000	0.1304	0.02	0.0065
Fenoxycarb	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000

MLRA 77E

Soil Series: Mobeetie

30 Year Storm Summary

2098	storms produced	1332.10	cm. of rainfall
11	storms produced	1.93	cm. of runoff
2	storms produced	1.10	cm. of percolation
11	storms produced	7.90	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0183	0.00	0.0009	0.0183	0.00	0.0009
Glyphosate	0.1846	0.01	0.0092	0.7795	0.03	0.0390	0.0000	0.00	0.0000	0.9641	0.04	0.0482
Hexazinone	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.3871	0.01	0.0194	0.3871	0.01	0.0194
Imazapyr Acid	0.0003	0.00	0.0000	0.0000	0.00	0.0000	0.0789	0.00	0.0039	0.0792	0.00	0.0040
Metsulfuron-Meth	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0041	0.01	0.0002	0.0041	0.01	0.0002
Sulfometuron-Met	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0005	0.00	0.0000	0.0005	0.00	0.0000
Triclopyr Amine	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.1234	0.01	0.0062	0.1234	0.01	0.0062
Clorpyrifos	0.1933	0.02	0.0097	0.2048	0.02	0.0102	0.0000	0.00	0.0000	0.3982	0.04	0.0199
Diazinon	0.0608	0.01	0.0030	0.0109	0.00	0.0005	0.0000	0.00	0.0000	0.0717	0.01	0.0036
Fenoxycarb	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000

MLRA 77E

Soil Series: Potter

30 Year Storm Summary

2098	storms produced	1332.10	cm. of rainfall
48	storms produced	15.41	cm. of runoff
2	storms produced	5.13	cm. of percolation
48	storms produced	43.10	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.2410	0.00	0.0121	0.2411	0.00	0.0121
Glyphosate	1.2841	0.05	0.0642	3.8288	0.15	0.1914	0.0000	0.00	0.0000	5.1129	0.20	0.2556
Hexazinone	0.0177	0.00	0.0009	0.0001	0.00	0.0000	5.9831	0.13	0.2992	6.0010	0.13	0.3001
Imazapyr Acid	0.0585	0.00	0.0029	0.0008	0.00	0.0000	1.4941	0.06	0.0747	1.5535	0.06	0.0777
Metsulfuron-Meth	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0670	0.08	0.0034	0.0671	0.08	0.0034
Sulfometuron-Met	0.0005	0.00	0.0000	0.0000	0.00	0.0000	0.0132	0.01	0.0007	0.0138	0.01	0.0007
Triclopyr Amine	0.0003	0.00	0.0000	0.0000	0.00	0.0000	1.6300	0.14	0.0815	1.6304	0.14	0.0815
Clorpyrifos	1.2723	0.11	0.0636	0.9623	0.08	0.0481	0.0000	0.00	0.0000	2.2346	0.19	0.1117
Diazinon	0.5168	0.09	0.0258	0.0645	0.01	0.0032	0.0000	0.00	0.0000	0.5813	0.10	0.0291
Fenoxycarb	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000

MLRA 78A

Soil Series: Burson

30 Year Storm Summary

2098	storms produced	1332.10	cm. of rainfall
41	storms produced	11.97	cm. of runoff
20	storms produced	27.20	cm. of percolation
41	storms produced	42.20	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0000	0.00	0.0000	0.0000	0.00	0.0000	5.0220	0.00	0.2511	5.0220	0.00	0.2511
Glyphosate	0.7749	0.03	0.0387	3.8804	0.15	0.1940	0.0000	0.00	0.0000	4.6553	0.18	0.2328
Hexazinone	0.0311	0.00	0.0016	0.0004	0.00	0.0000	37.7427	0.82	1.8871	37.7743	0.82	1.8887
Imazapyr Acid	0.1060	0.00	0.0053	0.0025	0.00	0.0001	6.5383	0.28	0.3269	6.6468	0.28	0.3323
Metsulfuron-Meth	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.5711	0.69	0.0286	0.5712	0.69	0.0286
Sulfometuron-Met	0.0010	0.00	0.0001	0.0000	0.00	0.0000	0.0983	0.10	0.0049	0.0994	0.10	0.0050
Triclopyr Amine	0.0004	0.00	0.0000	0.0000	0.00	0.0000	16.1771	1.40	0.8089	16.1775	1.40	0.8089
Clorpyrifos	0.8512	0.07	0.0426	1.0788	0.09	0.0539	0.0000	0.00	0.0000	1.9300	0.16	0.0965
Diazinon	0.5268	0.09	0.0263	0.1101	0.02	0.0055	0.0000	0.00	0.0000	0.6369	0.11	0.0318
Fenoxycarb	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000

MLRA 78A

Soil Series: Quay

30 Year Storm Summary

2098	storms produced	1332.10	cm. of rainfall
10	storms produced	1.71	cm. of runoff
1	storms produced	2.15	cm. of percolation
10	storms produced	2.45	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0135	0.00	0.0007	0.0135	0.00	0.0007
Glyphosate	0.1686	0.01	0.0084	0.2566	0.01	0.0128	0.0000	0.00	0.0000	0.4251	0.02	0.0213
Hexazinone	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.3676	0.01	0.0184	0.3676	0.01	0.0184
Imazapyr Acid	0.0003	0.00	0.0000	0.0000	0.00	0.0000	0.0954	0.00	0.0048	0.0957	0.00	0.0048
Metsulfuron-Meth	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0031	0.00	0.0002	0.0031	0.00	0.0002
Sulfometuron-Met	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0006	0.00	0.0000	0.0006	0.00	0.0000
Triclopyr Amine	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0939	0.01	0.0047	0.0939	0.01	0.0047
Clorpyrifos	0.1708	0.01	0.0085	0.0649	0.01	0.0032	0.0000	0.00	0.0000	0.2357	0.02	0.0118
Diazinon	0.0466	0.01	0.0023	0.0031	0.00	0.0002	0.0000	0.00	0.0000	0.0497	0.01	0.0025
Fenoxycarb	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000

MLRA 78A

Soil Series: Springer

30 Year Storm Summary

2098	storms produced	1332.10	cm. of rainfall
12	storms produced	2.06	cm. of runoff
2	storms produced	0.88	cm. of percolation
12	storms produced	0.99	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0159	0.00	0.0008	0.0159	0.00	0.0008
Glyphosate	0.0271	0.01	0.0014	0.0002	0.01	0.0000	0.0000	0.00	0.0000	0.0273	0.02	0.0014
Hexazinone	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.8840	0.01	0.0442	0.8840	0.01	0.0442
Imazapyr Acid	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.4188	0.00	0.0209	0.4188	0.00	0.0209
Metsulfuron-Meth	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0079	0.00	0.0004	0.0079	0.00	0.0004
Sulfometuron-Met	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0033	0.00	0.0002	0.0033	0.00	0.0002
Triclopyr Amine	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.1486	0.01	0.0074	0.1486	0.01	0.0074
Clorpyrifos	0.0005	0.01	0.0000	0.0000	0.01	0.0000	0.0000	0.00	0.0000	0.0005	0.02	0.0000
Diazinon	0.0000	0.01	0.0000	0.0000	0.00	0.0000	0.0072	0.00	0.0004	0.0072	0.01	0.0004
Fenoxycarb	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000

MLRA 78B

Soil Series: Knoco

30 Year Storm Summary

1257	storms produced	1598.21	cm. of rainfall
177	storms produced	51.83	cm. of runoff
100	storms produced	7.71	cm. of percolation
177	storms produced	127.08	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0087	0.00	0.0004	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0087	0.00	0.0004
Glyphosate	1.2968	0.05	0.0648	8.7091	0.34	0.4355	0.0000	0.00	0.0000	10.0059	0.39	0.5003
Hexazinone	3.0764	0.07	0.1538	0.0453	0.00	0.0023	0.0011	0.00	0.0001	3.1228	0.07	0.1561
Imazapyr Acid	4.3774	0.19	0.2189	0.1178	0.01	0.0059	0.0000	0.00	0.0000	4.4952	0.20	0.2248
Metsulfuron-Meth	0.0199	0.02	0.0010	0.0002	0.00	0.0000	0.0000	0.00	0.0000	0.0200	0.02	0.0010
Sulfometuron-Met	0.0789	0.08	0.0039	0.0016	0.00	0.0001	0.0000	0.00	0.0000	0.0805	0.08	0.0040
Triclopyr Amine	0.1200	0.01	0.0060	0.0007	0.00	0.0000	0.0001	0.00	0.0000	0.1208	0.01	0.0060
Clorpyrifos	1.6768	0.15	0.0838	2.8167	0.25	0.1408	0.0000	0.00	0.0000	4.4935	0.40	0.2247
Diazinon	2.4312	0.42	0.1216	0.6684	0.12	0.0334	0.0000	0.00	0.0000	3.0996	0.54	0.1550
Fenoxycarb	0.0036	0.02	0.0002	0.0010	0.00	0.0000	0.0000	0.00	0.0000	0.0046	0.02	0.0002

MLRA 78B

Soil Series: Miles

30 Year Storm Summary

1257	storms produced	1598.21	cm. of rainfall
15	storms produced	3.85	cm. of runoff
16	storms produced	13.12	cm. of percolation
15	storms produced	1.94	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0462	0.00	0.0023	0.0462	0.00	0.0023
Glyphosate	0.1684	0.01	0.0084	0.1295	0.01	0.0065	0.0000	0.00	0.0000	0.2979	0.02	0.0149
Hexazinone	0.0003	0.00	0.0000	0.0000	0.00	0.0000	0.7101	0.02	0.0355	0.7104	0.02	0.0355
Imazapyr Acid	0.0013	0.00	0.0001	0.0000	0.00	0.0000	0.1339	0.01	0.0067	0.1352	0.01	0.0068
Metsulfuron-Meth	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0027	0.00	0.0001	0.0027	0.00	0.0001
Sulfometuron-Met	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0003	0.00	0.0000	0.0003	0.00	0.0000
Triclopyr Amine	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.2419	0.02	0.0121	0.2419	0.02	0.0121
Clorpyrifos	0.1502	0.01	0.0075	0.0328	0.00	0.0016	0.0000	0.00	0.0000	0.1830	0.01	0.0091
Diazinon	0.0572	0.01	0.0029	0.0022	0.00	0.0001	0.0000	0.00	0.0000	0.0594	0.01	0.0030
Fenoxycarb	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0001	0.00	0.0000

MLRA 78B

Soil Series: Quinlan

30 Year Storm Summary

1257	storms produced	1598.21	cm. of rainfall
82	storms produced	18.61	cm. of runoff
11	storms produced	10.84	cm. of percolation
82	storms produced	65.40	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.4939	0.00	0.0247	0.4939	0.00	0.0247
Glyphosate	0.7943	0.03	0.0397	3.7614	0.15	0.1881	0.0000	0.00	0.0000	4.5557	0.18	0.2278
Hexazinone	0.0592	0.00	0.0030	0.0008	0.00	0.0000	1.9744	0.04	0.0987	2.0343	0.04	0.1017
Imazapyr Acid	0.1723	0.01	0.0086	0.0041	0.00	0.0002	0.1540	0.01	0.0077	0.3304	0.02	0.0165
Metsulfuron-Meth	0.0002	0.00	0.0000	0.0000	0.00	0.0000	0.0146	0.02	0.0007	0.0149	0.02	0.0007
Sulfometuron-Met	0.0023	0.00	0.0001	0.0000	0.00	0.0000	0.0002	0.00	0.0000	0.0026	0.00	0.0001
Triclopyr Amine	0.0009	0.00	0.0000	0.0000	0.00	0.0000	1.4990	0.13	0.0750	1.5000	0.13	0.0750
Clorpyrifos	0.8861	0.08	0.0443	1.0477	0.09	0.0524	0.0000	0.00	0.0000	1.9338	0.17	0.0967
Diazinon	0.6411	0.11	0.0321	0.1270	0.02	0.0063	0.0000	0.00	0.0000	0.7681	0.13	0.0384
Fenoxycarb	0.0009	0.00	0.0000	0.0002	0.00	0.0000	0.0000	0.00	0.0000	0.0011	0.00	0.0001

MLRA 78B

Soil Series: Stamford

30 Year Storm Summary

1257	storms produced	1598.21	cm. of rainfall
176	storms produced	57.90	cm. of runoff
73	storms produced	5.95	cm. of percolation
174	storms produced	7.24	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0081	0.00	0.0004	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0081	0.00	0.0004
Glyphosate	2.2616	0.09	0.1131	0.5005	0.02	0.0250	0.0000	0.00	0.0000	2.7620	0.11	0.1381
Hexazinone	1.2720	0.03	0.0636	0.0009	0.00	0.0000	0.0000	0.00	0.0000	1.2729	0.03	0.0636
Imazapyr Acid	1.8795	0.08	0.0940	0.0024	0.00	0.0001	0.0000	0.00	0.0000	1.8819	0.08	0.0941
Metsulfuron-Meth	0.0090	0.01	0.0004	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0090	0.01	0.0004
Sulfometuron-Met	0.0320	0.03	0.0016	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0320	0.03	0.0016
Triclopyr Amine	0.0690	0.01	0.0035	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0690	0.01	0.0035
Clorpyrifos	2.5405	0.22	0.1270	0.1421	0.01	0.0071	0.0000	0.00	0.0000	2.6826	0.23	0.1341
Diazinon	2.1630	0.37	0.1081	0.0210	0.00	0.0011	0.0000	0.00	0.0000	2.1840	0.37	0.1092
Fenoxycarb	0.0038	0.02	0.0002	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0038	0.02	0.0002

MLRA 78C

Soil Series: Rotan

30 Year Storm Summary

2132	storms produced	2005.39	cm. of rainfall
196	storms produced	99.31	cm. of runoff
30	storms produced	37.31	cm. of percolation
196	storms produced	7.42	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0129	0.00	0.0006	0.0000	0.00	0.0000	0.0092	0.00	0.0005	0.0221	0.00	0.0011
Glyphosate	2.2710	0.09	0.1136	0.4751	0.02	0.0238	0.0000	0.00	0.0000	2.7461	0.11	0.1373
Hexazinone	2.8606	0.06	0.1430	0.0016	0.00	0.0001	0.1696	0.00	0.0085	3.0318	0.06	0.1516
Imazapyr Acid	4.9894	0.22	0.2495	0.0048	0.00	0.0002	0.0126	0.00	0.0006	5.0068	0.22	0.2503
Metsulfuron-Meth	0.0181	0.02	0.0009	0.0000	0.00	0.0000	0.0002	0.00	0.0000	0.0183	0.02	0.0009
Sulfometuron-Met	0.0750	0.07	0.0037	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0750	0.07	0.0038
Triclopyr Amine	0.1197	0.01	0.0060	0.0000	0.00	0.0000	0.0274	0.00	0.0014	0.1471	0.01	0.0074
Clorpyrifos	2.7286	0.24	0.1364	0.1415	0.01	0.0071	0.0000	0.00	0.0000	2.8701	0.25	0.1435
Diazinon	3.9469	0.68	0.1973	0.0340	0.01	0.0017	0.0000	0.00	0.0000	3.9809	0.69	0.1990
Fenoxycarb	0.0004	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0004	0.00	0.0000

MLRA 78C

Soil Series: Tillman

30 Year Storm Summary

2132	storms produced	2005.39	cm. of rainfall
192	storms produced	97.63	cm. of runoff
34	storms produced	43.02	cm. of percolation
192	storms produced	14.84	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0111	0.00	0.0006	0.0000	0.00	0.0000	0.0097	0.00	0.0005	0.0208	0.00	0.0010
Glyphosate	2.2096	0.09	0.1105	0.9184	0.04	0.0459	0.0000	0.00	0.0000	3.1280	0.13	0.1564
Hexazinone	2.6643	0.06	0.1332	0.0030	0.00	0.0001	0.1795	0.00	0.0090	2.8468	0.06	0.1423
Imazapyr Acid	4.7584	0.21	0.2379	0.0089	0.00	0.0004	0.0134	0.00	0.0007	4.7807	0.21	0.2390
Metsulfuron-Meth	0.0165	0.02	0.0008	0.0000	0.00	0.0000	0.0003	0.00	0.0000	0.0168	0.02	0.0008
Sulfometuron-Met	0.0707	0.07	0.0035	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0708	0.07	0.0035
Triclopyr Amine	0.1070	0.01	0.0054	0.0000	0.00	0.0000	0.0286	0.00	0.0014	0.1357	0.01	0.0068
Clorpyrifos	2.6509	0.23	0.1325	0.2713	0.02	0.0136	0.0000	0.00	0.0000	2.9222	0.25	0.1461
Diazinon	3.8484	0.67	0.1924	0.0654	0.01	0.0033	0.0000	0.00	0.0000	3.9138	0.68	0.1957
Fenoxycarb	0.0004	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0004	0.00	0.0000

MLRA 78C

Soil Series: Vernon

30 Year Storm Summary

2132	storms produced	2005.39	cm. of rainfall
280	storms produced	145.57	cm. of runoff
1485	storms produced	75.87	cm. of percolation
279	storms produced	204.23	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0330	0.00	0.0016	0.0000	0.00	0.0000	0.0001	0.00	0.0000	0.0330	0.00	0.0017
Glyphosate	4.9977	0.19	0.2499	11.9447	0.46	0.5972	0.0000	0.00	0.0000	16.9423	0.65	0.8471
Hexazinone	2.7698	0.06	0.1385	0.0117	0.00	0.0006	0.1240	0.00	0.0062	2.9054	0.06	0.1453
Imazapyr Acid	3.9474	0.17	0.1974	0.0322	0.00	0.0016	0.0024	0.00	0.0001	3.9820	0.17	0.1991
Metsulfuron-Meth	0.0223	0.03	0.0011	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0224	0.03	0.0011
Sulfometuron-Met	0.0659	0.06	0.0033	0.0004	0.00	0.0000	0.0000	0.00	0.0000	0.0663	0.06	0.0033
Triclopyr Amine	0.1912	0.02	0.0096	0.0003	0.00	0.0000	0.0013	0.00	0.0001	0.1927	0.02	0.0096
Clorpyrifos	5.2995	0.46	0.2650	3.0876	0.27	0.1544	0.0000	0.00	0.0000	8.3871	0.73	0.4194
Diazinon	4.7164	0.82	0.2358	0.4428	0.08	0.0221	0.0000	0.00	0.0000	5.1592	0.90	0.2580
Fenoxycarb	0.0013	0.01	0.0001	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0014	0.01	0.0001

MLRA 78D

Soil Series: Leeray

30 Year Storm Summary

2132	storms produced	2166.73	cm. of rainfall
307	storms produced	185.28	cm. of runoff
1762	storms produced	114.85	cm. of percolation
307	storms produced	17.14	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	3.3747	0.00	0.1687	0.0003	0.00	0.0000	0.0000	0.00	0.0000	3.3749	0.00	0.1687
Glyphosate	2.6605	0.10	0.1330	1.0164	0.04	0.0508	0.0000	0.00	0.0000	3.6769	0.14	0.1838
Hexazinone	75.9306	1.64	3.7965	0.0551	0.00	0.0028	0.0000	0.00	0.0000	75.9857	1.64	3.7993
Imazapyr Acid	42.9214	1.85	2.1461	0.0612	0.00	0.0031	0.0000	0.00	0.0000	42.9826	1.85	2.1491
Metsulfuron-Meth	0.9756	1.18	0.0488	0.0004	0.00	0.0000	0.0000	0.00	0.0000	0.9761	1.18	0.0488
Sulfometuron-Met	1.2608	1.22	0.0630	0.0013	0.00	0.0001	0.0000	0.00	0.0000	1.2621	1.22	0.0631
Triclopyr Amine	12.4052	1.07	0.6203	0.0031	0.00	0.0002	0.0000	0.00	0.0000	12.4083	1.07	0.6204
Clorpyrifos	3.4361	0.30	0.1718	0.3248	0.03	0.0162	0.0000	0.00	0.0000	3.7609	0.33	0.1880
Diazinon	7.1429	1.23	0.3571	0.1105	0.02	0.0055	0.0000	0.00	0.0000	7.2534	1.25	0.3627
Fenoxycarb	0.0117	0.06	0.0006	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0118	0.06	0.0006

MLRA 78D

Soil Series: Palo Pinto

30 Year Storm Summary

2132	storms produced	2166.73	cm. of rainfall
306	storms produced	146.59	cm. of runoff
284	storms produced	275.95	cm. of percolation
306	storms produced	194.29	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0309	0.00	0.0015	0.0000	0.00	0.0000	20.9397	0.00	1.0470	20.9706	0.00	1.0485
Glyphosate	2.6623	0.10	0.1331	9.2714	0.36	0.4636	0.0000	0.00	0.0000	11.9337	0.46	0.5967
Hexazinone	9.9408	0.21	0.4970	0.0736	0.00	0.0037	326.5954	7.05	16.3298	336.6098	7.26	16.8305
Imazapyr Acid	13.3332	0.58	0.6667	0.1830	0.01	0.0092	106.7971	4.61	5.3399	120.3133	5.20	6.0157
Metsulfuron-Meth	0.0663	0.08	0.0033	0.0003	0.00	0.0000	2.5426	3.08	0.1271	2.6093	3.16	0.1305
Sulfometuron-Met	0.2477	0.24	0.0124	0.0026	0.00	0.0001	0.9237	0.89	0.0462	1.1740	1.13	0.0587
Triclopyr Amine	0.4018	0.03	0.0201	0.0011	0.00	0.0001	68.0478	5.88	3.4024	68.4507	5.91	3.4225
Clorpyrifos	3.2069	0.28	0.1603	2.7498	0.24	0.1375	0.0000	0.00	0.0000	5.9567	0.52	0.2978
Diazinon	5.0504	0.87	0.2525	0.7052	0.12	0.0353	0.0343	0.01	0.0017	5.7898	1.00	0.2895
Fenoxycarb	0.0041	0.02	0.0002	0.0005	0.00	0.0000	0.0000	0.00	0.0000	0.0046	0.02	0.0002

MLRA 78D

Soil Series: Lueders

30 Year Storm Summary

2132	storms produced	2166.73	cm. of rainfall
185	storms produced	67.63	cm. of runoff
119	storms produced	144.28	cm. of percolation
185	storms produced	91.89	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0032	0.00	0.0002	0.0000	0.00	0.0000	3.2187	0.00	0.1609	3.2219	0.00	0.1611
Glyphosate	1.2469	0.05	0.0623	4.5351	0.18	0.2268	0.0000	0.00	0.0000	5.7819	0.23	0.2891
Hexazinone	2.3661	0.05	0.1183	0.0189	0.00	0.0009	98.1281	2.12	4.9064	100.5131	2.17	5.0257
Imazapyr Acid	3.9257	0.17	0.1963	0.0585	0.00	0.0029	33.5006	1.45	1.6750	37.4848	1.62	1.8742
Metsulfuron-Meth	0.0134	0.02	0.0007	0.0001	0.00	0.0000	0.1878	0.23	0.0094	0.2012	0.25	0.0101
Sulfometuron-Met	0.0686	0.07	0.0034	0.0008	0.00	0.0000	0.0384	0.04	0.0019	0.1078	0.11	0.0054
Triclopyr Amine	0.0645	0.01	0.0032	0.0002	0.00	0.0000	11.6361	1.01	0.5818	11.7008	1.02	0.5850
Clorpyrifos	1.5031	0.13	0.0752	1.3432	0.12	0.0672	0.0000	0.00	0.0000	2.8463	0.25	0.1423
Diazinon	2.2480	0.39	0.1124	0.3290	0.06	0.0164	0.0005	0.00	0.0000	2.5775	0.45	0.1289
Fenoxycarb	0.0014	0.01	0.0001	0.0002	0.00	0.0000	0.0000	0.00	0.0000	0.0016	0.01	0.0001

MLRA 80B

Soil Series: Bonti

30 Year Storm Summary

2304	storms produced	2377.46	cm. of rainfall
188	storms produced	77.82	cm. of runoff
286	storms produced	388.94	cm. of percolation
188	storms produced	25.84	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0012	0.00	0.0001	0.00	0.00	0.0000	5.8045	0.00	0.2902	5.8057	0.00	0.2903
Glyphosate	1.4988	0.06	0.0749	1.44	0.06	0.0718	0.00	0.00	0.0000	2.9341	0.11	0.1467
Hexazinone	2.1069	0.05	0.1053	5.70E-03	0.00	0.0003	85.9147	1.86	4.2957	88.0273	1.90	4.4014
Imazapyr Acid	3.9682	0.17	0.1984	1.84E-02	0.00	0.0009	19.1096	0.83	0.9555	23.0963	1.00	1.1548
Metsulfuron-Meth	0.0107	0.01	0.0005	2.00E-05	0.00	0.0000	0.3477	0.42	0.0174	0.3584	0.43	0.0179
Sulfometuron-Met	0.0680	0.07	0.0034	2.43E-04	0.00	0.0000	0.0581	0.06	0.0029	0.1264	0.12	0.0063
Triclopyr Amine	0.0399	0.00	0.0020	4.67E-05	0.00	0.0000	16.2685	1.41	0.8134	16.3084	1.41	0.8154
Clorpyrifos	1.7755	0.15	0.0888	0.4265	0.04	0.0213	0.00	0.00	0.0000	2.2020	0.19	0.1101
Diazinon	2.4765	0.43	0.1238	0.1000	0.02	0.0050	1.67E-05	0.00	0.0000	2.5765	0.45	0.1288
Fenoxycarb	0.0019	0.01	0.0001	6.67E-05	0.00	0.0000	0.00	0.00	0.0000	0.0019	0.01	0.0001

MLRA 80B

Soil Series: Exray

30 Year Storm Summary

2304	storms produced	2377.46	cm. of rainfall
312	storms produced	152.22	cm. of runoff
307	storms produced	399.77	cm. of percolation
312	storms produced	24.39	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0036	0.00	0.0002	0.0000	0.00	0.0000	16.8977	0.00	0.8449	16.9013	0.00	0.8451
Glyphosate	6.7782	0.26	0.3389	1.1579	0.04	0.0579	0.0000	0.00	0.0000	7.9361	0.30	0.3968
Hexazinone	0.8967	0.02	0.0448	0.0005	0.00	0.0000	389.3443	8.41	19.4672	390.2415	8.43	19.5121
Imazapyr Acid	1.7733	0.08	0.0887	0.0016	0.00	0.0001	140.3387	6.06	7.0169	142.1135	6.14	7.1057
Metsulfuron-Meth	0.0057	0.01	0.0003	0.0000	0.00	0.0000	2.3318	2.82	0.1166	2.3375	2.83	0.1169
Sulfometuron-Met	0.0285	0.03	0.0014	0.0000	0.00	0.0000	0.9265	0.90	0.0463	0.9550	0.93	0.0478
Triclopyr Amine	0.0360	0.00	0.0018	0.0000	0.00	0.0000	63.7660	5.51	3.1883	63.8020	5.51	3.1901
Clorpyrifos	6.2721	0.55	0.3136	0.2688	0.02	0.0134	0.0000	0.00	0.0000	6.5408	0.57	0.3270
Diazinon	3.4118	0.59	0.1706	0.0248	0.00	0.0012	0.0296	0.01	0.0015	3.4662	0.60	0.1733
Fenoxycarb	0.0039	0.02	0.0002	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0039	0.02	0.0002

MLRA 80B

Soil Series: Truce

30 Year Storm Summary

2304	storms produced	2377.46	cm. of rainfall
183	storms produced	75.42	cm. of runoff
253	storms produced	368.57	cm. of percolation
183	storms produced	25.99	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0016	0.00	0.0001	0.0000	0.00	0.0000	0.2948	0.00	0.0147	0.2964	0.00	0.0148
Glyphosate	1.5132	0.06	0.0757	1.4866	0.06	0.0743	0.0000	0.00	0.0000	2.9998	0.12	0.1500
Hexazinone	2.3874	0.05	0.1194	0.0064	0.00	0.0003	10.6507	0.23	0.5325	13.0445	0.28	0.6522
Imazapyr Acid	4.3504	0.19	0.2175	0.0201	0.00	0.0010	1.6459	0.07	0.0823	6.0164	0.26	0.3008
Metsulfuron-Meth	0.0125	0.02	0.0006	0.0000	0.00	0.0000	0.0059	0.01	0.0003	0.0184	0.03	0.0009
Sulfometuron-Met	0.0746	0.07	0.0037	0.0003	0.00	0.0000	0.0006	0.00	0.0000	0.0755	0.07	0.0038
Triclopyr Amine	0.0488	0.00	0.0024	0.0001	0.00	0.0000	0.9552	0.08	0.0478	1.0041	0.08	0.0502
Clorpyrifos	1.8232	0.16	0.0912	0.4472	0.04	0.0224	0.0000	0.00	0.0000	2.2704	0.20	0.1135
Diazinon	2.5602	0.44	0.1280	0.1050	0.02	0.0052	0.0000	0.00	0.0000	2.6651	0.46	0.1333
Fenoxycarb	0.0019	0.01	0.0001	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0020	0.01	0.0001

MLRA 81A

Soil Series: Ector

30 Year Storm Summary

1031	storms produced	1123.99	cm. of rainfall
115	storms produced	36.67	cm. of runoff
23	storms produced	19.67	cm. of percolation
115	storms produced	115.72	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0020	0.00	0.0001	0.0000	0.00	0.0000	0.1541	0.00	0.0077	0.1562	0.00	0.0078
Glyphosate	0.4073	0.02	0.0204	3.3088	0.13	0.1654	0.0000	0.00	0.0000	3.7161	0.15	0.1858
Hexazinone	1.7045	0.04	0.0852	0.0287	0.00	0.0014	5.0085	0.11	0.2504	6.7417	0.15	0.3371
Imazapyr Acid	2.4601	0.11	0.1230	0.0764	0.00	0.0038	0.7014	0.03	0.0351	3.2380	0.14	0.1619
Metsulfuron-Meth	0.0091	0.01	0.0005	0.0001	0.00	0.0000	0.0030	0.00	0.0002	0.0123	0.01	0.0006
Sulfometuron-Met	0.0388	0.04	0.0019	0.0009	0.00	0.0000	0.0001	0.00	0.0000	0.0398	0.04	0.0020
Triclopyr Amine	0.0461	0.00	0.0023	0.0003	0.00	0.0000	0.9183	0.08	0.0459	0.9647	0.08	0.0482
Clorpyrifos	0.3841	0.03	0.0192	0.7488	0.07	0.0374	0.0000	0.00	0.0000	1.1329	0.10	0.0566
Diazinon	0.6995	0.12	0.0350	0.2254	0.04	0.0113	0.0000	0.00	0.0000	0.9249	0.16	0.0462
Fenoxycarb	0.0010	0.00	0.0001	0.0003	0.00	0.0000	0.0000	0.00	0.0000	0.0013	0.00	0.0001

MLRA 81A

Soil Series: Reagan

30 Year Storm Summary

1031	storms produced	1123.99	cm. of rainfall
9	storms produced	3.46	cm. of runoff
5	storms produced	4.76	cm. of percolation
9	storms produced	0.47	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0001	0.00	0.0000	0.0001	0.00	0.0000
Glyphosate	0.0302	0.00	0.0015	0.0080	0.00	0.0004	0.0000	0.00	0.0000	0.0382	0.00	0.0019
Hexazinone	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0937	0.00	0.0047	0.0937	0.00	0.0047
Imazapyr Acid	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0224	0.00	0.0011	0.0226	0.00	0.0011
Metsulfuron-Meth	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Sulfometuron-Met	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000
Triclopyr Amine	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0070	0.00	0.0004	0.0070	0.00	0.0004
Clorpyrifos	0.0125	0.00	0.0006	0.0008	0.00	0.0000	0.0000	0.00	0.0000	0.0134	0.00	0.0007
Diazinon	0.0087	0.00	0.0004	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0088	0.00	0.0004
Fenoxycarb	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000

MLRA 81B

Soil Series: Rough Creek

30 Year Storm Summary

2076	storms produced	1728.56	cm. of rainfall
204	storms produced	108.76	cm. of runoff
20	storms produced	22.87	cm. of percolation
204	storms produced	14.70	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0052	0.00	0.0003	0.0000	0.00	0.0000	0.3570	0.00	0.0178	0.3622	0.00	0.0181
Glyphosate	1.7723	0.07	0.0886	0.6873	0.03	0.0344	0.0000	0.00	0.0000	2.4596	0.10	0.1230
Hexazinone	2.6374	0.06	0.1319	0.0030	0.00	0.0001	9.5506	0.21	0.4775	12.1910	0.27	0.6095
Imazapyr Acid	3.8339	0.17	0.1917	0.0076	0.00	0.0004	2.2063	0.10	0.1103	6.0478	0.27	0.3024
Metsulfuron-Meth	0.0150	0.02	0.0008	0.0000	0.00	0.0000	0.0335	0.04	0.0017	0.0485	0.06	0.0024
Sulfometuron-Met	0.0590	0.06	0.0030	0.0001	0.00	0.0000	0.0035	0.00	0.0002	0.0626	0.06	0.0031
Triclopyr Amine	0.0902	0.01	0.0045	0.0000	0.00	0.0000	1.8377	0.16	0.0919	1.9279	0.17	0.0964
Clorpyrifos	1.6513	0.14	0.0826	0.1619	0.01	0.0081	0.0000	0.00	0.0000	1.8132	0.15	0.0907
Diazinon	2.2897	0.40	0.1145	0.0380	0.01	0.0019	0.0000	0.00	0.0000	2.3277	0.41	0.1164
Fenoxycarb	0.0016	0.01	0.0001	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0017	0.01	0.0001

MLRA 81B

Soil Series: Ector

30 Year Storm Summary

2076	storms produced	1728.56	cm. of rainfall
177	storms produced	93.64	cm. of runoff
92	storms produced	91.07	cm. of percolation
177	storms produced	309.90	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0020	0.00	0.0001	0.0000	0.00	0.0000	3.4737	0.00	0.1737	3.4757	0.00	0.1738
Glyphosate	1.4110	0.05	0.0705	13.1632	0.51	0.6582	0.0000	0.00	0.0000	14.5742	0.56	0.7287
Hexazinone	2.0335	0.04	0.1017	0.0362	0.00	0.0018	35.8306	0.77	1.7915	37.9003	0.81	1.8950
Imazapyr Acid	3.1682	0.14	0.1584	0.1045	0.00	0.0052	4.8020	0.21	0.2401	8.0747	0.35	0.4037
Metsulfuron-Meth	0.0104	0.01	0.0005	0.0001	0.00	0.0000	0.1878	0.23	0.0094	0.1983	0.24	0.0099
Sulfometuron-Met	0.0477	0.05	0.0024	0.0012	0.00	0.0001	0.0116	0.01	0.0006	0.0605	0.06	0.0030
Triclopyr Amine	0.0528	0.00	0.0026	0.0004	0.00	0.0000	12.3190	1.06	0.6160	12.3722	1.06	0.6186
Clorpyrifos	1.3084	0.11	0.0654	2.9361	0.26	0.1468	0.0000	0.00	0.0000	4.2445	0.37	0.2122
Diazinon	1.9267	0.33	0.0963	0.6894	0.12	0.0345	0.0000	0.00	0.0000	2.6161	0.45	0.1308
Fenoxycarb	0.0014	0.01	0.0001	0.0004	0.00	0.0000	0.0000	0.00	0.0000	0.0018	0.01	0.0001

MLRA 81B

Soil Series: Tarrant

30 Year Storm Summary

2076	storms produced	1728.56	cm. of rainfall
191	storms produced	96.66	cm. of runoff
20	storms produced	23.96	cm. of percolation
191	storms produced	232.09	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0160	0.00	0.0008	0.0001	0.00	0.0000	0.2151	0.00	0.0108	0.2311	0.00	0.0116
Glyphosate	0.8027	0.03	0.0401	12.1464	0.47	0.6073	0.0000	0.00	0.0000	12.9491	0.50	0.6475
Hexazinone	7.5676	0.16	0.3784	0.2186	0.00	0.0109	0.2416	0.01	0.0121	8.0278	0.17	0.4014
Imazapyr Acid	5.5002	0.24	0.2750	0.2987	0.01	0.0149	0.0059	0.00	0.0003	5.8048	0.25	0.2902
Metsulfuron-Meth	0.0528	0.06	0.0026	0.0010	0.00	0.0000	0.0012	0.00	0.0001	0.0550	0.06	0.0027
Sulfometuron-Met	0.1090	0.11	0.0055	0.0044	0.00	0.0002	0.0000	0.00	0.0000	0.1135	0.11	0.0057
Triclopyr Amine	0.3400	0.03	0.0170	0.0036	0.00	0.0002	0.3258	0.03	0.0163	0.6695	0.06	0.0335
Clorpyrifos	0.8209	0.07	0.0410	2.9988	0.26	0.1499	0.0000	0.00	0.0000	3.8196	0.33	0.1910
Diazinon	2.0830	0.36	0.1042	1.2452	0.22	0.0623	0.0000	0.00	0.0000	3.3283	0.58	0.1664
Fenoxycarb	0.0012	0.01	0.0001	0.0006	0.00	0.0000	0.0000	0.00	0.0000	0.0017	0.01	0.0001

MLRA 81C

Soil Series: Brackett

30 Year Storm Summary

2916	storms produced	2662.86	cm. of rainfall
576	storms produced	391.63	cm. of runoff
52	storms produced	55.08	cm. of percolation
575	storms produced	1288.13	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.1642	0.00	0.0082	0.0003	0.00	0.0000	0.2210	0.00	0.0110	0.3855	0.00	0.0193
Glyphosate	7.6211	0.30	0.3811	69.7563	2.70	3.4878	0.0000	0.00	0.0000	77.3774	3.00	3.8689
Hexazinone	40.1882	0.87	2.0094	0.7231	0.02	0.0362	4.9129	0.11	0.2456	45.8243	1.00	2.2912
Imazapyr Acid	48.2292	2.08	2.4115	1.7164	0.07	0.0858	1.1622	0.05	0.0581	51.1077	2.20	2.5554
Metsulfuron-Meth	0.2805	0.34	0.0140	0.0031	0.00	0.0002	0.0054	0.01	0.0003	0.2890	0.35	0.0144
Sulfometuron-Met	0.9109	0.88	0.0455	0.0251	0.02	0.0013	0.0005	0.00	0.0000	0.9365	0.90	0.0468
Triclopyr Amine	1.9523	0.17	0.0976	0.0115	0.00	0.0006	0.5971	0.05	0.0299	2.5609	0.22	0.1280
Clorpyrifos	9.4747	0.83	0.4737	22.0396	1.92	1.1020	0.0000	0.00	0.0000	31.5143	2.75	1.5757
Diazinon	15.3387	2.65	0.7669	5.8599	1.01	0.2930	0.0000	0.00	0.0000	21.1986	3.66	1.0599
Fenoxycarb	0.0233	0.11	0.0012	0.0099	0.05	0.0005	0.0000	0.00	0.0000	0.0331	0.16	0.0017

MLRA 81C

Soil Series: Eckrant

30 Year Storm Summary

2916	storms produced	2662.86	cm. of rainfall
614	storms produced	435.89	cm. of runoff
185	storms produced	172.28	cm. of percolation
613	storms produced	1144.93	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.5548	0.00	0.0277	0.0009	0.00	0.0000	4.5708	0.00	0.2285	5.1265	0.00	0.2563
Glyphosate	7.5505	0.29	0.3775	69.0643	2.67	3.4532	0.0000	0.00	0.0000	76.6149	2.96	3.8307
Hexazinone	64.3922	1.39	3.2196	1.1658	0.03	0.0583	86.3111	1.86	4.3156	151.8691	3.28	7.5935
Imazapyr Acid	59.7235	2.58	2.9862	2.1175	0.09	0.1059	26.3549	1.14	1.3177	88.1959	3.81	4.4098
Metsulfuron-Meth	0.5244	0.63	0.0262	0.0059	0.01	0.0003	0.3909	0.47	0.0195	0.9212	1.11	0.0461
Sulfometuron-Met	1.2885	1.25	0.0644	0.0355	0.03	0.0018	0.1144	0.11	0.0057	1.4384	1.39	0.0719
Triclopyr Amine	4.4106	0.38	0.2205	0.0266	0.00	0.0013	13.2510	1.14	0.6625	17.6882	1.52	0.8844
Clorpyrifos	9.5148	0.83	0.4757	22.1001	1.93	1.1050	0.0000	0.00	0.0000	31.6149	2.76	1.5807
Diazinon	16.5147	2.85	0.8257	6.2951	1.09	0.3148	0.0002	0.00	0.0000	22.8101	3.94	1.1405
Fenoxycarb	0.0296	0.14	0.0015	0.0125	0.06	0.0006	0.0000	0.00	0.0000	0.0421	0.20	0.0021

MLRA 81C

Soil Series: Comfort

30 Year Storm Summary

2916	storms produced	2662.86	cm. of rainfall
662	storms produced	479.19	cm. of runoff
175	storms produced	142.68	cm. of percolation
661	storms produced	1306.37	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.6238	0.00	0.0312	0.0011	0.00	0.0001	4.0704	0.00	0.2035	4.6953	0.00	0.2348
Glyphosate	7.7928	0.30	0.3896	74.0609	2.87	3.7030	0.0000	0.00	0.0000	81.8537	3.17	4.0927
Hexazinone	85.7768	1.85	4.2888	1.6176	0.03	0.0809	52.7063	1.14	2.6353	140.1007	3.02	7.0050
Imazapyr Acid	78.5228	3.39	3.9261	2.8993	0.13	0.1450	13.3569	0.58	0.6678	94.7790	4.10	4.7390
Metsulfuron-Meth	0.6996	0.85	0.0350	0.0082	0.01	0.0004	0.2558	0.31	0.0128	0.9636	1.17	0.0482
Sulfometuron-Met	1.6958	1.64	0.0848	0.0486	0.05	0.0024	0.0520	0.05	0.0026	1.7963	1.74	0.0898
Triclopyr Amine	5.6511	0.49	0.2826	0.0351	0.00	0.0018	9.7786	0.84	0.4889	15.4649	1.33	0.7732
Clorpyrifos	10.0253	0.87	0.5013	24.1881	2.11	1.2094	0.0000	0.00	0.0000	34.2134	2.98	1.7107
Diazinon	18.6278	3.22	0.9314	7.3671	1.27	0.3684	0.0000	0.00	0.0000	25.9950	4.49	1.2997
Fenoxycarb	0.0293	0.14	0.0015	0.0128	0.06	0.0006	0.0000	0.00	0.0000	0.0421	0.20	0.0021

MLRA 82

Soil Series: Castell

30 Year Storm Summary

2231	storms produced	2035.73	cm. of rainfall
483	storms produced	223.35	cm. of runoff
109	storms produced	70.42	cm. of percolation
481	storms produced	23.33	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0497	0.00	0.0025	0.0000	0.00	0.0000	0.4507	0.00	0.0225	0.5004	0.00	0.0250
Glyphosate	7.4413	0.29	0.3721	1.0802	0.04	0.0540	0.0000	0.00	0.0000	8.5215	0.33	0.4261
Hexazinone	14.5458	0.31	0.7273	0.0052	0.00	0.0003	10.9441	0.24	0.5472	25.4950	0.55	1.2748
Imazapyr Acid	20.2708	0.88	1.0135	0.0129	0.00	0.0006	1.8438	0.08	0.0922	22.1276	0.96	1.1064
Metsulfuron-Meth	0.1023	0.12	0.0051	0.0000	0.00	0.0000	0.0078	0.01	0.0004	0.1101	0.13	0.0055
Sulfometuron-Met	0.3667	0.35	0.0183	0.0002	0.00	0.0000	0.0008	0.00	0.0000	0.3677	0.35	0.0184
Triclopyr Amine	0.6606	0.06	0.0330	0.0001	0.00	0.0000	0.9779	0.08	0.0489	1.6386	0.14	0.0819
Clorpyrifos	8.5004	0.74	0.4250	0.3076	0.03	0.0154	0.0000	0.00	0.0000	8.8080	0.77	0.4404
Diazinon	9.2441	1.60	0.4622	0.0553	0.01	0.0028	0.0000	0.00	0.0000	9.2994	1.61	0.4650
Fenoxycarb	0.0196	0.09	0.0010	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0197	0.09	0.0010

MLRA 82

Soil Series: Eckert

30 Year Storm Summary

2231	storms produced	2035.73	cm. of rainfall
485	storms produced	219.12	cm. of runoff
206	storms produced	190.38	cm. of percolation
485	storms produced	270.13	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.1293	0.00	0.0065	0.0001	0.00	0.0000	8.3860	0.00	0.4193	8.5153	0.00	0.4258
Glyphosate	3.9342	0.15	0.1967	13.2834	0.51	0.6642	0.0000	0.00	0.0000	17.2177	0.66	0.8609
Hexazinone	32.9685	0.71	1.6484	0.2335	0.01	0.0117	44.0858	0.95	2.2043	77.2878	1.67	3.8644
Imazapyr Acid	35.4965	1.53	1.7748	0.4745	0.02	0.0237	6.8892	0.30	0.3445	42.8603	1.85	2.1430
Metsulfuron-Meth	0.2506	0.30	0.0125	0.0011	0.00	0.0001	0.2727	0.33	0.0136	0.5245	0.63	0.0262
Sulfometuron-Met	0.7139	0.69	0.0357	0.0074	0.01	0.0004	0.0311	0.03	0.0016	0.7523	0.73	0.0376
Triclopyr Amine	1.7504	0.15	0.0875	0.0045	0.00	0.0002	14.3325	1.24	0.7166	16.0874	1.39	0.8044
Clorpyrifos	4.9427	0.43	0.2471	4.2106	0.37	0.2105	0.0000	0.00	0.0000	9.1532	0.80	0.4577
Diazinon	8.7291	1.51	0.4365	1.2179	0.21	0.0609	0.0000	0.00	0.0000	9.9471	1.72	0.4974
Fenoxycarb	0.0172	0.08	0.0009	0.0026	0.01	0.0001	0.0000	0.00	0.0000	0.0198	0.09	0.0010

MLRA 82

Soil Series: Keese

30 Year Storm Summary

2231	storms produced	2035.73	cm. of rainfall
459	storms produced	206.75	cm. of runoff
98	storms produced	83.22	cm. of percolation
459	storms produced	463.12	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0270	0.00	0.0013	0.0000	0.00	0.0000	1.2181	0.00	0.0609	1.2451	0.00	0.0623
Glyphosate	6.6203	0.26	0.3310	20.2631	0.78	1.0132	0.0000	0.00	0.0000	26.8834	1.04	1.3442
Hexazinone	10.8220	0.23	0.5411	0.0636	0.00	0.0032	7.9288	0.17	0.3964	18.8144	0.40	0.9407
Imazapyr Acid	16.2716	0.70	0.8136	0.1852	0.01	0.0093	0.5791	0.03	0.0290	17.0359	0.74	0.8518
Metsulfuron-Meth	0.0707	0.09	0.0035	0.0003	0.00	0.0000	0.0072	0.01	0.0004	0.0782	0.10	0.0039
Sulfometuron-Met	0.2822	0.27	0.0141	0.0025	0.00	0.0001	0.0003	0.00	0.0000	0.2849	0.27	0.0142
Triclopyr Amine	0.4230	0.04	0.0212	0.0009	0.00	0.0000	1.5825	0.14	0.0791	2.0064	0.18	0.1003
Clorpyrifos	7.5286	0.66	0.3764	5.8095	0.51	0.2905	0.0000	0.00	0.0000	13.3382	1.17	0.6669
Diazinon	8.1644	1.41	0.4082	1.0227	0.18	0.0511	0.0000	0.00	0.0000	9.1870	1.59	0.4594
Fenoxycarb	0.0174	0.08	0.0009	0.0024	0.01	0.0001	0.0000	0.00	0.0000	0.0198	0.09	0.0010

MLRA 83A

Soil Series: Duval

30 Year Storm Summary

1872	storms produced	1965.18	cm. of rainfall
395	storms produced	287.96	cm. of runoff
21	storms produced	26.39	cm. of percolation
395	storms produced	38.06	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0243	0.00	0.0012	0.0000	0.00	0.0000	0.0043	0.00	0.0002	0.0285	0.00	0.0014
Glyphosate	11.0553	0.43	0.5528	2.0276	0.08	0.1014	0.0000	0.00	0.0000	13.0829	0.51	0.6541
Hexazinone	9.9615	0.22	0.4981	0.0046	0.00	0.0002	0.8148	0.02	0.0407	10.7809	0.24	0.5390
Imazapyr Acid	15.8859	0.69	0.7943	0.0127	0.00	0.0006	0.0528	0.00	0.0026	15.9514	0.69	0.7976
Metsulfuron-Meth	0.0606	0.07	0.0030	0.0000	0.00	0.0000	0.0004	0.00	0.0000	0.0610	0.07	0.0031
Sulfometuron-Met	0.2403	0.23	0.0120	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.2405	0.23	0.0120
Triclopyr Amine	0.3801	0.03	0.0190	0.0001	0.00	0.0000	0.0336	0.00	0.0017	0.4138	0.03	0.0207
Clorpyrifos	11.8623	1.03	0.5931	0.5399	0.05	0.0270	0.0000	0.00	0.0000	12.4022	1.08	0.6201
Diazinon	11.3625	1.96	0.5681	0.0848	0.01	0.0042	0.0000	0.00	0.0000	11.4473	1.97	0.5724
Fenoxycarb	0.0197	0.10	0.0010	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0199	0.10	0.0010

MLRA 83A

Soil Series: Knippa

30 Year Storm Summary

1872	storms produced	1965.18	cm. of rainfall
416	storms produced	299.40	cm. of runoff
19	storms produced	21.10	cm. of percolation
416	storms produced	13.91	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.1325	0.00	0.0066	0.0000	0.00	0.0000	0.0001	0.00	0.0000	0.1326	0.00	0.0066
Glyphosate	5.4682	0.21	0.2734	0.8853	0.03	0.0443	0.0000	0.00	0.0000	6.3535	0.24	0.3177
Hexazinone	48.4958	1.05	2.4248	0.0186	0.00	0.0009	0.0001	0.00	0.0000	48.5145	1.05	2.4257
Imazapyr Acid	50.6592	2.19	2.5330	0.0350	0.00	0.0018	0.0000	0.00	0.0000	50.6942	2.19	2.5347
Metsulfuron-Meth	0.3468	0.42	0.0173	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.3469	0.42	0.0173
Sulfometuron-Met	0.9627	0.93	0.0481	0.0005	0.00	0.0000	0.0000	0.00	0.0000	0.9632	0.93	0.0482
Triclopyr Amine	2.2697	0.20	0.1135	0.0003	0.00	0.0000	0.0001	0.00	0.0000	2.2701	0.20	0.1135
Clorpyrifos	6.8737	0.60	0.3437	0.2764	0.02	0.0138	0.0000	0.00	0.0000	7.1502	0.62	0.3575
Diazinon	13.2063	2.28	0.6603	0.0879	0.02	0.0044	0.0000	0.00	0.0000	13.2942	2.30	0.6647
Fenoxycarb	0.0206	0.10	0.0010	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0207	0.10	0.0010

MLRA 83A

Soil Series: Poth

30 Year Storm Summary

1872	storms produced	1965.18	cm. of rainfall
399	storms produced	292.62	cm. of runoff
15	storms produced	15.24	cm. of percolation
399	storms produced	40.79	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0148	0.00	0.0007	0.0000	0.00	0.0000	0.0019	0.00	0.0001	0.0167	0.00	0.0008
Glyphosate	10.8307	0.42	0.5415	2.1151	0.08	0.1058	0.0000	0.00	0.0000	12.9458	0.50	0.6473
Hexazinone	9.9634	0.22	0.4982	0.0048	0.00	0.0002	0.0308	0.00	0.0015	9.9991	0.22	0.5000
Imazapyr Acid	17.0019	0.73	0.8501	0.0144	0.00	0.0007	0.0006	0.00	0.0000	17.0168	0.73	0.8508
Metsulfuron-Meth	0.0559	0.07	0.0028	0.0000	0.00	0.0000	0.0001	0.00	0.0000	0.0559	0.07	0.0028
Sulfometuron-Met	0.2504	0.24	0.0125	0.0002	0.00	0.0000	0.0000	0.00	0.0000	0.2506	0.24	0.0125
Triclopyr Amine	0.3090	0.03	0.0155	0.0001	0.00	0.0000	0.0066	0.00	0.0003	0.3157	0.03	0.0158
Clorpyrifos	11.8069	1.03	0.5903	0.5722	0.05	0.0286	0.0000	0.00	0.0000	12.3791	1.08	0.6190
Diazinon	11.9042	2.06	0.5952	0.0947	0.02	0.0047	0.0000	0.00	0.0000	11.9989	2.08	0.5999
Fenoxycarb	0.0191	0.09	0.0010	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0192	0.09	0.0010

MLRA 83A

Soil Series: Uvalde

30 Year Storm Summary

1872	storms produced	1965.18	cm. of rainfall
429	storms produced	310.09	cm. of runoff
10	storms produced	7.82	cm. of percolation
429	storms produced	16.76	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.1065	0.00	0.0053	0.0000	0.00	0.0000	0.0001	0.00	0.0000	0.1066	0.00	0.0053
Glyphosate	6.7309	0.26	0.3365	1.0050	0.04	0.0503	0.0000	0.00	0.0000	7.7359	0.30	0.3868
Hexazinone	40.2509	0.87	2.0125	0.0143	0.00	0.0007	0.0022	0.00	0.0001	40.2674	0.87	2.0134
Imazapyr Acid	48.1132	2.08	2.4057	0.0308	0.00	0.0015	0.0000	0.00	0.0000	48.1440	2.08	2.4072
Metsulfuron-Meth	0.2800	0.34	0.0140	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.2801	0.34	0.0140
Sulfometuron-Met	0.8604	0.83	0.0430	0.0004	0.00	0.0000	0.0000	0.00	0.0000	0.8609	0.83	0.0430
Triclopyr Amine	1.7994	0.16	0.0900	0.0003	0.00	0.0000	0.0002	0.00	0.0000	1.7998	0.16	0.0900
Clorpyrifos	8.3139	0.72	0.4157	0.3073	0.03	0.0154	0.0000	0.00	0.0000	8.6212	0.75	0.4311
Diazinon	14.1305	2.44	0.7065	0.0864	0.01	0.0043	0.0000	0.00	0.0000	14.2169	2.45	0.7108
Fenoxycarb	0.0218	0.11	0.0011	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0219	0.11	0.0011

MLRA 83A

Soil Series: Webb

30 Year Storm Summary

1872	storms produced	1965.18	cm. of rainfall
394	storms produced	284.71	cm. of runoff
24	storms produced	20.87	cm. of percolation
394	storms produced	39.24	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0362	0.00	0.0018	0.0000	0.00	0.0000	0.0014	0.00	0.0001	0.0375	0.00	0.0019
Glyphosate	11.2600	0.44	0.5630	2.1508	0.08	0.1075	0.0000	0.00	0.0000	13.4107	0.52	0.6705
Hexazinone	10.2500	0.22	0.5125	0.0049	0.00	0.0002	0.5206	0.01	0.0260	10.7755	0.23	0.5388
Imazapyr Acid	15.2720	0.66	0.7636	0.0127	0.00	0.0006	0.1022	0.00	0.0051	15.3869	0.66	0.7693
Metsulfuron-Meth	0.0668	0.08	0.0033	0.0000	0.00	0.0000	0.0002	0.00	0.0000	0.0670	0.08	0.0034
Sulfometuron-Met	0.2358	0.23	0.0118	0.0002	0.00	0.0000	0.0000	0.00	0.0000	0.2360	0.23	0.0118
Triclopyr Amine	0.4654	0.04	0.0233	0.0001	0.00	0.0000	0.0109	0.00	0.0005	0.4764	0.04	0.0238
Clorpyrifos	11.9189	1.04	0.5959	0.5650	0.05	0.0282	0.0000	0.00	0.0000	12.4839	1.09	0.6242
Diazinon	10.9229	1.89	0.5461	0.0849	0.01	0.0042	0.0000	0.00	0.0000	11.0078	1.90	0.5504
Fenoxycarb	0.0200	0.10	0.0010	0.0002	0.00	0.0000	0.0000	0.00	0.0000	0.0202	0.10	0.0010

MLRA 83A

Soil Series: Monteolo

30 Year Storm Summary

1872	storms produced	1965.18	cm. of rainfall
438	storms produced	317.18	cm. of runoff
405	storms produced	18.29	cm. of percolation
438	storms produced	32.80	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.2222	0.00	0.0111	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.2222	0.00	0.0111
Glyphosate	7.6497	0.30	0.3825	2.2063	0.09	0.1103	0.0000	0.00	0.0000	9.8560	0.39	0.4928
Hexazinone	37.9340	0.82	1.8967	0.0238	0.00	0.0012	0.0000	0.00	0.0000	37.9578	0.82	1.8979
Imazapyr Acid	41.4046	1.79	2.0702	0.0481	0.00	0.0024	0.0000	0.00	0.0000	41.4527	1.79	2.0726
Metsulfuron-Meth	0.2987	0.36	0.0149	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.2988	0.36	0.0149
Sulfometuron-Met	0.7823	0.76	0.0391	0.0007	0.00	0.0000	0.0000	0.00	0.0000	0.7830	0.76	0.0391
Triclopyr Amine	2.3225	0.20	0.1161	0.0005	0.00	0.0000	0.0000	0.00	0.0000	2.3230	0.20	0.1162
Clorpyrifos	9.2088	0.80	0.4604	0.6592	0.06	0.0330	0.0000	0.00	0.0000	9.8680	0.86	0.4934
Diazinon	14.0770	2.43	0.7038	0.1655	0.03	0.0083	0.0000	0.00	0.0000	14.2425	2.46	0.7121
Fenoxycarb	0.0253	0.12	0.0013	0.0003	0.00	0.0000	0.0000	0.00	0.0000	0.0256	0.12	0.0013

MLRA 83B

Soil Series: Catarina

30 Year Storm Summary

1982	storms produced	1692.51	cm. of rainfall
365	storms produced	265.38	cm. of runoff
586	storms produced	15.39	cm. of percolation
365	storms produced	31.67	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.1657	0.00	0.0083	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.1657	0.00	0.0083
Glyphosate	7.2044	0.28	0.3602	1.7683	0.07	0.0884	0.0000	0.00	0.0000	8.9727	0.35	0.4486
Hexazinone	23.3234	0.50	1.1662	0.0125	0.00	0.0006	0.0000	0.00	0.0000	23.3359	0.50	1.1668
Imazapyr Acid	29.6417	1.28	1.4821	0.0297	0.00	0.0015	0.0000	0.00	0.0000	29.6714	1.28	1.4836
Metsulfuron-Meth	0.1779	0.22	0.0089	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.1780	0.22	0.0089
Sulfometuron-Met	0.5244	0.51	0.0262	0.0004	0.00	0.0000	0.0000	0.00	0.0000	0.5247	0.51	0.0262
Triclopyr Amine	1.3596	0.12	0.0680	0.0003	0.00	0.0000	0.0000	0.00	0.0000	1.3599	0.12	0.0680
Clorpyrifos	7.8757	0.69	0.3938	0.4820	0.04	0.0241	0.0000	0.00	0.0000	8.3577	0.73	0.4179
Diazinon	10.3762	1.79	0.5188	0.1043	0.02	0.0052	0.0000	0.00	0.0000	10.4804	1.81	0.5240
Fenoxycarb	0.0060	0.03	0.0003	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0061	0.03	0.0003

MLRA 83B

Soil Series: Maverick

30 Year Storm Summary

1982	storms produced	1692.51	cm. of rainfall
360	storms produced	258.40	cm. of runoff
516	storms produced	14.26	cm. of percolation
360	storms produced	103.85	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.1616	0.00	0.0081	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.1616	0.00	0.0081
Glyphosate	10.1334	0.39	0.5067	5.5487	0.21	0.2774	0.0000	0.00	0.0000	15.6821	0.60	0.7841
Hexazinone	12.7694	0.28	0.6385	0.0141	0.00	0.0007	0.0000	0.00	0.0000	12.7835	0.28	0.6392
Imazapyr Acid	15.5627	0.67	0.7781	0.0327	0.00	0.0016	0.0000	0.00	0.0000	15.5954	0.67	0.7798
Metsulfuron-Meth	0.1089	0.13	0.0054	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.1090	0.13	0.0054
Sulfometuron-Met	0.2809	0.27	0.0140	0.0004	0.00	0.0000	0.0000	0.00	0.0000	0.2814	0.27	0.0141
Triclopyr Amine	0.9866	0.09	0.0493	0.0004	0.00	0.0000	0.0000	0.00	0.0000	0.9869	0.09	0.0493
Clorpyrifos	9.8973	0.86	0.4949	1.3477	0.12	0.0674	0.0000	0.00	0.0000	11.2449	0.98	0.5622
Diazinon	8.6645	1.50	0.4332	0.1907	0.03	0.0095	0.0000	0.00	0.0000	8.8552	1.53	0.4428
Fenoxycarb	0.0058	0.03	0.0003	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0060	0.03	0.0003

MLRA 83B

Soil Series: Montell

30 Year Storm Summary

1982	storms produced	1692.51	cm. of rainfall
357	storms produced	253.71	cm. of runoff
152	storms produced	2.50	cm. of percolation
357	storms produced	13.28	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.2329	0.00	0.0116	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.2329	0.00	0.0116
Glyphosate	5.6825	0.22	0.2841	0.8334	0.03	0.0417	0.0000	0.00	0.0000	6.5158	0.25	0.3258
Hexazinone	32.3228	0.70	1.6161	0.0108	0.00	0.0005	0.0000	0.00	0.0000	32.3337	0.70	1.6167
Imazapyr Acid	35.8198	1.55	1.7910	0.0221	0.00	0.0011	0.0000	0.00	0.0000	35.8420	1.55	1.7921
Metsulfuron-Meth	0.2505	0.30	0.0125	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.2506	0.30	0.0125
Sulfometuron-Met	0.6573	0.64	0.0329	0.0003	0.00	0.0000	0.0000	0.00	0.0000	0.6576	0.64	0.0329
Triclopyr Amine	1.9782	0.17	0.0989	0.0002	0.00	0.0000	0.0000	0.00	0.0000	1.9785	0.17	0.0989
Clorpyrifos	6.3874	0.56	0.3194	0.2351	0.02	0.0118	0.0000	0.00	0.0000	6.6225	0.58	0.3311
Diazinon	9.8855	1.71	0.4943	0.0603	0.01	0.0030	0.0000	0.00	0.0000	9.9458	1.72	0.4973
Fenoxycarb	0.0052	0.03	0.0003	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0052	0.03	0.0003

MLRA 83C

Soil Series: Delmita

30 Year Storm Summary

1790	storms produced	1815.67	cm. of rainfall
352	storms produced	256.10	cm. of runoff
21	storms produced	20.35	cm. of percolation
352	storms produced	15.46	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0113	0.00	0.0006	0.0000	0.00	0.0000	0.0574	0.00	0.0029	0.0687	0.00	0.0034
Glyphosate	10.1024	0.39	0.5051	0.6609	0.03	0.0330	0.0000	0.00	0.0000	10.7633	0.42	0.5382
Hexazinone	3.0669	0.07	0.1533	0.0007	0.00	0.0000	4.5469	0.10	0.2273	7.6145	0.17	0.3807
Imazapyr Acid	5.1959	0.22	0.2598	0.0019	0.00	0.0001	0.8958	0.04	0.0448	6.0936	0.26	0.3047
Metsulfuron-Meth	0.0193	0.02	0.0010	0.0000	0.00	0.0000	0.0004	0.00	0.0000	0.0197	0.02	0.0010
Sulfometuron-Met	0.0776	0.08	0.0039	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0776	0.08	0.0039
Triclopyr Amine	0.1347	0.01	0.0067	0.0000	0.00	0.0000	0.3725	0.03	0.0186	0.5072	0.04	0.0254
Clorpyrifos	8.7704	0.76	0.4385	0.1441	0.01	0.0072	0.0000	0.00	0.0000	8.9145	0.77	0.4457
Diazinon	6.1007	1.05	0.3050	0.0170	0.00	0.0008	0.0000	0.00	0.0000	6.1177	1.05	0.3059
Fenoxycarb	0.0057	0.03	0.0003	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0057	0.03	0.0003

MLRA 83C

Soil Series: Randado

30 Year Storm Summary

1790	storms produced	1815.67	cm. of rainfall
341	storms produced	246.57	cm. of runoff
69	storms produced	71.11	cm. of percolation
341	storms produced	32.40	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0192	0.00	0.0010	0.0000	0.00	0.0000	1.7791	0.00	0.0890	1.7983	0.00	0.0899
Glyphosate	7.8406	0.30	0.3920	1.4458	0.06	0.0723	0.0000	0.00	0.0000	9.2864	0.36	0.4643
Hexazinone	4.6650	0.10	0.2332	0.0024	0.00	0.0001	74.6665	1.61	3.7333	79.3338	1.71	3.9667
Imazapyr Acid	7.4334	0.32	0.3717	0.0064	0.00	0.0003	22.5215	0.97	1.1261	29.9614	1.29	1.4981
Metsulfuron-Meth	0.0297	0.04	0.0015	0.0000	0.00	0.0000	0.2236	0.27	0.0112	0.2533	0.31	0.0127
Sulfometuron-Met	0.1166	0.11	0.0058	0.0001	0.00	0.0000	0.0151	0.01	0.0008	0.1318	0.12	0.0066
Triclopyr Amine	0.2080	0.02	0.0104	0.0000	0.00	0.0000	10.5576	0.91	0.5279	10.7656	0.93	0.5383
Clorpyrifos	7.2573	0.63	0.3629	0.3309	0.03	0.0165	0.0000	0.00	0.0000	7.5882	0.66	0.3794
Diazinon	6.4204	1.11	0.3210	0.0482	0.01	0.0024	0.0002	0.00	0.0000	6.4688	1.12	0.3234
Fenoxycarb	0.0059	0.03	0.0003	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0060	0.03	0.0003

MLRA 83C

Soil Series: Sarita

30 Year Storm Summary

1790	storms produced	1815.67	cm. of rainfall
359	storms produced	262.66	cm. of runoff
8	storms produced	7.09	cm. of percolation
359	storms produced	35.07	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0068	0.00	0.0003	0.0000	0.00	0.0000	0.0001	0.00	0.0000	0.0068	0.00	0.0003
Glyphosate	7.8405	0.30	0.3920	1.4814	0.06	0.0741	0.0000	0.00	0.0000	9.3219	0.36	0.4661
Hexazinone	5.3100	0.11	0.2655	0.0029	0.00	0.0001	0.0042	0.00	0.0002	5.3171	0.11	0.2659
Imazapyr Acid	9.7222	0.42	0.4861	0.0088	0.00	0.0004	0.0000	0.00	0.0000	9.7311	0.42	0.4866
Metsulfuron-Meth	0.0287	0.03	0.0014	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0287	0.03	0.0014
Sulfometuron-Met	0.1409	0.14	0.0070	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.1410	0.14	0.0071
Triclopyr Amine	0.1535	0.01	0.0077	0.0000	0.00	0.0000	0.0004	0.00	0.0000	0.1540	0.01	0.0077
Clorpyrifos	7.6051	0.66	0.3803	0.3546	0.03	0.0177	0.0000	0.00	0.0000	7.9597	0.69	0.3980
Diazinon	7.6487	1.32	0.3824	0.0586	0.01	0.0029	0.0000	0.00	0.0000	7.7073	1.33	0.3854
Fenoxycarb	0.0057	0.03	0.0003	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0057	0.03	0.0003

MLRA 83D

Soil Series: Brennan

30 Year Storm Summary

1790	storms produced	1815.67	cm. of rainfall
348	storms produced	253.97	cm. of runoff
21	storms produced	20.22	cm. of percolation
348	storms produced	33.19	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0118	0.00	0.0006	0.0000	0.00	0.0000	0.0078	0.00	0.0004	0.0196	0.00	0.0010
Glyphosate	7.8439	0.30	0.3922	1.4391	0.06	0.0720	0.0000	0.00	0.0000	9.2831	0.36	0.4642
Hexazinone	4.8889	0.11	0.2444	0.0026	0.00	0.0001	0.5427	0.01	0.0271	5.4342	0.12	0.2717
Imazapyr Acid	8.2835	0.36	0.4142	0.0073	0.00	0.0004	0.0562	0.00	0.0028	8.3470	0.36	0.4174
Metsulfuron-Meth	0.0284	0.03	0.0014	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0285	0.03	0.0014
Sulfometuron-Met	0.1229	0.12	0.0061	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.1230	0.12	0.0061
Triclopyr Amine	0.1784	0.02	0.0089	0.0000	0.00	0.0000	0.0457	0.00	0.0023	0.2241	0.02	0.0112
Clorpyrifos	7.4504	0.65	0.3725	0.3379	0.03	0.0169	0.0000	0.00	0.0000	7.7883	0.68	0.3894
Diazinon	6.9973	1.21	0.3499	0.0522	0.01	0.0026	0.0000	0.00	0.0000	7.0495	1.22	0.3525
Fenoxycarb	0.0057	0.03	0.0003	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0058	0.03	0.0003

MLRA 83D

Soil Series: Hidalgo

30 Year Storm Summary

1790	storms produced	1815.67	cm. of rainfall
336	storms produced	246.32	cm. of runoff
19	storms produced	17.68	cm. of percolation
336	storms produced	29.35	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0303	0.00	0.0015	0.0000	0.00	0.0000	0.0045	0.00	0.0002	0.0347	0.00	0.0017
Glyphosate	4.2198	0.16	0.2110	1.4037	0.05	0.0702	0.0000	0.00	0.0000	5.6235	0.21	0.2812
Hexazinone	16.8500	0.36	0.8425	0.0142	0.00	0.0007	0.1289	0.00	0.0064	16.9931	0.36	0.8497
Imazapyr Acid	22.8965	0.99	1.1448	0.0334	0.00	0.0017	0.0015	0.00	0.0001	22.9314	0.99	1.1466
Metsulfuron-Meth	0.1020	0.12	0.0051	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.1020	0.12	0.0051
Sulfometuron-Met	0.3737	0.36	0.0187	0.0004	0.00	0.0000	0.0000	0.00	0.0000	0.3742	0.36	0.0187
Triclopyr Amine	0.5951	0.05	0.0298	0.0002	0.00	0.0000	0.0148	0.00	0.0007	0.6101	0.05	0.0305
Clorpyrifos	4.5966	0.40	0.2298	0.3786	0.03	0.0189	0.0000	0.00	0.0000	4.9752	0.43	0.2488
Diazinon	7.7890	1.35	0.3894	0.1055	0.02	0.0053	0.0000	0.00	0.0000	7.8945	1.37	0.3947
Fenoxycarb	0.0053	0.03	0.0003	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0054	0.03	0.0003

MLRA 83D

Soil Series: McAllen

30 Year Storm Summary

1790	storms produced	1815.67	cm. of rainfall
342	storms produced	250.66	cm. of runoff
21	storms produced	20.90	cm. of percolation
342	storms produced	32.64	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0118	0.00	0.0006	0.0000	0.00	0.0000	0.0091	0.00	0.0005	0.0209	0.00	0.0010
Glyphosate	9.9451	0.38	0.4973	1.3543	0.05	0.0677	0.0000	0.00	0.0000	11.2994	0.43	0.5650
Hexazinone	2.6165	0.06	0.1308	0.0011	0.00	0.0001	0.9039	0.02	0.0452	3.5214	0.08	0.1761
Imazapyr Acid	4.3140	0.19	0.2157	0.0029	0.00	0.0001	0.1372	0.01	0.0069	4.4542	0.20	0.2227
Metsulfuron-Meth	0.0172	0.02	0.0009	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0173	0.02	0.0009
Sulfometuron-Met	0.0665	0.06	0.0033	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0665	0.06	0.0033
Triclopyr Amine	0.1258	0.01	0.0063	0.0000	0.00	0.0000	0.0591	0.01	0.0030	0.1849	0.02	0.0092
Clorpyrifos	8.5318	0.74	0.4266	0.2870	0.03	0.0143	0.0000	0.00	0.0000	8.8188	0.77	0.4409
Diazinon	5.6427	0.98	0.2821	0.0313	0.01	0.0016	0.0000	0.00	0.0000	5.6740	0.99	0.2837
Fenoxycarb	0.0056	0.03	0.0003	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0056	0.03	0.0003

MLRA 84B

Soil Series: Chaney

30 Year Storm Summary

2583	storms produced	2045.35	cm. of rainfall
517	storms produced	246.14	cm. of runoff
26	storms produced	26.51	cm. of percolation
517	storms produced	64.96	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.1270	0.00	0.0064	0.0000	0.00	0.0000	0.0045	0.00	0.0002	0.1315	0.00	0.0066
Glyphosate	13.9218	0.54	0.6961	5.1944	0.20	0.2597	0.0000	0.00	0.0000	19.1162	0.74	0.9558
Hexazinone	23.9599	0.52	1.1980	0.0197	0.00	0.0010	0.1406	0.00	0.0070	24.1203	0.52	1.2060
Imazapyr Acid	31.7223	1.37	1.5861	0.0480	0.00	0.0024	0.0082	0.00	0.0004	31.7786	1.37	1.5889
Metsulfuron-Meth	0.1797	0.22	0.0090	0.0001	0.00	0.0000	0.0001	0.00	0.0000	0.1799	0.22	0.0090
Sulfometuron-Met	0.6377	0.62	0.0319	0.0008	0.00	0.0000	0.0000	0.00	0.0000	0.6385	0.62	0.0319
Triclopyr Amine	1.2917	0.11	0.0646	0.0004	0.00	0.0000	0.0073	0.00	0.0004	1.2994	0.11	0.0650
Clorpyrifos	16.5955	1.45	0.8298	1.5458	0.13	0.0773	0.0000	0.00	0.0000	18.1413	1.58	0.9071
Diazinon	16.4916	2.85	0.8246	0.2483	0.04	0.0124	0.0000	0.00	0.0000	16.7399	2.89	0.8370
Fenoxycarb	0.0473	0.23	0.0024	0.0008	0.00	0.0000	0.0000	0.00	0.0000	0.0480	0.23	0.0024

MLRA 84B

Soil Series: Duffau

30 Year Storm Summary

2583	storms produced	2045.35	cm. of rainfall
474	storms produced	218.30	cm. of runoff
62	storms produced	68.43	cm. of percolation
474	storms produced	62.12	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0735	0.00	0.0037	0.0000	0.00	0.0000	0.0293	0.00	0.0015	0.1028	0.00	0.0051
Glyphosate	12.0741	0.47	0.6037	4.8644	0.19	0.2432	0.0000	0.00	0.0000	16.9385	0.66	0.8469
Hexazinone	14.8101	0.32	0.7405	0.0144	0.00	0.0007	0.8408	0.02	0.0420	15.6652	0.34	0.7833
Imazapyr Acid	21.0796	0.91	1.0540	0.0362	0.00	0.0018	0.0653	0.00	0.0033	21.1811	0.91	1.0591
Metsulfuron-Meth	0.1053	0.13	0.0053	0.0001	0.00	0.0000	0.0009	0.00	0.0000	0.1062	0.13	0.0053
Sulfometuron-Met	0.4036	0.39	0.0202	0.0005	0.00	0.0000	0.0001	0.00	0.0000	0.4042	0.39	0.0202
Triclopyr Amine	0.7493	0.06	0.0375	0.0003	0.00	0.0000	0.0535	0.00	0.0027	0.8031	0.06	0.0402
Clorpyrifos	14.1313	1.23	0.7066	1.4226	0.12	0.0711	0.0000	0.00	0.0000	15.5539	1.35	0.7777
Diazinon	13.3064	2.30	0.6653	0.2166	0.04	0.0108	0.0000	0.00	0.0000	13.5230	2.34	0.6761
Fenoxycarb	0.0402	0.19	0.0020	0.0007	0.00	0.0000	0.0000	0.00	0.0000	0.0409	0.19	0.0020

MLRA 84B

Soil Series: Windthorst

30 Year Storm Summary

2583	storms produced	2045.35	cm. of rainfall
487	storms produced	224.90	cm. of runoff
36	storms produced	35.73	cm. of percolation
487	storms produced	130.21	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0954	0.00	0.0048	0.0000	0.00	0.0000	0.0079	0.00	0.0004	0.1033	0.00	0.0052
Glyphosate	12.5544	0.49	0.6277	10.3635	0.40	0.5182	0.0000	0.00	0.0000	22.9179	0.89	1.1459
Hexazinone	16.9887	0.37	0.8494	0.0301	0.00	0.0015	0.3709	0.01	0.0185	17.3897	0.38	0.8695
Imazapyr Acid	23.2700	1.01	1.1635	0.0762	0.00	0.0038	0.0404	0.00	0.0020	23.3866	1.01	1.1693
Metsulfuron-Meth	0.1248	0.15	0.0062	0.0001	0.00	0.0000	0.0003	0.00	0.0000	0.1252	0.15	0.0063
Sulfometuron-Met	0.4533	0.44	0.0227	0.0012	0.00	0.0001	0.0000	0.00	0.0000	0.4545	0.44	0.0227
Triclopyr Amine	0.9197	0.08	0.0460	0.0006	0.00	0.0000	0.0160	0.00	0.0008	0.9364	0.08	0.0468
Clorpyrifos	14.7354	1.28	0.7368	3.0410	0.27	0.1521	0.0000	0.00	0.0000	17.7764	1.55	0.8888
Diazinon	13.9490	2.41	0.6975	0.4623	0.08	0.0231	0.0000	0.00	0.0000	14.4113	2.49	0.7206
Fenoxycarb	0.0422	0.20	0.0021	0.0015	0.01	0.0001	0.0000	0.00	0.0000	0.0437	0.21	0.0022

MLRA 84C

Soil Series: Aubrey

30 Year Storm Summary

3398	storms produced	2598.48	cm. of rainfall
640	storms produced	356.38	cm. of runoff
183	storms produced	163.96	cm. of percolation
640	storms produced	511.83	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0532	0.00	0.0027	0.0000	0.00	0.0000	0.2499	0.00	0.0125	0.3031	0.00	0.0152
Glyphosate	16.3765	0.63	0.8188	0.2875	0.01	0.0144	0.0000	0.00	0.0000	16.6640	0.64	0.8332
Hexazinone	0.7889	0.02	0.0394	0.0000	0.00	0.0000	46.9278	1.01	2.3464	47.7167	1.03	2.3858
Imazapyr Acid	0.4145	0.02	0.0207	0.0000	0.00	0.0000	23.1106	1.00	1.1555	23.5251	1.02	1.1763
Metsulfuron-Meth	0.0117	0.01	0.0006	0.0000	0.00	0.0000	0.0273	0.03	0.0014	0.0391	0.04	0.0020
Sulfometuron-Met	0.0116	0.01	0.0006	0.0000	0.00	0.0000	0.0193	0.02	0.0010	0.0309	0.03	0.0015
Triclopyr Amine	0.1807	0.02	0.0090	0.0000	0.00	0.0000	1.2571	0.11	0.0629	1.4378	0.13	0.0719
Clorpyrifos	3.8104	0.33	0.1905	0.0185	0.00	0.0009	0.0000	0.00	0.0000	3.8288	0.33	0.1914
Diazinon	0.1554	0.03	0.0078	0.0001	0.00	0.0000	0.0381	0.01	0.0019	0.1936	0.04	0.0097
Fenoxycarb	0.0009	0.00	0.0000	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0009	0.00	0.0000

MLRA 84C

Soil Series: Callisburg

30 Year Storm Summary

3398	storms produced	2598.48	cm. of rainfall
640	storms produced	361.63	cm. of runoff
151	storms produced	158.72	cm. of percolation
640	storms produced	99.79	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.1461	0.00	0.0073	0.0000	0.00	0.0000	0.0102	0.00	0.0005	0.1564	0.00	0:0078
Glyphosate	7.7528	0.30	0.3876	2.9961	0.12	0.1498	0.0000	0.00	0.0000	10.7489	0.42	0.5374
Hexazinone	13.4567	0.29	0.6728	0.0113	0.00	0.0006	4.6144	0.10	0.2307	18.0825	0.39	0.9041
Imazapyr Acid	14.6251	0.63	0.7313	0.0229	0.00	0.0011	1.3323	0.06	0.0666	15.9803	0.69	0.7990
Metsulfuron-Meth	0.1192	0.14	0.0060	0.0001	0.00	0.0000	0.0005	0.00	0.0000	0.1198	0.14	0.0060
Sulfometuron-Met	0.2750	0.27	0.0138	0.0003	0.00	0.0000	0.0002	0.00	0.0000	0.2755	0.27	0.0138
Triclopyr Amine	1.0579	0.09	0.0529	0.0003	0.00	0.0000	0.0537	0.00	0.0027	1.1120	0.09	0.0556
Clorpyrifos	7.5446	0.66	0.3772	0.7272	0.06	0.0364	0.0000	0.00	0.0000	8.2718	0.72	0.4136
Diazinon	6.7010	1.16	0.3350	0.1060	0.02	0.0053	0.0000	0.00	0.0000	6.8070	1.18	0.3403
Fenoxycarb	0.0067	0.03	0.0003	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0068	0.03	0.0003

MLRA 84C

Soil Series: Crosstell

30 Year Storm Summary

3398	storms produced	2598.48	cm. of rainfall
683	storms produced	433.90	cm. of runoff
2569	storms produced	150.74	cm. of percolation
683	storms produced	254.21	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	1.4919	0.00	0.0746	0.0002	0.00	0.0000	0.0000	0.00	0.0000	1.4921	0.00	0.0746
Glyphosate	9.7198	0.38	0.4860	7.9229	0.31	0.3961	0.0000	0.00	0.0000	17.6427	0.69	0.8821
Hexazinone	42.2530	0.91	2.1126	0.0574	0.00	0.0029	0.0029	0.00	0.0001	42.3133	0.91	2.1157
Imazapyr Acid	33.2202	1.44	1.6610	0.0880	0.00	0.0044	0.0000	0.00	0.0000	33.3082	1.44	1.6654
Metsulfuron-Meth	0.5013	0.61	0.0251	0.0004	0.00	0.0000	0.0000	0.00	0.0000	0.5017	0.61	0.0251
Sulfometuron-Met	0.8421	0.81	0.0421	0.0017	0.00	0.0001	0.0000	0.00	0.0000	0.8437	0.81	0.0422
Triclopyr Amine	5.8095	0.50	0.2905	0.0028	0.00	0.0001	0.0000	0.00	0.0000	5.8122	0.50	0.2906
Clorpyrifos	9.8660	0.86	0.4933	2.0031	0.17	0.1002	0.0000	0.00	0.0000	11.8691	1.03	0.5935
Diazinon	9.3450	1.61	0.4672	0.3034	0.05	0.0152	0.0000	0.00	0.0000	9.6483	1.66	0.4824
Fenoxycarb	0.0187	0.09	0.0009	0.0005	0.00	0.0000	0.0000	0.00	0.0000	0.0192	0.09	0.0010

MLRA 85

Soil Series: Aledo

30 Year Storm Summary

2149	storms produced	2483.01	cm. of rainfall
569	storms produced	367.52	cm. of runoff
207	storms produced	211.29	cm. of percolation
568	storms produced	1320.18	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0470	0.00	0.0024	0.0000	0.00	0.0000	8.8679	0.00	0.4434	8.9150	0.00	0.4457
Glyphosate	31.3213	1.21	1.5661	1.5652	0.06	0.0783	0.0529	0.00	0.0026	32.9394	1.27	1.6470
Hexazinone	0.7193	0.02	0.0360	0.0001	0.00	0.0000	293.0080	6.33	14.6504	293.7273	6.35	14.6864
Imazapyr Acid	0.3791	0.02	0.0190	0.0001	0.00	0.0000	148.3334	6.41	7.4167	148.7126	6.43	7.4356
Metsulfuron-Meth	0.0099	0.01	0.0005	0.0000	0.00	0.0000	1.8213	2.20	0.0911	1.8312	2.21	0.0916
Sulfometuron-Met	0.0097	0.01	0.0005	0.0000	0.00	0.0000	1.4384	1.39	0.0719	1.4482	1.40	0.0724
Triclopyr Amine	0.1599	0.01	0.0080	0.0000	0.00	0.0000	36.7533	3.18	1.8377	36.9132	3.19	1.8457
Clorpyrifos	5.3202	0.46	0.2660	0.0586	0.01	0.0029	0.4245	0.04	0.0212	5.8033	0.51	0.2902
Diazinon	0.1456	0.03	0.0073	0.0002	0.00	0.0000	6.4646	1.12	0.3232	6.6104	1.15	0.3305
Fenoxycarb	0.0002	0.00	0.0000	0.0000	0.00	0.0000	0.0039	0.02	0.0002	0.0042	0.02	0.0002

MLRA 85

Soil Series: Slidell

30 Year Storm Summary

2149	storms produced	2483.01	cm. of rainfall
599	storms produced	506.79	cm. of runoff
1142	storms produced	72.45	cm. of percolation
598	storms produced	1405.78	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	1.2278	0.00	0.0614	0.0033	0.00	0.0002	0.0000	0.00	0.0000	1.2311	0.00	0.0616
Glyphosate	7.3867	0.29	0.3693	76.3785	2.96	3.8189	0.0000	0.00	0.0000	83.7651	3.25	4.1883
Hexazinone	127.1038	2.75	6.3552	2.8273	0.06	0.1414	0.0000	0.00	0.0000	129.9312	2.81	6.4966
Imazapyr Acid	104.0606	4.50	5.2030	4.2792	0.18	0.2140	0.0000	0.00	0.0000	108.3399	4.68	5.4170
Metsulfuron-Meth	1.2080	1.46	0.0604	0.0178	0.02	0.0009	0.0000	0.00	0.0000	1.2259	1.48	0.0613
Sulfometuron-Met	2.4337	2.36	0.1217	0.0793	0.08	0.0040	0.0000	0.00	0.0000	2.5129	2.44	0.1256
Triclopyr Amine	10.3697	0.90	0.5185	0.0889	0.01	0.0044	0.0000	0.00	0.0000	10.4586	0.91	0.5229
Clorpyrifos	9.7011	0.85	0.4851	25.3281	2.21	1.2664	0.0000	0.00	0.0000	35.0292	3.06	1.7515
Diazinon	19.7901	3.42	0.9895	8.5266	1.47	0.4263	0.0000	0.00	0.0000	28.3167	4.89	1.4158
Fenoxycarb	0.0228	0.11	0.0011	0.0110	0.05	0.0006	0.0000	0.00	0.0000	0.0338	0.16	0.0017

MLRA 85

Soil Series: Topsey

30 Year Storm Summary

2149	storms produced	2483.01	cm. of rainfall
540	storms produced	354.70	cm. of runoff
18	storms produced	12.04	cm. of percolation
538	storms produced	86.15	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.4035	0.00	0.0202	0.0001	0.00	0.0000	0.0004	0.00	0.0000	0.4040	0.00	0.0202
Glyphosate	6.1209	0.24	0.3060	5.3317	0.21	0.2666	0.0000	0.00	0.0000	11.4525	0.45	0.5726
Hexazinone	73.9314	1.60	3.6966	0.1338	0.00	0.0067	0.1082	0.00	0.0054	74.1733	1.60	3.7087
Imazapyr Acid	67.8123	2.93	3.3906	0.2312	0.01	0.0116	0.0108	0.00	0.0005	68.0543	2.94	3.4027
Metsulfuron-Meth	0.6122	0.74	0.0306	0.0007	0.00	0.0000	0.0000	0.00	0.0000	0.6129	0.74	0.0306
Sulfometuron-Met	1.5030	1.45	0.0752	0.0040	0.00	0.0002	0.0000	0.00	0.0000	1.5070	1.45	0.0753
Triclopyr Amine	4.5614	0.39	0.2281	0.0030	0.00	0.0001	0.0012	0.00	0.0001	4.5656	0.39	0.2283
Clorpyrifos	7.9580	0.69	0.3979	1.7373	0.15	0.0869	0.0000	0.00	0.0000	9.6953	0.84	0.4848
Diazinon	15.3922	2.66	0.7696	0.5528	0.10	0.0276	0.0000	0.00	0.0000	15.9450	2.76	0.7973
Fenoxycarb	0.0180	0.09	0.0009	0.0007	0.00	0.0000	0.0000	0.00	0.0000	0.0187	0.09	0.0009

MLRA 86A

Soil Series: Crockett

30 Year Storm Summary

3333	storms produced	2465.25	cm. of rainfall
220	storms produced	88.72	cm. of runoff
3095	storms produced	259.25	cm. of percolation
218	storms produced	44.05	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0322	0.00	0.0016	0.0000	0.00	0.0000	0.0001	0.00	0.0000	0.0322	0.00	0.0016
Glyphosate	3.3519	0.13	0.1676	2.8546	0.11	0.1427	0.0000	0.00	0.0000	6.2065	0.24	0.3103
Hexazinone	5.0864	0.11	0.2543	0.0094	0.00	0.0005	5.6375	0.12	0.2819	10.7333	0.23	0.5367
Imazapyr Acid	7.2817	0.31	0.3641	0.0251	0.00	0.0013	0.6359	0.03	0.0318	7.9427	0.34	0.3971
Metsulfuron-Meth	0.0386	0.05	0.0019	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0386	0.05	0.0019
Sulfometuron-Met	0.1563	0.15	0.0078	0.0004	0.00	0.0000	0.0000	0.00	0.0000	0.1567	0.15	0.0078
Triclopyr Amine	0.2598	0.02	0.0130	0.0002	0.00	0.0000	0.0037	0.00	0.0002	0.2638	0.02	0.0132
Clorpyrifos	4.3592	0.38	0.2180	0.9241	0.08	0.0462	0.0000	0.00	0.0000	5.2832	0.46	0.2642
Diazinon	4.6992	0.81	0.2350	0.1633	0.03	0.0082	0.0000	0.00	0.0000	4.8625	0.84	0.2431
Fenoxycarb	0.0115	0.06	0.0006	0.0004	0.00	0.0000	0.0000	0.00	0.0000	0.0118	0.06	0.0006

MLRA 86A

Soil Series: Heiden

30 Year Storm Summary

3333	storms produced	2465.25	cm. of rainfall
394	storms produced	197.74	cm. of runoff
3333	storms produced	266.53	cm. of percolation
393	storms produced	197.93	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	1.6402	0.00	0.0820	0.0017	0.00	0.0001	0.0000	0.00	0.0000	1.6418	0.00	0.0821
Glyphosate	3.9072	0.15	0.1954	14.3438	0.56	0.7172	0.0000	0.00	0.0000	18.2510	0.71	0.9125
Hexazinone	68.8711	1.49	3.4436	0.5984	0.01	0.0299	0.0102	0.00	0.0005	69.4797	1.50	3.4740
Imazapyr Acid	51.3218	2.22	2.5661	0.8198	0.04	0.0410	0.0000	0.00	0.0000	52.1416	2.26	2.6071
Metsulfuron-Meth	0.7791	0.94	0.0390	0.0044	0.01	0.0002	0.0000	0.00	0.0000	0.7835	0.95	0.0392
Sulfometuron-Met	1.4582	1.41	0.0729	0.0184	0.02	0.0009	0.0000	0.00	0.0000	1.4766	1.43	0.0738
Triclopyr Amine	7.9623	0.69	0.3981	0.0262	0.00	0.0013	0.0000	0.00	0.0000	7.9885	0.69	0.3994
Clorpyrifos	5.5276	0.48	0.2764	5.2022	0.45	0.2601	0.0000	0.00	0.0000	10.7298	0.93	0.5365
Diazinon	10.2279	1.77	0.5114	1.5998	0.28	0.0800	0.0000	0.00	0.0000	11.8277	2.05	0.5914
Fenoxycarb	0.0220	0.11	0.0011	0.0037	0.02	0.0002	0.0000	0.00	0.0000	0.0256	0.13	0.0013

MLRA 86A

Soil Series: Houston Black

30 Year Storm Summary

3333	storms produced	2465.25	cm. of rainfall
393	storms produced	207.08	cm. of runoff
3105	storms produced	134.99	cm. of percolation
389	storms produced	39.25	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	1.1640	0.00	0.0582	0.0002	0.00	0.0000	0.0000	0.00	0.0000	1.1642	0.00	0.0582
Glyphosate	3.6088	0.14	0.1804	2.8715	0.11	0.1436	0.0000	0.00	0.0000	6.4802	0.25	0.3240
Hexazinone	67.7148	1.46	3.3857	0.1209	0.00	0.0060	0.0000	0.00	0.0000	67.8357	1.46	3.3918
Imazapyr Acid	48.7098	2.10	2.4355	0.1625	0.01	0.0081	0.0000	0.00	0.0000	48.8724	2.11	2.4436
Metsulfuron-Meth	0.7222	0.87	0.0361	0.0008	0.00	0.0000	0.0000	0.00	0.0000	0.7230	0.87	0.0362
Sulfometuron-Met	1.3692	1.33	0.0685	0.0035	0.00	0.0002	0.0000	0.00	0.0000	1.3727	1.33	0.0686
Triclopyr Amine	6.7939	0.59	0.3397	0.0045	0.00	0.0002	0.0000	0.00	0.0000	6.7984	0.59	0.3399
Clorpyrifos	5.0660	0.44	0.2533	1.0165	0.09	0.0508	0.0000	0.00	0.0000	6.0825	0.53	0.3041
Diazinon	10.0182	1.73	0.5009	0.3326	0.06	0.0166	0.0000	0.00	0.0000	10.3508	1.79	0.5175
Fenoxycarb	0.0203	0.10	0.0010	0.0007	0.00	0.0000	0.0000	0.00	0.0000	0.0210	0.10	0.0010

MLRA 86B

Soil Series: Burleson

30 Year Storm Summary

2455	storms produced	2980.89	cm. of rainfall
742	storms produced	635.92	cm. of runoff
2355	storms produced	159.12	cm. of percolation
741	storms produced	63.65	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.9818	0.00	0.0491	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.9818	0.00	0.0491
Glyphosate	12.0410	0.47	0.6021	3.4199	0.13	0.1710	0.0000	0.00	0.0000	15.4609	0.60	0.7730
Hexazinone	103.6404	2.24	5.1820	0.0601	0.00	0.0030	0.0000	0.00	0.0000	103.7006	2.24	5.1850
Imazapyr Acid	98.0656	4.24	4.9033	0.1097	0.00	0.0055	0.0000	0.00	0.0000	98.1753	4.24	4.9088
Metsulfuron-Meth	0.9239	1.12	0.0462	0.0003	0.00	0.0000	0.0000	0.00	0.0000	0.9243	1.12	0.0462
Sulfometuron-Met	2.1356	2.07	0.1068	0.0018	0.00	0.0001	0.0000	0.00	0.0000	2.1374	2.07	0.1069
Triclopyr Amine	7.9471	0.69	0.3974	0.0016	0.00	0.0001	0.0000	0.00	0.0000	7.9486	0.69	0.3974
Clorpyrifos	15.2790	1.33	0.7640	1.0921	0.10	0.0546	0.0000	0.00	0.0000	16.3711	1.43	0.8186
Diazinon	24.6192	4.25	1.2310	0.2912	0.05	0.0146	0.0000	0.00	0.0000	24.9104	4.30	1.2455
Fenoxycarb	0.0389	0.19	0.0019	0.0005	0.00	0.0000	0.0000	0.00	0.0000	0.0394	0.19	0.0020

MLRA 86B

Soil Series: Frelsburg

30 Year Storm Summary

2455	storms produced	2980.89	cm. of rainfall
720	storms produced	553.57	cm. of runoff
4331	storms produced	332.73	cm. of percolation
719	storms produced	113.17	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	1.0219	0.00	0.0511	0.0001	0.00	0.0000	0.0000	0.00	0.0000	1.0221	0.00	0.0511
Glyphosate	9.0278	0.35	0.4514	6.6007	0.26	0.3300	0.0000	0.00	0.0000	15.6286	0.61	0.7814
Hexazinone	80.4066	1.74	4.0203	0.1164	0.00	0.0058	0.0001	0.00	0.0000	80.5231	1.74	4.0262
Imazapyr Acid	68.4716	2.96	3.4236	0.1935	0.01	0.0097	0.0000	0.00	0.0000	68.6651	2.97	3.4333
Metsulfuron-Meth	0.7529	0.91	0.0376	0.0007	0.00	0.0000	0.0000	0.00	0.0000	0.7536	0.91	0.0377
Sulfometuron-Met	1.5879	1.54	0.0794	0.0034	0.00	0.0002	0.0000	0.00	0.0000	1.5913	1.54	0.0796
Triclopyr Amine	6.9306	0.60	0.3465	0.0034	0.00	0.0002	0.0000	0.00	0.0000	6.9340	0.60	0.3467
Clorpyrifos	11.5057	1.00	0.5753	2.1275	0.19	0.1064	0.0000	0.00	0.0000	13.6333	1.19	0.6817
Diazinon	19.3689	3.35	0.9684	0.5920	0.10	0.0296	0.0000	0.00	0.0000	19.9609	3.45	0.9980
Fenoxycarb	0.0324	0.16	0.0016	0.0010	0.00	0.0000	0.0000	0.00	0.0000	0.0334	0.16	0.0017

MLRA 86B

Soil Series: Wilson

30 Year Storm Summary

2455	storms produced	2980.89	cm. of rainfall
710	storms produced	531.89	cm. of runoff
2455	storms produced	149.39	cm. of percolation
709	storms produced	70.98	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.3442	0.00	0.0172	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.3443	0.00	0.0172
Glyphosate	15.2025	0.59	0.7601	3.6201	0.14	0.1810	0.0000	0.00	0.0000	18.8226	0.73	0.9411
Hexazinone	38.0034	0.82	1.9002	0.0196	0.00	0.0010	1.5380	0.03	0.0769	39.5610	0.85	1.9780
Imazapyr Acid	43.9541	1.90	2.1977	0.0423	0.00	0.0021	0.0796	0.00	0.0040	44.0760	1.90	2.2038
Metsulfuron-Meth	0.3273	0.40	0.0164	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.3274	0.40	0.0164
Sulfometuron-Met	0.8631	0.84	0.0432	0.0006	0.00	0.0000	0.0000	0.00	0.0000	0.8638	0.84	0.0432
Triclopyr Amine	2.7685	0.24	0.1384	0.0005	0.00	0.0000	0.0002	0.00	0.0000	2.7692	0.24	0.1385
Clorpyrifos	17.7379	1.55	0.8869	1.0647	0.09	0.0532	0.0000	0.00	0.0000	18.8026	1.64	0.9401
Diazinon	19.7841	3.42	0.9892	0.1965	0.03	0.0098	0.0000	0.00	0.0000	19.9807	3.45	0.9990
Fenoxycarb	0.0340	0.16	0.0017	0.0003	0.00	0.0000	0.0000	0.00	0.0000	0.0343	0.16	0.0017

MLRA 87A

Soil Series: Edge

30 Year Storm Summary

3333	storms produced	2465.25	cm. of rainfall
613	storms produced	351.58	cm. of runoff
35	storms produced	32.72	cm. of percolation
611	storms produced	206.86	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.1587	0.00	0.0079	0.0000	0.00	0.0000	0.0007	0.00	0.0000	0.1594	0.00	0.0080
Glyphosate	11.7069	0.45	0.5853	9.9094	0.38	0.4955	0.0000	0.00	0.0000	21.6163	0.83	1.0808
Hexazinone	31.3461	0.68	1.5673	0.0555	0.00	0.0028	0.5688	0.01	0.0284	31.9705	0.69	1.5985
Imazapyr Acid	40.8110	1.76	2.0405	0.1374	0.01	0.0069	0.0755	0.00	0.0038	41.0238	1.77	2.0512
Metsulfuron-Meth	0.2390	0.29	0.0119	0.0003	0.00	0.0000	0.0000	0.00	0.0000	0.2393	0.29	0.0120
Sulfometuron-Met	0.8028	0.78	0.0401	0.0021	0.00	0.0001	0.0000	0.00	0.0000	0.8049	0.78	0.0402
Triclopyr Amine	1.6804	0.15	0.0840	0.0011	0.00	0.0001	0.0033	0.00	0.0002	1.6848	0.15	0.0842
Clorpyrifos	13.9757	1.22	0.6988	3.0130	0.26	0.1506	0.0000	0.00	0.0000	16.9887	1.48	0.8494
Diazinon	15.6194	2.70	0.7810	0.5553	0.10	0.0278	0.0000	0.00	0.0000	16.1748	2.80	0.8087
Fenoxycarb	0.0227	0.11	0.0011	0.0008	0.00	0.0000	0.0000	0.00	0.0000	0.0236	0.11	0.0012

MLRA 87A

Soil Series: Padina

30 Year Storm Summary

3333	storms produced	2465.25	cm. of rainfall
565	storms produced	310.89	cm. of runoff
59	storms produced	56.71	cm. of percolation
564	storms produced	247.35	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0476	0.00	0.0024	0.0000	0.00	0.0000	0.0499	0.00	0.0025	0.0975	0.00	0.0049
Glyphosate	9.9343	0.38	0.4967	11.4226	0.44	0.5711	0.0000	0.00	0.0000	21.3568	0.82	1.0678
Hexazinone	17.4561	0.38	0.8728	0.0414	0.00	0.0021	4.7667	0.10	0.2383	22.2641	0.48	1.1132
Imazapyr Acid	26.8022	1.16	1.3401	0.1210	0.01	0.0060	0.9511	0.04	0.0476	27.8743	1.21	1.3937
Metsulfuron-Meth	0.1164	0.14	0.0058	0.0002	0.00	0.0000	0.0016	0.00	0.0001	0.1182	0.14	0.0059
Sulfometuron-Met	0.4921	0.48	0.0246	0.0017	0.00	0.0001	0.0003	0.00	0.0000	0.4941	0.48	0.0247
Triclopyr Amine	0.6906	0.06	0.0345	0.0006	0.00	0.0000	0.1511	0.01	0.0076	0.8422	0.07	0.0421
Clorpyrifos	11.7366	1.02	0.5868	3.4414	0.30	0.1721	0.0000	0.00	0.0000	15.1780	1.32	0.7589
Diazinon	12.9296	2.23	0.6465	0.6239	0.11	0.0312	0.0000	0.00	0.0000	13.5534	2.34	0.6777
Fenoxycarb	0.0180	0.09	0.0009	0.0009	0.00	0.0000	0.0000	0.00	0.0000	0.0189	0.09	0.0009

MLRA 87A

Soil Series: Silstid

30 Year Storm Summary

3333	storms produced	2465.25	cm. of rainfall
587	storms produced	330.35	cm. of runoff
10	storms produced	10.34	cm. of percolation
586	storms produced	83.07	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0701	0.00	0.0035	0.0000	0.00	0.0000	0.0076	0.00	0.0004	0.0778	0.00	0.0039
Glyphosate	10.7020	0.41	0.5351	3.8565	0.15	0.1928	0.0000	0.00	0.0000	14.5585	0.56	0.7279
Hexazinone	22.0052	0.48	1.1003	0.0172	0.00	0.0009	0.1232	0.00	0.0062	22.1456	0.48	1.1073
Imazapyr Acid	32.0502	1.38	1.6025	0.0466	0.00	0.0023	0.0010	0.00	0.0001	32.0978	1.38	1.6049
Metsulfuron-Meth	0.1525	0.18	0.0076	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.1526	0.18	0.0076
Sulfometuron-Met	0.6020	0.58	0.0301	0.0007	0.00	0.0000	0.0000	0.00	0.0000	0.6027	0.58	0.0301
Triclopyr Amine	0.9445	0.08	0.0472	0.0003	0.00	0.0000	0.0058	0.00	0.0003	0.9506	0.08	0.0475
Clorpyrifos	12.6823	1.11	0.6341	1.1555	0.10	0.0578	0.0000	0.00	0.0000	13.8378	1.21	0.6919
Diazinon	14.1156	2.44	0.7058	0.2117	0.04	0.0106	0.0000	0.00	0.0000	14.3273	2.48	0.7164
Fenoxycarb	0.0197	0.10	0.0010	0.0003	0.00	0.0000	0.0000	0.00	0.0000	0.0200	0.10	0.0010

MLRA 87B

Soil Series: Gredge

30 Year Storm Summary

3466	storms produced	3413.89	cm. of rainfall
901	storms produced	614.66	cm. of runoff
2550	storms produced	426.29	cm. of percolation
899	storms produced	345.47	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.3021	0.00	0.0151	0.0001	0.00	0.0000	0.0007	0.00	0.0000	0.3028	0.00	0.0151
Glyphosate	14.3581	0.56	0.7179	11.2397	0.44	0.5620	0.0000	0.00	0.0000	25.5978	1.00	1.2799
Hexazinone	25.7435	0.56	1.2872	0.0400	0.00	0.0020	40.4552	0.87	2.0228	66.2386	1.43	3.3119
Imazapyr Acid	28.2901	1.22	1.4145	0.0823	0.00	0.0041	14.3082	0.62	0.7154	42.6807	1.84	2.1340
Metsulfuron-Meth	0.2265	0.27	0.0113	0.0002	0.00	0.0000	0.0000	0.00	0.0000	0.2268	0.27	0.0113
Sulfometuron-Met	0.5598	0.54	0.0280	0.0013	0.00	0.0001	0.0000	0.00	0.0000	0.5610	0.54	0.0281
Triclopyr Amine	2.0285	0.18	0.1014	0.0012	0.00	0.0001	0.1154	0.01	0.0058	2.1450	0.19	0.1073
Clorpyrifos	14.3199	1.25	0.7160	2.8012	0.24	0.1401	0.0000	0.00	0.0000	17.1212	1.49	0.8561
Diazinon	13.0114	2.25	0.6506	0.4102	0.07	0.0205	0.0000	0.00	0.0000	13.4216	2.32	0.6711
Fenoxycarb	0.0147	0.07	0.0007	0.0004	0.00	0.0000	0.0000	0.00	0.0000	0.0151	0.07	0.0008

MLRA 87B

Soil Series: Lufkin

30 Year Storm Summary

3466	storms produced	3413.89	cm. of rainfall
832	storms produced	531.25	cm. of runoff
4490	storms produced	700.96	cm. of percolation
826	storms produced	31.62	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.1952	0.00	0.0098	0.0000	0.00	0.0000	0.0003	0.00	0.0000	0.1955	0.00	0.0098
Glyphosate	10.4884	0.41	0.5244	1.1286	0.04	0.0564	0.0000	0.00	0.0000	11.6169	0.45	0.5808
Hexazinone	19.3335	0.42	0.9667	0.0053	0.00	0.0003	31.1078	0.67	1.5554	50.4465	1.09	2.5223
Imazapyr Acid	22.1134	0.96	1.1057	0.0107	0.00	0.0005	7.2831	0.31	0.3642	29.4072	1.27	1.4704
Metsulfuron-Meth	0.1621	0.20	0.0081	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.1622	0.20	0.0081
Sulfometuron-Met	0.4222	0.41	0.0211	0.0002	0.00	0.0000	0.0000	0.00	0.0000	0.4224	0.41	0.0211
Triclopyr Amine	1.3995	0.12	0.0700	0.0001	0.00	0.0000	0.0270	0.00	0.0014	1.4266	0.12	0.0713
Clorpyrifos	10.5098	0.92	0.5255	0.2816	0.02	0.0141	0.0000	0.00	0.0000	10.7914	0.94	0.5396
Diazinon	10.5621	1.83	0.5281	0.0469	0.01	0.0023	0.0000	0.00	0.0000	10.6090	1.84	0.5304
Fenoxycarb	0.0112	0.05	0.0006	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0112	0.05	0.0006

MLRA 87B

Soil Series: Rader

30 Year Storm Summary

3466	storms produced	3413.89	cm. of rainfall
832	storms produced	531.25	cm. of runoff
4490	storms produced	700.96	cm. of percolation
826	storms produced	31.62	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.1952	0.00	0.0098	0.0000	0.00	0.0000	0.0003	0.00	0.0000	0.1955	0.00	0.0098
Glyphosate	10.4884	0.41	0.5244	1.1286	0.04	0.0564	0.0000	0.00	0.0000	11.6169	0.45	0.5808
Hexazinone	19.3335	0.42	0.9667	0.0053	0.00	0.0003	31.1078	0.67	1.5554	50.4465	1.09	2.5223
Imazapyr Acid	22.1134	0.96	1.1057	0.0107	0.00	0.0005	7.2831	0.31	0.3642	29.4072	1.27	1.4704
Metsulfuron-Meth	0.1621	0.20	0.0081	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.1622	0.20	0.0081
Sulfometuron-Met	0.4222	0.41	0.0211	0.0002	0.00	0.0000	0.0000	0.00	0.0000	0.4224	0.41	0.0211
Triclopyr Amine	1.3995	0.12	0.0700	0.0001	0.00	0.0000	0.0270	0.00	0.0014	1.4266	0.12	0.0713
Clorpyrifos	10.5098	0.92	0.5255	0.2816	0.02	0.0141	0.0000	0.00	0.0000	10.7914	0.94	0.5396
Diazinon	10.5621	1.83	0.5281	0.0469	0.01	0.0023	0.0000	0.00	0.0000	10.6090	1.84	0.5304
Fenoxycarb	0.0112	0.05	0.0006	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0112	0.05	0.0006

MLRA 133B

Soil Series: Cuthbert

30 Year Storm Summary

3466	storms produced	3413.89	cm. of rainfall
905	storms produced	611.87	cm. of runoff
480	storms produced	435.76	cm. of percolation
903	storms produced	1188.42	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.4247	0.00	0.0212	0.0005	0.00	0.0000	0.0028	0.00	0.0001	0.4279	0.00	0.0214
Glyphosate	7.6104	0.29	0.3805	41.1141	1.59	2.0557	0.0000	0.00	0.0000	48.7245	1.88	2.4362
Hexazinone	66.7867	1.44	3.3393	0.6901	0.01	0.0345	19.6022	0.42	0.9801	87.0790	1.87	4.3539
Imazapyr Acid	66.7541	2.88	3.3377	1.3410	0.06	0.0671	4.0427	0.17	0.2021	72.1377	3.11	3.6069
Metsulfuron-Meth	0.5610	0.68	0.0281	0.0037	0.00	0.0002	0.0001	0.00	0.0000	0.5647	0.68	0.0282
Sulfometuron-Met	1.3410	1.30	0.0671	0.0204	0.02	0.0010	0.0000	0.00	0.0000	1.3615	1.32	0.0681
Triclopyr Amine	4.3998	0.38	0.2200	0.0161	0.00	0.0008	0.1564	0.01	0.0078	4.5723	0.39	0.2286
Clorpyrifos	9.0201	0.79	0.4510	12.2548	1.07	0.6127	0.0000	0.00	0.0000	21.2748	1.86	1.0637
Diazinon	15.3346	2.65	0.7667	3.3971	0.59	0.1699	0.0000	0.00	0.0000	18.7317	3.24	0.9366
Fenoxycarb	0.0130	0.06	0.0006	0.0026	0.01	0.0001	0.0000	0.00	0.0000	0.0156	0.07	0.0008

MLRA 133B

Soil Series: Lilbert

30 Year Storm Summary

3466	storms produced	3413.89	cm. of rainfall
862	storms produced	560.20	cm. of runoff
458	storms produced	437.05	cm. of percolation
860	storms produced	134.36	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.2582	0.00	0.0129	0.0000	0.00	0.0000	0.0252	0.00	0.0013	0.2834	0.00	0.0142
Glyphosate	7.1703	0.28	0.3585	4.8239	0.19	0.2412	0.0000	0.00	0.0000	11.9942	0.47	0.5997
Hexazinone	53.0027	1.14	2.6501	0.0757	0.00	0.0038	37.9100	0.82	1.8955	90.9884	1.96	4.5494
Imazapyr Acid	56.3106	2.43	2.8155	0.1497	0.01	0.0075	8.1496	0.35	0.4075	64.6099	2.79	3.2305
Metsulfuron-Meth	0.4226	0.51	0.0211	0.0004	0.00	0.0000	0.0004	0.00	0.0000	0.4234	0.51	0.0212
Sulfometuron-Met	1.0968	1.06	0.0548	0.0022	0.00	0.0001	0.0000	0.00	0.0000	1.0991	1.06	0.0550
Triclopyr Amine	3.0928	0.27	0.1546	0.0017	0.00	0.0001	1.1301	0.10	0.0565	4.2246	0.37	0.2112
Clorpyrifos	8.3238	0.73	0.4162	1.3985	0.12	0.0699	0.0000	0.00	0.0000	9.7223	0.85	0.4861
Diazinon	14.0284	2.42	0.7014	0.3861	0.07	0.0193	0.0000	0.00	0.0000	14.4145	2.49	0.7207
Fenoxycarb	0.0110	0.05	0.0005	0.0003	0.00	0.0000	0.0000	0.00	0.0000	0.0113	0.05	0.0006

MLRA 150A

Soil Series: Lake Charles

30 Year Storm Summary

2219	storms produced	3084.22	cm. of rainfall
673	storms produced	467.95	cm. of runoff
2219	storms produced	394.03	cm. of percolation
673	storms produced	88.26	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.3760	0.00	0.0188	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.3761	0.00	0.0188
Glyphosate	4.9286	0.19	0.2464	5.2249	0.20	0.2612	0.0000	0.00	0.0000	10.1535	0.39	0.5077
Hexazinone	70.6369	1.53	3.5318	0.1562	0.00	0.0078	0.0000	0.00	0.0000	70.7931	1.53	3.5397
Imazapyr Acid	49.6659	2.15	2.4833	0.2073	0.01	0.0104	0.0000	0.00	0.0000	49.8732	2.16	2.4937
Metsulfuron-Meth	0.6229	0.75	0.0311	0.0009	0.00	0.0000	0.0000	0.00	0.0000	0.6238	0.75	0.0312
Sulfometuron-Met	1.1509	1.11	0.0575	0.0037	0.00	0.0002	0.0000	0.00	0.0000	1.1546	1.11	0.0577
Triclopyr Amine	4.6489	0.40	0.2324	0.0037	0.00	0.0002	0.0000	0.00	0.0000	4.6526	0.40	0.2326
Clorpyrifos	6.2596	0.55	0.3130	1.6630	0.14	0.0832	0.0000	0.00	0.0000	7.9226	0.69	0.3961
Diazinon	13.2646	2.29	0.6632	0.5767	0.10	0.0288	0.0000	0.00	0.0000	13.8413	2.39	0.6921
Fenoxycarb	0.0168	0.08	0.0008	0.0007	0.00	0.0000	0.0000	0.00	0.0000	0.0175	0.08	0.0009

MLRA 150A

Soil Series: Victoria

30 Year Storm Summary

2219	storms produced	3084.22	cm. of rainfall
763	storms produced	582.27	cm. of runoff
2219	storms produced	328.29	cm. of percolation
763	storms produced	25.05	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.7817	0.00	0.0391	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.7817	0.00	0.0391
Glyphosate	10.8787	0.42	0.5439	1.3058	0.05	0.0653	0.0000	0.00	0.0000	12.1845	0.47	0.6092
Hexazinone	63.6323	1.37	3.1816	0.0155	0.00	0.0008	0.0002	0.00	0.0000	63.6480	1.37	3.1824
Imazapyr Acid	60.1639	2.60	3.0082	0.0284	0.00	0.0014	0.0000	0.00	0.0000	60.1922	2.60	3.0096
Metsulfuron-Meth	0.5962	0.72	0.0298	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.5962	0.72	0.0298
Sulfometuron-Met	1.3073	1.27	0.0654	0.0005	0.00	0.0000	0.0000	0.00	0.0000	1.3077	1.27	0.0654
Triclopyr Amine	5.3940	0.47	0.2697	0.0004	0.00	0.0000	0.0000	0.00	0.0000	5.3944	0.47	0.2697
Clorpyrifos	12.9261	1.13	0.6463	0.3859	0.03	0.0193	0.0000	0.00	0.0000	13.3120	1.16	0.6656
Diazinon	18.2305	3.15	0.9115	0.0897	0.02	0.0045	0.0000	0.00	0.0000	18.3202	3.17	0.9160
Fenoxycarb	0.0290	0.14	0.0014	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0291	0.14	0.0015

MLRA 150A

Soil Series: Bernard

30 Year Storm Summary

2219	storms produced	3084.22	cm. of rainfall
689	storms produced	492.70	cm. of runoff
2219	storms produced	381.22	cm. of percolation
689	storms produced	24.65	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.5316	0.00	0.0266	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.5316	0.00	0.0266
Glyphosate	5.1882	0.20	0.2594	1.4283	0.06	0.0714	0.0000	0.00	0.0000	6.6166	0.26	0.3308
Hexazinone	76.4764	1.65	3.8238	0.0506	0.00	0.0025	0.1714	0.00	0.0086	76.6984	1.65	3.8349
Imazapyr Acid	51.6335	2.23	2.5817	0.0625	0.00	0.0031	0.0000	0.00	0.0000	51.6960	2.23	2.5848
Metsulfuron-Meth	0.7050	0.85	0.0353	0.0003	0.00	0.0000	0.0000	0.00	0.0000	0.7053	0.85	0.0353
Sulfometuron-Met	1.2238	1.18	0.0612	0.0011	0.00	0.0001	0.0000	0.00	0.0000	1.2249	1.18	0.0612
Triclopyr Amine	5.6690	0.49	0.2835	0.0014	0.00	0.0001	0.0000	0.00	0.0000	5.6705	0.49	0.2835
Clorpyrifos	6.5555	0.57	0.3278	0.4510	0.04	0.0225	0.0000	0.00	0.0000	7.0065	0.61	0.3503
Diazinon	13.8381	2.39	0.6919	0.1586	0.03	0.0079	0.0000	0.00	0.0000	13.9967	2.42	0.6998
Fenoxycarb	0.0177	0.09	0.0009	0.0002	0.00	0.0000	0.0000	0.00	0.0000	0.0178	0.09	0.0009

MLRA 150B

Soil Series: Mustang

30 Year Storm Summary

3221	storms produced	2370.05	cm. of rainfall
447	storms produced	371.52	cm. of runoff
29	storms produced	36.79	cm. of percolation
447	storms produced	18.21	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0124	0.00	0.0006	0.0000	0.00	0.0000	0.0794	0.00	0.0040	0.0918	0.00	0.0046
Glyphosate	10.0712	0.39	0.5036	0.7177	0.03	0.0359	0.0000	0.00	0.0000	10.7889	0.42	0.5394
Hexazinone	6.2503	0.14	0.3125	0.0012	0.00	0.0001	9.2351	0.20	0.4618	15.4866	0.34	0.7743
Imazapyr Acid	11.2923	0.49	0.5646	0.0038	0.00	0.0002	1.6378	0.07	0.0819	12.9339	0.56	0.6467
Metsulfuron-Meth	0.0352	0.04	0.0018	0.0000	0.00	0.0000	0.0029	0.00	0.0001	0.0381	0.04	0.0019
Sulfometuron-Met	0.1499	0.15	0.0075	0.0000	0.00	0.0000	0.0001	0.00	0.0000	0.1500	0.15	0.0075
Triclopyr Amine	0.1989	0.02	0.0099	0.0000	0.00	0.0000	0.9026	0.08	0.0451	1.1014	0.10	0.0551
Clorpyrifos	9.2713	0.81	0.4636	0.1653	0.01	0.0083	0.0000	0.00	0.0000	9.4367	0.82	0.4718
Diazinon	8.0481	1.39	0.4024	0.0240	0.00	0.0012	0.0000	0.00	0.0000	8.0721	1.39	0.4036
Fenoxycarb	0.0013	0.01	0.0001	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0013	0.01	0.0001

MLRA 150B

Soil Series: Veston

30 Year Storm Summary

3221	storms produced	2370.05	cm. of rainfall
454	storms produced	375.60	cm. of runoff
11	storms produced	8.35	cm. of percolation
454	storms produced	7.17	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.0212	0.00	0.0011	0.0000	0.00	0.0000	0.0003	0.00	0.0000	0.0216	0.00	0.0011
Glyphosate	10.5792	0.41	0.5290	0.3031	0.01	0.0152	0.0000	0.00	0.0000	10.8823	0.42	0.5441
Hexazinone	6.7442	0.15	0.3372	0.0006	0.00	0.0000	0.2023	0.00	0.0101	6.9471	0.15	0.3474
Imazapyr Acid	10.9598	0.47	0.5480	0.0017	0.00	0.0001	0.0385	0.00	0.0019	10.9999	0.47	0.5500
Metsulfuron-Meth	0.0400	0.05	0.0020	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0401	0.05	0.0020
Sulfometuron-Met	0.1426	0.14	0.0071	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.1426	0.14	0.0071
Triclopyr Amine	0.2697	0.02	0.0135	0.0000	0.00	0.0000	0.0067	0.00	0.0003	0.2764	0.02	0.0138
Clorpyrifos	9.4370	0.82	0.4718	0.0694	0.01	0.0035	0.0000	0.00	0.0000	9.5064	0.83	0.4753
Diazinon	7.5542	1.31	0.3777	0.0097	0.00	0.0005	0.0000	0.00	0.0000	7.5639	1.31	0.3782
Fenoxycarb	0.0012	0.01	0.0001	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0012	0.01	0.0001

MLRA 152B

Soil Series: Conroe

30 Year Storm Summary

3466	storms produced	3413.89	cm. of rainfall
896	storms produced	604.71	cm. of runoff
371	storms produced	338.34	cm. of percolation
894	storms produced	320.73	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.2486	0.00	0.0124	0.0001	0.00	0.0000	0.0070	0.00	0.0004	0.2557	0.00	0.0128
Glyphosate	7.4555	0.29	0.3728	11.0103	0.43	0.5505	0.0000	0.00	0.0000	18.4659	0.72	0.9233
Hexazinone	70.2402	1.52	3.5120	0.2086	0.00	0.0104	2.5720	0.06	0.1286	73.0208	1.58	3.6510
Imazapyr Acid	74.1079	3.20	3.7054	0.4212	0.02	0.0211	0.0051	0.00	0.0003	74.5341	3.22	3.7267
Metsulfuron-Meth	0.5528	0.67	0.0276	0.0010	0.00	0.0001	0.0000	0.00	0.0000	0.5539	0.67	0.0277
Sulfometuron-Met	1.4499	1.40	0.0725	0.0063	0.01	0.0003	0.0000	0.00	0.0000	1.4562	1.41	0.0728
Triclopyr Amine	3.7947	0.33	0.1897	0.0041	0.00	0.0002	0.0702	0.01	0.0035	3.8689	0.34	0.1934
Clorpyrifos	8.9149	0.78	0.4457	3.2991	0.29	0.1650	0.0000	0.00	0.0000	12.2140	1.07	0.6107
Diazinon	15.9936	2.76	0.7997	0.9688	0.17	0.0484	0.0000	0.00	0.0000	16.9624	2.93	0.8481
Fenoxycarb	0.0119	0.06	0.0006	0.0007	0.00	0.0000	0.0000	0.00	0.0000	0.0126	0.06	0.0006

MLRA 152B

Soil Series: Kirbyville

30 Year Storm Summary

3466	storms produced	3413.89	cm. of rainfall
840	storms produced	537.96	cm. of runoff
384	storms produced	378.06	cm. of percolation
835	storms produced	72.51	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.1179	0.00	0.0059	0.0000	0.00	0.0000	0.0299	0.00	0.0015	0.1478	0.00	0.0074
Glyphosate	12.5358	0.49	0.6268	2.3867	0.09	0.1193	0.0000	0.00	0.0000	14.9226	0.58	0.7461
Hexazinone	16.8085	0.36	0.8404	0.0073	0.00	0.0004	29.0077	0.63	1.4504	45.8235	0.99	2.2912
Imazapyr Acid	21.0995	0.91	1.0550	0.0165	0.00	0.0008	4.7839	0.21	0.2392	25.9000	1.12	1.2950
Metsulfuron-Meth	0.1315	0.16	0.0066	0.0000	0.00	0.0000	0.0004	0.00	0.0000	0.1319	0.16	0.0066
Sulfometuron-Met	0.3887	0.38	0.0194	0.0002	0.00	0.0000	0.0000	0.00	0.0000	0.3889	0.38	0.0194
Triclopyr Amine	1.0233	0.09	0.0512	0.0002	0.00	0.0000	1.0751	0.09	0.0538	2.0986	0.18	0.1049
Clorpyrifos	12.4417	1.08	0.6221	0.5884	0.05	0.0294	0.0000	0.00	0.0000	13.0301	1.13	0.6515
Diazinon	11.4132	1.97	0.5707	0.0880	0.02	0.0044	0.0000	0.00	0.0000	11.5012	1.99	0.5751
Fenoxycarb	0.0112	0.05	0.0006	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0113	0.05	0.0006

MLRA 152B

Soil Series: Otanya

30 Year Storm Summary

3466	storms produced	3413.89	cm. of rainfall
823	storms produced	515.72	cm. of runoff
441	storms produced	441.69	cm. of percolation
818	storms produced	68.32	t/ha of sediment

Average Annual Pesticide Losses

PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
Clopyralid	0.1214	0.00	0.0061	0.0000	0.00	0.0000	0.0638	0.00	0.0032	0.1852	0.00	0.0093
Glyphosate	12.1828	0.47	0.6091	2.2865	0.09	0.1143	0.0000	0.00	0.0000	14.4693	0.56	0.7235
Hexazinone	14.9231	0.32	0.7462	0.0065	0.00	0.0003	70.1155	1.51	3.5058	85.0451	1.83	4.2523
Imazapyr Acid	18.4153	0.80	0.9208	0.0145	0.00	0.0007	22.9693	0.99	1.1485	41.3991	1.79	2.0700
Metsulfuron-Meth	0.1200	0.15	0.0060	0.0000	0.00	0.0000	0.0024	0.00	0.0001	0.1224	0.15	0.0061
Sulfometuron-Met	0.3416	0.33	0.0171	0.0002	0.00	0.0000	0.0004	0.00	0.0000	0.3422	0.33	0.0171
Triclopyr Amine	0.9708	0.08	0.0485	0.0002	0.00	0.0000	2.1482	0.19	0.1074	3.1191	0.27	0.1560
Clorpyrifos	11.8909	1.04	0.5945	0.5550	0.05	0.0277	0.0000	0.00	0.0000	12.4459	1.09	0.6223
Diazinon	10.4790	1.81	0.5239	0.0799	0.01	0.0040	0.0000	0.00	0.0000	10.5588	1.82	0.5279
Fenoxycarb	0.0105	0.05	0.0005	0.0001	0.00	0.0000	0.0000	0.00	0.0000	0.0105	0.05	0.0005

Appendix 1B

Thirty year Gleams runs for selected soil series in 14 Major Land Resource Areas in Texas and average annual losses for Triclopyr amine (Garlon-3) and Triclopyr ester (Garlon-4).

Comparison of Losses of Triclopyr Amine and Triclopyr Ester

MLRA	PESTICIDE	RUNOFF			SEDIMENT			PERCOLATION			TOTAL		
		Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray	Broadcast		Spot Spray
		g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha	g/ha	%App	g/ha
42	Triclopyr Amine	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0022	0.00	0.0001	0.0022	0.00	0.0001
	Triclopyr Ester	0.0239	0.00	0.0012	0.0003	0.00	0.0000	0.0000	0.00	0.0000	0.0243	0.00	0.0012
77	Triclopyr Amine	0.0167	0.00	0.0008	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0167	0.00	0.0008
	Triclopyr Ester	2.3803	0.27	0.1190	0.0407	0.00	0.0020	0.0000	0.00	0.0000	2.4209	0.28	0.1210
78	Triclopyr Amine	0.0000	0.00	0.0000	0.0000	0.00	0.0000	0.0930	0.00	0.0046	0.0930	0.00	0.0046
	Triclopyr Ester	0.0556	0.01	0.0028	0.0030	0.00	0.0001	0.0000	0.00	0.0000	0.0586	0.01	0.0029
80	Triclopyr Amine	0.0488	0.00	0.0024	0.0001	0.00	0.0000	0.9489	0.00	0.0474	0.9978	0.00	0.0499
	Triclopyr Ester	4.2769	0.49	0.2138	0.1384	0.02	0.0069	0.0000	0.00	0.0000	4.4153	0.51	0.2208
81	Triclopyr Amine	0.0460	0.00	0.0023	0.0003	0.00	0.0000	0.9079	0.00	0.0454	0.9541	0.00	0.0477
	Triclopyr Ester	1.4825	0.17	0.0741	0.3876	0.04	0.0194	0.0000	0.00	0.0000	1.8700	0.22	0.0935
82	Triclopyr Amine	0.6601	0.00	0.0330	0.0001	0.00	0.0000	0.9537	0.00	0.0477	1.6139	0.00	0.0807
	Triclopyr Ester	14.4383	1.66	0.7219	0.0681	0.01	0.0034	0.0000	0.00	0.0000	14.5064	1.67	0.7253
83	Triclopyr Amine	0.3794	0.00	0.0190	0.0001	0.00	0.0000	0.0330	0.00	0.0017	0.4125	0.00	0.0206
	Triclopyr Ester	18.8186	2.17	0.9409	0.1105	0.01	0.0055	0.0000	0.00	0.0000	18.9291	2.18	0.9465
84	Triclopyr Amine	1.2903	0.00	0.0645	0.0004	0.00	0.0000	0.0072	0.00	0.0004	1.2978	0.00	0.0649
	Triclopyr Ester	22.8054	2.63	1.1403	0.2667	0.03	0.0133	0.0000	0.00	0.0000	23.0721	2.66	1.1536
85	Triclopyr Amine	4.5589	0.00	0.2279	0.0030	0.00	0.0001	0.0011	0.00	0.0001	4.5630	0.00	0.2282
	Triclopyr Ester	26.8267	3.09	1.3413	0.7493	0.09	0.0375	0.0000	0.00	0.0000	27.5759	3.18	1.3788
86	Triclopyr Amine	0.2598	0.00	0.0130	0.0002	0.00	0.0000	0.0037	0.00	0.0002	0.2636	0.00	0.0132
	Triclopyr Ester	6.6198	0.76	0.3310	0.1815	0.02	0.0091	0.0000	0.00	0.0000	6.8014	0.78	0.3401
87	Triclopyr Amine	1.6786	0.00	0.0839	0.0011	0.00	0.0001	0.0032	0.00	0.0002	1.6829	0.00	0.0841
	Triclopyr Ester	24.3972	2.81	1.2199	0.6696	0.08	0.0335	0.0000	0.00	0.0000	25.0668	2.89	1.2533
133	Triclopyr Amine	4.3951	0.00	0.2198	0.0160	0.00	0.0008	0.1506	0.00	0.0075	4.5617	0.00	0.2281
	Triclopyr Ester	27.5832	3.18	1.3792	1.5151	0.56	0.0758	0.0000	0.00	0.0000	32.4316	3.74	1.6216
150	Triclopyr Amine	4.6491	0.00	0.2325	0.0037	0.00	0.0002	0.0000	0.00	0.0000	4.6528	0.00	0.2326
	Triclopyr Ester	25.2581	2.91	1.2629	0.8585	0.10	0.0429	0.0000	0.00	0.0000	26.1166	3.01	1.3058
152	Triclopyr Amine	3.7908	0.00	0.1895	0.0041	0.00	0.0002	0.0668	0.00	0.0033	3.8617	0.00	0.1931
	Triclopyr Ester	29.2723	3.37	1.4636	1.4067	0.16	0.0703	0.0000	0.00	0.0000	30.6790	3.53	1.5340

(30 year averages for representative soils)

Appendix 2

Soils database listing characteristics used in GLEAMS runs. Selected soils from each Major Land Resource Area in Texas.

GLMSOIL 8-13-1994

SOIL SERIES NAME : BREWSTER
STATE / ID : TX / 0602
MINERALOGY : MIXED
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm) : 30.48

Number of Horizons : 2

Horizon :	1	2
Depth (cm) :	20.320	30.480
Texture ** :	CL	UWB
Eff Sat Cond (cm/hr) :	2.782	9.078
Porosity (cc/cc) :	.474	.349
F.Cap. W.C.(vol/vol) :	.292	.099
Wilt. Point(vol/vol) :	.085	.001
Organic Matter (%) :	2.000	.250
Clay (mass/mass) :	.250	.000
Silt (mass/mass) :	.265	.000
Sand (mass/mass) :	.485	1.000
Soil Eros Factor K :	.359	
pH :	6.950	.000
CEC (meg/100g) :	4.723	.664

** LEGEND **

C = CLAY	S = SAND
CL = CLAY LOAM	SC = SANDY CLAY
COS = COARSE SAND	SCL = SANDY CLAY LOAM
COSL = COARSE SANDY LOAM	SI = SILT
FS = FINE SAND	SIC = SILTY CLAY
FSL = FINE SANDY LOAM	SICL = SILTY CLAY LOAM
L = LOAM	SIL = SILT LOAM
LCOS = LOAMY COARSE SAND	SL = SANDY LOAM
LFS = LOAMY FINE SAND	VFS = VERY FINE SAND
LS = LOAMY SAND	VFSL = VERY FINE SANDY LOAM
LVFS = LOAMY VERY FINE SAND	

GLMSOIL 8-13-1994

SOIL SERIES NAME : DELNORTE
STATE / ID : TX / 0275
MINERALOGY : MIXED
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon	:	1	2	3
Depth (cm)	:	30.480	50.800	152.000
Texture **	:	L	IND	SL
Eff Sat Cond (cm/hr)	:	2.782	9.078	15.240
Porosity (cc/cc)	:	.407	.350	.364
F.Cap. W.C.(vol/vol)	:	.262	.099	.226
Wilt. Point(vol/vol)	:	.094	.001	.047
Organic Matter (%)	:	.750	.094	.012
Clay (mass/mass)	:	.200	.000	.115
Silt (mass/mass)	:	.243	.000	.368
Sand (mass/mass)	:	.557	1.000	.517
Soil Eros Factor K	:	.410		
pH	:	8.150	.000	8.150
CEC (meg/100g)	:	1.927	.273	.100

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : REAGAN
STATE / ID : TX / 0123
MINERALOGY : MIXED
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon	1	2	3
Depth (cm)	20.320	76.200	152.000
Texture **	SIL	L	L
Eff Sat Cond (cm/hr)	2.782	2.782	2.782
Porosity (cc/cc)	.470	.424	.392
F.Cap. W.C.(vol/vol)	.289	.336	.341
Wilt. Point(vol/vol)	.138	.200	.224
Organic Matter (%)	1.250	.156	.020
Clay (mass/mass)	.225	.325	.350
Silt (mass/mass)	.380	.371	.363
Sand (mass/mass)	.395	.304	.287
Soil Eros Factor K	.418		
pH	8.150	8.150	8.150
CEC (meg/100g)	2.986	.636	.248

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : REAKOR
STATE / ID : NM / 0048
MINERALOGY : MIXED
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 2

Horizon	:	1	2
Depth (cm)	:	17.780	152.000
Texture **	:	CL	CL
Eff Sat Cond (cm/hr)	:	.880	.880
Porosity (cc/cc)	:	.463	.384
F.Cap. W.C.(vol/vol)	:	.327	.320
Wilt. Point(vol/vol)	:	.189	.204
Organic Matter (%)	:	.750	.094
Clay (mass/mass)	:	.315	.305
Silt (mass/mass)	:	.290	.363
Sand (mass/mass)	:	.395	.332
Soil Eros Factor K	:	.395	
pH	:	7.900	8.150
CEC (meg/100g)	:	1.833	.477

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : DARROUZETT
STATE / ID : TX / 0483
MINERALOGY : MIXED
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 2

Horizon	:	1	2
Depth (cm)	:	15.240	152.000
Texture **	:	CL	SICL
Eff Sat Cond (cm/hr)	:	2.782	.880
Porosity (cc/cc)	:	.504	.400
F.Cap. W.C.(vol/vol)	:	.330	.370
Wilt. Point(vol/vol)	:	.180	.252
Organic Matter (%)	:	2.500	.313
Clay (mass/mass)	:	.310	.400
Silt (mass/mass)	:	.349	.299
Sand (mass/mass)	:	.341	.301
Soil Eros Factor K	:	.337	
pH	:	7.500	7.900
CEC (meg/100g)	:	5.652	1.279

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : SHERM
STATE / ID : TX / 0243
MINERALOGY : MIXED
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon :	1	2	3
Depth (cm) :	12.700	88.900	152.000
Texture ** :	CL	C	CL
Eff Sat Cond (cm/hr):	.508	.030	.508
Porosity (cc/cc) :	.492	.453	.408
F.Cap. W.C.(vol/vol):	.340	.391	.335
Wilt. Point(vol/vol):	.196	.278	.280
Organic Matter (%) :	2.000	.250	.031
Clay (mass/mass) :	.335	.475	.450
Silt (mass/mass) :	.310	.293	.281
Sand (mass/mass) :	.355	.232	.269
Soil Eros Factor K :	.353		
pH :	7.200	7.900	8.150
CEC (meg/100g) :	4.489	1.002	.344

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : CONLEN
STATE / ID : TX / 0420
MINERALOGY : CARBONATIC
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon	:	1	2	3
Depth (cm)	:	25.400	76.200	152.000
Texture **	:	L	L	L
Eff Sat Cond (cm/hr)	:	2.782	2.782	2.782
Porosity (cc/cc)	:	.427	.401	.372
F.Cap. W.C.(vol/vol)	:	.277	.289	.296
Wilt. Point(vol/vol)	:	.149	.170	.193
Organic Matter (%)	:	2.000	.250	.031
Clay (mass/mass)	:	.225	.275	.295
Silt (mass/mass)	:	.229	.238	.251
Sand (mass/mass)	:	.546	.487	.454
Soil Eros Factor K	:	.357		
pH	:	8.150	8.150	8.150
CEC (meg/100g)	:	4.805	.874	.235

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : DALLAM
STATE / ID : TX / 0266
MINERALOGY : MIXED
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm) : 152.00

Number of Horizons : 3

Horizon	:	1	2	3
Depth (cm)	:	20.320	81.280	152.000
Texture **	:	FSL	SCL	CL
Eff Sat Cond (cm/hr)	:	8.799	2.782	2.782
Porosity (cc/cc)	:	.425	.402	.369
F.Cap. W.C.(vol/vol)	:	.225	.294	.288
Wilt. Point(vol/vol)	:	.095	.185	.188
Organic Matter (%)	:	1.000	.125	.016
Clay (mass/mass)	:	.140	.285	.275
Silt (mass/mass)	:	.173	.197	.221
Sand (mass/mass)	:	.687	.518	.504
Soil Eros Factor K	:	.407		
pH	:	7.200	7.900	8.150
CEC (meg/100g)	:	2.369	.525	.196

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : LINCOLN
STATE / ID : OK / 0046
MINERALOGY : MIXED
HYDROLOGIC GROUP : A
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 2

Horizon	:	1	2
Depth (cm)	:	27.940	152.000
Texture **	:	FS	
Eff Sat Cond (cm/hr)	:	27.824	27.824
Porosity (cc/cc)	:	.347	.332
F.Cap. W.C.(vol/vol)	:	.163	.229
Wilt. Point(vol/vol)	:	.028	.074
Organic Matter (%)	:	.500	.063
Clay (mass/mass)	:	.025	.100
Silt (mass/mass)	:	.068	.068
Sand (mass/mass)	:	.907	.832
Soil Eros Factor K	:	.447	
pH	:	7.900	8.150
CEC (meg/100g)	:	1.205	.270

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : VINGO
STATE / ID : TX / 0459
MINERALOGY : MIXED
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon :	1	2	3
Depth (cm) :	45.720	121.920	152.000
Texture ** :	LFS	FSL	SCL
Eff Sat Cond (cm/hr):	27.824	8.799	2.782
Porosity (cc/cc) :	.365	.346	.359
F.Cap. W.C.(vol/vol):	.233	.232	.249
Wilt. Point(vol/vol):	.071	.115	.139
Organic Matter (%) :	1.000	.125	.016
Clay (mass/mass) :	.100	.160	.195
Silt (mass/mass) :	.100	.160	.207
Sand (mass/mass) :	.800	.680	.598
Soil Eros Factor K :	.394		
pH :	7.200	7.200	7.900
CEC (meg/100g) :	2.645	.511	.159

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : AMARILLO
STATE / ID : TX / 0130
MINERALOGY : MIXED
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon	1	2	3
Depth (cm)	27.940	96.520	152.000
Texture **	FSL	SCL	SCL
Eff Sat Cond (cm/hr)	8.799	2.782	2.782
Porosity (cc/cc)	.397	.397	.366
F.Cap. W.C.(vol/vol)	.239	.285	.284
Wilt. Point(vol/vol)	.100	.182	.185
Organic Matter (%)	.750	.094	.012
Clay (mass/mass)	.140	.275	.275
Silt (mass/mass)	.190	.150	.185
Sand (mass/mass)	.670	.575	.540
Soil Eros Factor K	.416		
pH	7.200	7.900	8.150
CEC (meg/100g)	1.859	.439	.183

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : PULLMAN
STATE / ID : TX / 0247
MINERALOGY : MIXED
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm) : 152.00

Number of Horizons : 4

Horizon	1	2	3	4
Depth (cm)	15.240	96.520	132.080	152.000
Texture **	CL	C	CL	CL
Eff Sat Cond (cm/hr)	.880	.030	.508	.508
Porosity (cc/cc)	.494	.453	.394	.396
F.Cap. W.C.(vol/vol)	.342	.391	.351	.336
Wilt. Point(vol/vol)	.195	.278	.244	.267
Organic Matter (%)	2.000	.250	.031	.004
Clay (mass/mass)	.335	.475	.375	.425
Silt (mass/mass)	.327	.293	.327	.313
Sand (mass/mass)	.338	.232	.298	.262
Soil Eros Factor K	.356			
pH	7.500	7.900	8.150	8.150
CEC (meg/100g)	4.565	1.018	.305	.228

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : SPRINGER
STATE / ID : TX / 0134
MINERALOGY : MIXED
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 4

Horizon :	1	2	3	4
Depth (cm) :	40.640	106.680	142.240	152.000
Texture ** :	LFS	FSL	LS	FSL
Eff Sat Cond (cm/hr):	15.240	8.799	15.240	4.819
Porosity (cc/cc) :	.351	.331	.321	.333
F.Cap. W.C.(vol/vol):	.214	.234	.217	.238
Wilt. Point(vol/vol):	.067	.100	.070	.125
Organic Matter (%) :	.000	.000	.000	.000
Clay (mass/mass) :	.100	.140	.100	.175
Silt (mass/mass) :	.046	.064	.046	.075
Sand (mass/mass) :	.854	.796	.854	.750
Soil Eros Factor K :	.349			
pH :	7.200	7.500	7.500	7.500
CEC (meg/100g) :	.050	.070	.050	.087

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : JALMAR
STATE / ID : TX / 0138
MINERALOGY : MIXED
HYDROLOGIC GROUP : A
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 2

Horizon :	1	2
Depth (cm) :	66.040	152.000
Texture ** :	FS	SCL
Eff Sat Cond (cm/hr):	27.824	2.782
Porosity (cc/cc) :	.366	.356
F.Cap. W.C.(vol/vol):	.218	.272
Wilt. Point(vol/vol):	.053	.192
Organic Matter (%) :	.500	.063
Clay (mass/mass) :	.065	.275
Silt (mass/mass) :	.108	.052
Sand (mass/mass) :	.827	.673
Soil Eros Factor K :	.427	
pH :	7.200	7.500
CEC (meg/100g) :	1.432	.369

** LEGEND **

C = CLAY	S = SAND
CL = CLAY LOAM	SC = SANDY CLAY
COS = COARSE SAND	SCL = SANDY CLAY LOAM
COSL = COARSE SANDY LOAM	SI = SILT
FS = FINE SAND	SIC = SILTY CLAY
FSL = FINE SANDY LOAM	SICL = SILTY CLAY LOAM
L = LOAM	SIL = SILT LOAM
LCOS = LOAMY COARSE SAND	SL = SANDY LOAM
LFS = LOAMY FINE SAND	VFS = VERY FINE SAND
LS = LOAMY SAND	VFSL = VERY FINE SANDY LOAM
LVFS = LOAMY VERY FINE SAND	

GLMSOIL 8-13-1994

SOIL SERIES NAME	:	PENWELL	
STATE / ID	:	TX / 0228	
MINERALOGY	:	SILICEOUS	
HYDROLOGIC GROUP	:	A	
ROOT ZONE DEPTH (cm)	:	152.00	
Number of Horizons	:	2	
Horizon	:	1	2
Depth (cm)	:	33.020	152.000
Texture **	:	FS	FS
Eff Sat Cond (cm/hr)	:	27.824	27.824
Porosity (cc/cc)	:	.346	.314
F.Cap. W.C.(vol/vol)	:	.192	.200
Wilt. Point(vol/vol)	:	.050	.056
Organic Matter (%)	:	.500	.063
Clay (mass/mass)	:	.065	.075
Silt (mass/mass)	:	.048	.058
Sand (mass/mass)	:	.887	.867
Soil Eros Factor K	:	.379	
pH	:	7.200	7.200
CEC (meg/100g)	:	1.263	.259

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : TRIOMAS
STATE / ID : TX / 0119
MINERALOGY : MIXED
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 2

Horizon	:	1	2
Depth (cm)	:	40.640	152.000
Texture **	:	FS	SCL
Eff Sat Cond (cm/hr)	:	27.824	2.782
Porosity (cc/cc)	:	.374	.354
F.Cap. W.C.(vol/vol)	:	.226	.270
Wilt. Point(vol/vol)	:	.060	.190
Organic Matter (%)	:	1.000	.125
Clay (mass/mass)	:	.070	.275
Silt (mass/mass)	:	.073	.039
Sand (mass/mass)	:	.857	.686
Soil Eros Factor K	:	.396	
pH	:	7.200	7.500
CEC (meg/100g)	:	2.588	.586

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : BERDA
STATE / ID : TX / 0127
MINERALOGY : MIXED
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 2

Horizon :	1	2
Depth (cm) :	25.400	152.000
Texture ** :	L	L
Eff Sat Cond (cm/hr):	2.782	2.782
Porosity (cc/cc) :	.413	.365
F.Cap. W.C.(vol/vol):	.286	.281
Wilt. Point(vol/vol):	.158	.175
Organic Matter (%) :	1.000	.125
Clay (mass/mass) :	.250	.265
Silt (mass/mass) :	.203	.193
Sand (mass/mass) :	.547	.542
Soil Eros Factor K :	.383	
pH :	8.150	8.150
CEC (meg/100g) :	2.482	.571

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : MOBEETIE
STATE / ID : TX / 0315
MINERALOGY : MIXED
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon :	1	2	3
Depth (cm) :	25.400	106.680	152.000
Texture ** :	FSL	FSL	FSL
Eff Sat Cond (cm/hr):	8.799	8.799	8.799
Porosity (cc/cc) :	.390	.347	.348
F.Cap. W.C.(vol/vol):	.235	.228	.229
Wilt. Point(vol/vol):	.095	.097	.096
Organic Matter (%) :	.750	.094	.012
Clay (mass/mass) :	.140	.140	.140
Silt (mass/mass) :	.187	.187	.195
Sand (mass/mass) :	.673	.673	.665
Soil Eros Factor K :	.415		
pH :	8.150	8.150	8.150
CEC (meg/100g) :	1.838	.376	.116

** LEGEND **

C = CLAY	S = SAND
CL = CLAY LOAM	SC = SANDY CLAY
COS = COARSE SAND	SCL = SANDY CLAY LOAM
COSL = COARSE SANDY LOAM	SI = SILT
FS = FINE SAND	SIC = SILTY CLAY
FSL = FINE SANDY LOAM	SICL = SILTY CLAY LOAM
L = LOAM	SIL = SILT LOAM
LCOS = LOAMY COARSE SAND	SL = SANDY LOAM
LFS = LOAMY FINE SAND	VFS = VERY FINE SAND
LS = LOAMY SAND	VFSL = VERY FINE SANDY LOAM
LVFS = LOAMY VERY FINE SAND	

GLMSOIL 8-13-1994

SOIL SERIES NAME : POTTER
STATE / ID : TX / 0124
MINERALOGY : CARBONATIC
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm): 76.20

Number of Horizons : 2

Horizon :	1	2
Depth (cm) :	22.860	76.200
Texture ** :	L	L
Eff Sat Cond (cm/hr):	2.782	4.819
Porosity (cc/cc) :	.450	.397
F.Cap. W.C.(vol/vol):	.302	.260
Wilt. Point(vol/vol):	.151	.068
Organic Matter (%) :	.750	.094
Clay (mass/mass) :	.265	.210
Silt (mass/mass) :	.274	.280
Sand (mass/mass) :	.461	.510
Soil Eros Factor K :	.402	
pH :	8.150	8.150
CEC (meg/100g) :	1.853	.369

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : BURSON
STATE / ID : TX / 0322
MINERALOGY : MIXED (CALCAREOUS)
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm): 101.60

Number of Horizons : 2

Horizon :	1	2
Depth (cm) :	15.240	101.600
Texture ** :	VFSL	WB
Eff Sat Cond (cm/hr):	2.782	6.335
Porosity (cc/cc) :	.449	.320
F.Cap. W.C.(vol/vol):	.254	.098
Wilt. Point(vol/vol):	.111	.001
Organic Matter (%) :	1.000	.125
Clay (mass/mass) :	.175	.000
Silt (mass/mass) :	.304	.000
Sand (mass/mass) :	.521	1.000
Soil Eros Factor K :	.425	
pH :	8.150	.000
CEC (meg/100g) :	2.286	.395

** LEGEND **

C = CLAY	S = SAND
CL = CLAY LOAM	SC = SANDY CLAY
COS = COARSE SAND	SCL = SANDY CLAY LOAM
COSL = COARSE SANDY LOAM	SI = SILT
FS = FINE SAND	SIC = SILTY CLAY
FSL = FINE SANDY LOAM	SICL = SILTY CLAY LOAM
L = LOAM	SIL = SILT LOAM
LCOS = LOAMY COARSE SAND	SL = SANDY LOAM
LFS = LOAMY FINE SAND	VFS = VERY FINE SAND
LS = LOAMY SAND	VFSL = VERY FINE SANDY LOAM
LVFS = LOAMY VERY FINE SAND	

GLMSOIL 8-13-1994

SOIL SERIES NAME : QUAY
STATE / ID : NM / 0351
MINERALOGY : MIXED
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon	1	2	3
Depth (cm)	22.860	66.040	152.000
Texture **	FSL	CL	SCL
Eff Sat Cond (cm/hr)	8.799	2.782	2.782
Porosity (cc/cc)	.435	.416	.378
F.Cap. W.C.(vol/vol)	.230	.308	.298
Wilt. Point(vol/vol)	.094	.168	.181
Organic Matter (%)	.750	.094	.012
Clay (mass/mass)	.140	.265	.265
Silt (mass/mass)	.257	.387	.340
Sand (mass/mass)	.603	.348	.395
Soil Eros Factor K	.431		
pH	8.150	8.150	8.150
CEC (meg/100g)	1.817	.411	.176

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : SPRINGER
STATE / ID : TX / 0134
MINERALOGY : MIXED
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm) : 152.00

Number of Horizons : 4

Horizon :	1	2	3	4
Depth (cm) :	40.640	106.680	142.240	152.000
Texture ** :	LFS	FSL	LS	FSL
Eff Sat Cond (cm/hr) :	15.240	8.799	15.240	4.819
Porosity (cc/cc) :	.351	.331	.321	.333
F.Cap. W.C.(vol/vol) :	.214	.234	.217	.238
Wilt. Point(vol/vol) :	.067	.100	.070	.125
Organic Matter (%) :	.000	.000	.000	.000
Clay (mass/mass) :	.100	.140	.100	.175
Silt (mass/mass) :	.046	.064	.046	.075
Sand (mass/mass) :	.854	.796	.854	.750
Soil Eros Factor K :	.349			
pH :	7.200	7.500	7.500	7.500
CEC (meg/100g) :	.050	.070	.050	.087

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : KNOCO
STATE / ID : TX / 0338
MINERALOGY : MIXED (CALCAREOUS)
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon :	1	2	3
Depth (cm) :	22.860	48.260	152.000
Texture ** :	C	C	C
Eff Sat Cond (cm/hr):	.073	.029	.015
Porosity (cc/cc) :	.523	.453	.415
F.Cap. W.C.(vol/vol):	.386	.392	.342
Wilt. Point(vol/vol):	.237	.264	.276
Organic Matter (%) :	2.000	.250	.031
Clay (mass/mass) :	.475	.475	.475
Silt (mass/mass) :	.239	.296	.296
Sand (mass/mass) :	.286	.229	.229
Soil Eros Factor K :	.317		
pH :	8.150	8.150	8.150
CEC (meg/100g) :	4.895	.946	.351

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : MILES
STATE / ID : TX / 0245
MINERALOGY : MIXED
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon :	1	2	3
Depth (cm) :	25.400	139.700	152.000
Texture ** :	FSL	SCL	SCL
Eff Sat Cond (cm/hr):	8.799	2.782	2.782
Porosity (cc/cc) :	.391	.364	.366
F.Cap. W.C.(vol/vol):	.235	.282	.283
Wilt. Point(vol/vol):	.090	.189	.185
Organic Matter (%) :	.750	.094	.012
Clay (mass/mass) :	.125	.275	.275
Silt (mass/mass) :	.189	.164	.175
Sand (mass/mass) :	.686	.561	.550
Soil Eros Factor K :	.421		
pH :	6.950	7.500	7.900
CEC (meg/100g) :	1.831	.460	.185

** LEGEND **

C = CLAY	S = SAND
CL = CLAY LOAM	SC = SANDY CLAY
COS = COARSE SAND	SCL = SANDY CLAY LOAM
COSL = COARSE SANDY LOAM	SI = SILT
FS = FINE SAND	SIC = SILTY CLAY
FSL = FINE SANDY LOAM	SICL = SILTY CLAY LOAM
L = LOAM	SIL = SILT LOAM
LCOS = LOAMY COARSE SAND	SL = SANDY LOAM
LFS = LOAMY FINE SAND	VFS = VERY FINE SAND
LS = LOAMY SAND	VFSL = VERY FINE SANDY LOAM
LVFS = LOAMY VERY FINE SAND	

GLMSOIL 8-13-1994

SOIL SERIES NAME : QUINLAN
STATE / ID : OK0054
MINERALOGY : MIXED
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm) : 152.00

Number of Horizons : 2

Horizon	:	1	2
Depth (cm)	:	33.020	152.000
Texture **	:	L	WB
Eff Sat Cond (cm/hr)	:	2.782	6.335
Porosity (cc/cc)	:	.423	.320
F.Cap. W.C.(vol/vol)	:	.284	.098
Wilt. Point(vol/vol)	:	.139	.001
Organic Matter (%)	:	1.000	.125
Clay (mass/mass)	:	.210	.000
Silt (mass/mass)	:	.366	.000
Sand (mass/mass)	:	.424	1.000
Soil Eros Factor K	:	.426	
pH	:	7.900	.000
CEC (meg/100g)	:	2.566	.443

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : STAMFORD
STATE / ID : TX / 0579
MINERALOGY : MONTMORILLONITIC
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon :	1	2	3
Depth (cm) :	22.860	88.900	152.000
Texture ** :	C	C	C
Eff Sat Cond (cm/hr):	.022	.009	.004
Porosity (cc/cc) :	.552	.486	.444
F.Cap. W.C.(vol/vol):	.405	.410	.364
Wilt. Point(vol/vol):	.274	.303	.323
Organic Matter (%) :	1.250	.156	.020
Clay (mass/mass) :	.500	.500	.500
Silt (mass/mass) :	.268	.268	.262
Sand (mass/mass) :	.232	.232	.238
Soil Eros Factor K :	.352		
pH :	8.150	8.150	8.150
CEC (meg/100g) :	3.311	.888	.474

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : ROTAN
STATE / ID : TX / 0354
MINERALOGY : MIXED
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon :	1	2	3
Depth (cm) :	15.240	121.920	152.000
Texture ** :	CL	C	CL
Eff Sat Cond (cm/hr):	2.782	.880	2.782
Porosity (cc/cc) :	.494	.397	.392
F.Cap. W.C.(vol/vol):	.337	.371	.340
Wilt. Point(vol/vol):	.183	.254	.216
Organic Matter (%) :	2.000	.250	.031
Clay (mass/mass) :	.315	.400	.350
Silt (mass/mass) :	.368	.312	.359
Sand (mass/mass) :	.317	.288	.291
Soil Eros Factor K :	.365		
pH :	7.900	7.900	8.150
CEC (meg/100g) :	4.555	1.021	.298

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : TILLMAN
STATE / ID : TX / 0250
MINERALOGY : MIXED
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon	1	2	3
Depth (cm)	15.240	124.460	152.000
Texture **	SICL	C	C
Eff Sat Cond (cm/hr)	.880	.508	.508
Porosity (cc/cc)	.489	.396	.394
F.Cap. W.C.(vol/vol)	.330	.369	.357
Wilt. Point(vol/vol)	.183	.252	.247
Organic Matter (%)	2.000	.250	.031
Clay (mass/mass)	.310	.400	.400
Silt (mass/mass)	.327	.303	.260
Sand (mass/mass)	.363	.297	.340
Soil Eros Factor K	.360		
pH	7.500	7.900	8.150
CEC (meg/100g)	4.553	1.024	.324

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : VERNON
STATE / ID : TX / 0249
MINERALOGY : MIXED
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon	:	1	2	3
Depth (cm)	:	12.700	63.500	152.000
Texture **	:	C	C	C
Eff Sat Cond (cm/hr)	:	.039	.016	.008
Porosity (cc/cc)	:	.525	.461	.419
F.Cap. W.C.(vol/vol)	:	.398	.404	.347
Wilt. Point(vol/vol)	:	.255	.279	.288
Organic Matter (%)	:	1.250	.156	.020
Clay (mass/mass)	:	.500	.500	.500
Silt (mass/mass)	:	.291	.291	.247
Sand (mass/mass)	:	.209	.209	.253
Soil Eros Factor K	:	.357		
pH	:	8.150	8.150	8.150
CEC (meg/100g)	:	2.951	.700	.322

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : LEERAY
STATE / ID : TX / 0202
MINERALOGY : MONTMORILLONITIC
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon :	1	2	3
Depth (cm) :	45.720	137.160	152.000
Texture ** :	C	C	C
Eff Sat Cond (cm/hr):	.017	.004	.004
Porosity (cc/cc) :	.536	.446	.442
F.Cap. W.C.(vol/vol):	.397	.360	.363
Wilt. Point(vol/vol):	.283	.317	.319
Organic Matter (%) :	3.000	.375	.047
Clay (mass/mass) :	.500	.500	.500
Silt (mass/mass) :	.245	.248	.231
Sand (mass/mass) :	.255	.252	.269
Soil Eros Factor K :	.278		
pH :	7.900	8.150	8.150
CEC (meg/100g) :	8.185	1.726	.588

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : PALOPINTO
STATE / ID : TX / 0778
MINERALOGY : MIXED
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm) : 35.56

Number of Horizons : 3

Horizon	:	1	2	3
Depth (cm)	:	10.160	30.480	35.560
Texture **	:	CL	CL	UWB
Eff Sat Cond (cm/hr)	:	2.782	2.782	9.078
Porosity (cc/cc)	:	.490	.418	.350
F.Cap. W.C.(vol/vol)	:	.318	.312	.099
Wilt. Point(vol/vol)	:	.111	.067	.001
Organic Matter (%)	:	2.000	.250	.031
Clay (mass/mass)	:	.265	.265	.000
Silt (mass/mass)	:	.418	.413	.000
Sand (mass/mass)	:	.317	.322	1.000
Soil Eros Factor K	:	.380		
pH	:	7.250	7.250	.000
CEC (meg/100g)	:	4.371	.771	.087

** LEGEND **

C = CLAY	S = SAND
CL = CLAY LOAM	SC = SANDY CLAY
COS = COARSE SAND	SCL = SANDY CLAY LOAM
COSL = COARSE SANDY LOAM	SI = SILT
FS = FINE SAND	SIC = SILTY CLAY
FSL = FINE SANDY LOAM	SICL = SILTY CLAY LOAM
L = LOAM	SIL = SILT LOAM
LCOS = LOAMY COARSE SAND	SL = SANDY LOAM
LFS = LOAMY FINE SAND	VFS = VERY FINE SAND
LS = LOAMY SAND	VFSL = VERY FINE SANDY LOAM
LVFS = LOAMY VERY FINE SAND	

GLMSOIL 8-13-1994

SOIL SERIES NAME : LUEDERS
STATE / ID : TX / 0614
MINERALOGY : CARBONATIC
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm): 121.92

Number of Horizons : 4

Horizon	:	1	2	3	4
Depth (cm)	:	12.700	25.400	33.020	121.920
Texture **	:	L	L	L	UWB
Eff Sat Cond (cm/hr)	:	2.782	2.782	2.782	5.856
Porosity (cc/cc)	:	.481	.414	.414	.314
F.Cap. W.C.(vol/vol)	:	.314	.309	.307	.096
Wilt. Point(vol/vol)	:	.138	.081	.072	.001
Organic Matter (%)	:	2.000	.250	.031	.004
Clay (mass/mass)	:	.275	.275	.275	.000
Silt (mass/mass)	:	.333	.388	.378	.000
Sand (mass/mass)	:	.392	.337	.347	1.000
Soil Eros Factor K	:	.367			
pH	:	8.150	8.150	8.150	.000
CEC (meg/100g)	:	4.432	.743	.195	.013

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : BONTI
STATE / ID : TX / 0160
MINERALOGY : MIXED
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm) : 81.28

Number of Horizons : 3

Horizon :	1	2	3
Depth (cm) :	20.320	76.200	81.280
Texture ** :	FSL	C	WB
Eff Sat Cond (cm/hr) :	2.782	.880	9.078
Porosity (cc/cc) :	.456	.426	.350
F.Cap. W.C.(vol/vol) :	.240	.352	.099
Wilt. Point(vol/vol) :	.099	.243	.001
Organic Matter (%) :	2.000	.250	.031
Clay (mass/mass) :	.150	.425	.000
Silt (mass/mass) :	.233	.146	.000
Sand (mass/mass) :	.617	.429	1.000
Soil Eros Factor K :	.377		
pH :	6.450	5.550	.000
CEC (meg/100g) :	4.673	.970	.106

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : EXRAY
STATE / ID : TX / 0181
MINERALOGY : MIXED
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm) : 60.96

Number of Horizons : 3

Horizon	:	1	2	3
Depth (cm)	:	20.320	40.640	60.960
Texture **	:	L	C	WB
Eff Sat Cond (cm/hr)	:	2.782	.880	9.078
Porosity (cc/cc)	:	.450	.431	.350
F.Cap. W.C.(vol/vol)	:	.271	.373	.099
Wilt. Point (vol/vol)	:	.119	.240	.001
Organic Matter (%)	:	.750	.094	.012
Clay (mass/mass)	:	.205	.425	.000
Silt (mass/mass)	:	.320	.198	.000
Sand (mass/mass)	:	.475	.377	1.000
Soil Eros Factor K	:	.424		
pH	:	6.700	6.050	.000
CEC (meg/100g)	:	1.827	.470	.036

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : TRUCE
STATE / ID : TX / 0193
MINERALOGY : MIXED
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon :	1	2	3
Depth (cm) :	20.320	114.300	152.000
Texture ** :	FSL	C	C
Eff Sat Cond (cm/hr):	2.782	.508	.152
Porosity (cc/cc) :	.463	.399	.406
F.Cap. W.C.(vol/vol):	.243	.332	.335
Wilt. Point(vol/vol):	.094	.278	.271
Organic Matter (%) :	2.000	.250	.031
Clay (mass/mass) :	.140	.450	.450
Silt (mass/mass) :	.293	.191	.259
Sand (mass/mass) :	.567	.359	.291
Soil Eros Factor K :	.390		
pH :	6.450	7.250	7.500
CEC (meg/100g) :	4.668	1.043	.348

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : ECTOR
STATE / ID : TX / 0285
MINERALOGY : CARBONATIC
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm) : 76.20

Number of Horizons : 2

Horizon	:	1	2
Depth (cm)	:	20.320	76.200
Texture **	:	L	UWB
Eff Sat Cond (cm/hr)	:	2.782	9.078
Porosity (cc/cc)	:	.481	.349
F.Cap. W.C.(vol/vol)	:	.315	.091
Wilt. Point(vol/vol)	:	.109	.001
Organic Matter (%)	:	2.000	.250
Clay (mass/mass)	:	.275	.000
Silt (mass/mass)	:	.338	.000
Sand (mass/mass)	:	.387	1.000
Soil Eros Factor K	:	.367	
pH	:	8.150	.000
CEC (meg/100g)	:	4.708	.757

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : REAGAN
STATE / ID : TX / 0123
MINERALOGY : MIXED
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon	:	1	2	3
Depth (cm)	:	20.320	76.200	152.000
Texture **	:	SIL	L	L
Eff Sat Cond (cm/hr)	:	2.782	2.782	2.782
Porosity (cc/cc)	:	.470	.424	.392
F.Cap. W.C.(vol/vol)	:	.289	.336	.341
Wilt. Point(vol/vol)	:	.138	.200	.224
Organic Matter (%)	:	1.250	.156	.020
Clay (mass/mass)	:	.225	.325	.350
Silt (mass/mass)	:	.380	.371	.363
Sand (mass/mass)	:	.395	.304	.287
Soil Eros Factor K	:	.418		
pH	:	8.150	8.150	8.150
CEC (meg/100g)	:	2.986	.636	.248

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : ROUGHCREEK
STATE / ID : TX / 0830
MINERALOGY : MONTMORILLONITIC
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm): 60.96

Number of Horizons : 3

Horizon	1	2	3
Depth (cm)	17.780	45.720	60.960
Texture **	CL	C	UWB
Eff Sat Cond (cm/hr)	.880	.278	9.079
Porosity (cc/cc)	.524	.481	.350
F.Cap. W.C.(vol/vol)	.361	.427	.133
Wilt. Point(vol/vol)	.148	.190	.001
Organic Matter (%)	2.000	.250	.031
Clay (mass/mass)	.350	.500	.000
Silt (mass/mass)	.347	.225	.000
Sand (mass/mass)	.303	.275	1.000
Soil Eros Factor K	.357		
pH	6.950	6.950	.000
CEC (meg/100g)	4.748	1.091	.097

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : ECTOR
STATE / ID : TX / 0285
MINERALOGY : CARBONATIC
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm) : 76.20

Number of Horizons : 2

Horizon	:	1	2
Depth (cm)	:	20.320	76.200
Texture **	:	L	UWB
Eff Sat Cond (cm/hr)	:	2.782	9.078
Porosity (cc/cc)	:	.481	.349
F.Cap. W.C.(vol/vol)	:	.315	.091
Wilt. Point(vol/vol)	:	.109	.001
Organic Matter (%)	:	2.000	.250
Clay (mass/mass)	:	.275	.000
Silt (mass/mass)	:	.338	.000
Sand (mass/mass)	:	.387	1.000
Soil Eros Factor K	:	.367	
pH	:	8.150	.000
CEC (meg/100g)	:	4.708	.757

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : TARRANT
STATE / ID : TX / 0091
MINERALOGY : MONTMORILLONITIC
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm): 76.20

Number of Horizons : 2

Horizon	:	1	2
Depth (cm)	:	33.020	76.200
Texture **	:	C	IND
Eff Sat Cond (cm/hr)	:	.880	9.837
Porosity (cc/cc)	:	.574	.354
F.Cap. W.C.(vol/vol)	:	.378	.131
Wilt. Point(vol/vol)	:	.132	.001
Organic Matter (%)	:	4.500	.563
Clay (mass/mass)	:	.500	.000
Silt (mass/mass)	:	.245	.000
Sand (mass/mass)	:	.255	1.000
Soil Eros Factor K	:	.268	
pH	:	8.150	.000
CEC (meg/100g)	:	11.476	1.749

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : BRACKETT
STATE / ID : TX / 0145
MINERALOGY : CARBONATIC
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm): 127.00

Number of Horizons : 4

Horizon	:	1	2	3	4
Depth (cm)	:	15.240	40.640	91.440	127.000
Texture **	:	L	L	CL	L
Eff Sat Cond (cm/hr)	:	2.782	2.782	2.782	.880
Porosity (cc/cc)	:	.475	.410	.408	.378
F.Cap. W.C.(vol/vol)	:	.284	.299	.285	.328
Wilt. Point(vol/vol)	:	.132	.158	.120	.196
Organic Matter (%)	:	2.000	.250	.031	.004
Clay (mass/mass)	:	.225	.265	.235	.315
Silt (mass/mass)	:	.351	.353	.368	.381
Sand (mass/mass)	:	.424	.382	.397	.304
Soil Eros Factor K	:	.378			
pH	:	8.150	8.150	8.150	8.150
CEC (meg/100g)	:	4.488	.779	.196	.140

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : ECKRANT
STATE / ID : TX / 0366
MINERALOGY : MONTMORILLONITIC
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm) : 76.20

Number of Horizons : 3

Horizon	:	1	2	3
Depth (cm)	:	10.160	30.480	76.200
Texture **	:	C	C	UWB
Eff Sat Cond (cm/hr)	:	.880	.880	9.079
Porosity (cc/cc)	:	.578	.490	.350
F.Cap. W.C.(vol/vol)	:	.398	.404	.133
Wilt. Point(vol/vol)	:	.213	.140	.001
Organic Matter (%)	:	2.500	.313	.039
Clay (mass/mass)	:	.500	.500	.000
Silt (mass/mass)	:	.287	.276	.000
Sand (mass/mass)	:	.213	.224	1.000
Soil Eros Factor K	:	.302		
pH	:	7.500	7.500	.000
CEC (meg/100g)	:	5.698	1.198	.121

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : COMFORT
STATE / ID : TX / 0816
MINERALOGY : MIXED
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm) : 50.80

Number of Horizons : 3

Horizon	1	2	3
Depth (cm)	12.700	43.180	50.800
Texture **	C	C	UWB
Eff Sat Cond (cm/hr)	.508	.278	9.078
Porosity (cc/cc)	.526	.511	.350
F.Cap. W.C.(vol/vol)	.369	.459	.099
Wilt. Point(vol/vol)	.123	.161	.001
Organic Matter (%)	2.500	.313	.039
Clay (mass/mass)	.425	.650	.000
Silt (mass/mass)	.296	.171	.000
Sand (mass/mass)	.279	.179	1.000
Soil Eros Factor K	.313		
pH	7.500	7.500	.000
CEC (meg/100g)	5.614	1.167	.117

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : CASTELL
STATE / ID : TX / 0131
MINERALOGY : MIXED
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm) : 91.44

Number of Horizons : 3

Horizon :	1	2	3
Depth (cm) :	33.020	60.960	91.440
Texture ** :	LS	C	WB
Eff Sat Cond (cm/hr) :	8.799	.278	9.078
Porosity (cc/cc) :	.349	.428	.350
F.Cap. W.C.(vol/vol) :	.228	.356	.099
Wilt. Point(vol/vol) :	.070	.212	.001
Organic Matter (%) :	1.000	.125	.016
Clay (mass/mass) :	.130	.450	.000
Silt (mass/mass) :	.058	.091	.000
Sand (mass/mass) :	.812	.459	1.000
Soil Eros Factor K :	.341		
pH :	6.050	6.050	.000
CEC (meg/100g) :	2.526	.600	.053

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : ECKERT
STATE / ID : TX / 0365
MINERALOGY : MIXED
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm) : 38.10

Number of Horizons : 2

Horizon	:	1	2
Depth (cm)	:	30.480	38.100
Texture **	:	SIL	IND
Eff Sat Cond (cm/hr)	:	2.782	9.078
Porosity (cc/cc)	:	.445	.349
F.Cap. W.C.(vol/vol)	:	.293	.099
Wilt. Point(vol/vol)	:	.099	.001
Organic Matter (%)	:	2.000	.250
Clay (mass/mass)	:	.210	.000
Silt (mass/mass)	:	.409	.000
Sand (mass/mass)	:	.381	1.000
Soil Eros Factor K	:	.388	
pH	:	7.500	.000
CEC (meg/100g)	:	4.978	.704

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : KEESE
STATE / ID : TX / 0436
MINERALOGY : MIXED
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm): 101.60

Number of Horizons : 2

Horizon	:	1	2
Depth (cm)	:	48.260	101.600
Texture **	:	SL	UWB
Eff Sat Cond (cm/hr)	:	8.799	6.335
Porosity (cc/cc)	:	.336	.320
F.Cap. W.C.(vol/vol)	:	.198	.098
Wilt. Point(vol/vol)	:	.050	.001
Organic Matter (%)	:	1.000	.125
Clay (mass/mass)	:	.125	.000
Silt (mass/mass)	:	.060	.000
Sand (mass/mass)	:	.815	1.000
Soil Eros Factor K	:	.345	
pH	:	6.050	.000
CEC (meg/100g)	:	2.698	.419

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : DUVAL
STATE / ID : TX / 0208
MINERALOGY : MIXED
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 4

Horizon :	1	2	3	4
Depth (cm) :	40.640	111.760	132.080	152.000
Texture ** :	FSL	SCL	SCL	WB
Eff Sat Cond (cm/hr):	2.782	2.782	2.782	5.856
Porosity (cc/cc) :	.400	.362	.358	.314
F.Cap. W.C.(vol/vol):	.245	.274	.264	.099
Wilt. Point(vol/vol):	.089	.167	.153	.001
Organic Matter (%) :	1.000	.125	.016	.002
Clay (mass/mass) :	.130	.260	.240	.000
Silt (mass/mass) :	.161	.154	.134	.000
Sand (mass/mass) :	.709	.586	.626	1.000
Soil Eros Factor K :	.407			
pH :	6.700	6.950	7.250	.000
CEC (meg/100g) :	2.618	.552	.180	.008

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : KNIPPA
STATE / ID : TX / 0435
MINERALOGY : MIXED
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm) : 152.00

Number of Horizons : 2

Horizon	1	2
Depth (cm)	88.900	152.000
Texture **	C	CL
Eff Sat Cond (cm/hr)	.880	.880
Porosity (cc/cc)	.493	.409
F.Cap. W.C. (vol/vol)	.388	.328
Wilt. Point (vol/vol)	.242	.252
Organic Matter (%)	2.500	.313
Clay (mass/mass)	.450	.425
Silt (mass/mass)	.313	.346
Sand (mass/mass)	.237	.229
Soil Eros Factor K	.313	
pH	8.150	8.150
CEC (meg/100g)	7.654	1.403

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : POTH
STATE / ID : TX / 0045
MINERALOGY : MIXED
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons	:	3		
Horizon	:	1	2	3
Depth (cm)	:	76.200	111.760	152.000
Texture **	:	LFS	SC	SCL
Eff Sat Cond (cm/hr)	:	8.799	.508	2.782
Porosity (cc/cc)	:	.357	.387	.366
F.Cap. W.C.(vol/vol)	:	.223	.344	.288
Wilt. Point(vol/vol)	:	.054	.274	.189
Organic Matter (%)	:	1.000	.125	.016
Clay (mass/mass)	:	.070	.435	.290
Silt (mass/mass)	:	.158	.078	.151
Sand (mass/mass)	:	.772	.487	.559
Soil Eros Factor K	:	.435		
pH	:	6.450	6.950	7.250
CEC (meg/100g)	:	2.916	.662	.206

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : UVALDE
STATE / ID : TX / 0231
MINERALOGY : MIXED
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm) : 152.00

Number of Horizons : 2

Horizon	:	1	2
Depth (cm)	:	43.180	152.000
Texture **	:	CL	CL
Eff Sat Cond (cm/hr)	:	2.782	2.782
Porosity (cc/cc)	:	.459	.397
F.Cap. W.C.(vol/vol)	:	.347	.370
Wilt. Point(vol/vol)	:	.204	.246
Organic Matter (%)	:	2.000	.250
Clay (mass/mass)	:	.335	.390
Silt (mass/mass)	:	.375	.338
Sand (mass/mass)	:	.290	.272
Soil Eros Factor K	:	.363	
pH	:	8.150	8.150
CEC (meg/100g)	:	5.316	1.094

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : WEBB
STATE / ID : TX / 0559
MINERALOGY : MONTMORILLONITIC
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 4

Horizon	1	2	3	4
Depth (cm)	30.480	43.180	76.200	152.000
Texture **	FSL	SCL	SC	SCL
Eff Sat Cond (cm/hr)	2.782	2.782	.880	2.782
Porosity (cc/cc)	.434	.425	.449	.385
F.Cap. W.C.(vol/vol)	.253	.294	.363	.309
Wilt. Point(vol/vol)	.093	.166	.255	.191
Organic Matter (%)	1.000	.125	.016	.002
Clay (mass/mass)	.130	.245	.400	.265
Silt (mass/mass)	.220	.240	.193	.262
Sand (mass/mass)	.650	.515	.407	.473
Soil Eros Factor K	.423			
pH	6.450	6.450	6.700	7.500
CEC (meg/100g)	2.541	.552	.370	.219

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : MONTEOLA
STATE / ID : TX / 0175
MINERALOGY : MONTMORILLONITIC
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon	:	1	2	3
Depth (cm)	:	12.700	93.980	152.000
Texture **	:	C	C	C
Eff Sat Cond (cm/hr)	:	.044	.008	.004
Porosity (cc/cc)	:	.551	.488	.447
F.Cap. W.C.(vol/vol)	:	.409	.414	.365
Wilt. Point(vol/vol)	:	.250	.284	.303
Organic Matter (%)	:	2.000	.250	.031
Clay (mass/mass)	:	.475	.500	.500
Silt (mass/mass)	:	.294	.300	.300
Sand (mass/mass)	:	.231	.200	.200
Soil Eros Factor K	:	.330		
pH	:	8.450	8.450	8.450
CEC (meg/100g)	:	4.702	1.174	.520

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : CATARINA
STATE / ID : TX / 0255
MINERALOGY : MONTMORILLONITIC
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon	1	2	3
Depth (cm)	35.560	127.000	152.000
Texture **	C	C	C
Eff Sat Cond (cm/hr)	.026	.010	.010
Porosity (cc/cc)	.498	.435	.433
F.Cap. W.C.(vol/vol)	.414	.353	.352
Wilt. Point(vol/vol)	.259	.285	.293
Organic Matter (%)	1.500	.188	.023
Clay (mass/mass)	.450	.450	.450
Silt (mass/mass)	.352	.352	.314
Sand (mass/mass)	.198	.198	.236
Soil Eros Factor K	.368		
pH	8.200	8.200	8.200
CEC (meg/100g)	4.088	1.003	.453

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : MAVERICK
STATE / ID : TX / 0475
MINERALOGY : MONTMORILLONITIC
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 4

Horizon :	1	2	3	4
Depth (cm) :	12.700	53.340	66.040	152.000
Texture ** :	C	C	C	C
Eff Sat Cond (cm/hr):	.508	.508	.508	.003
Porosity (cc/cc) :	.522	.473	.472	.433
F.Cap. W.C.(vol/vol):	.394	.397	.395	.369
Wilt. Point(vol/vol):	.225	.280	.277	.319
Organic Matter (%) :	1.000	.125	.016	.002
Clay (mass/mass) :	.425	.450	.450	.500
Silt (mass/mass) :	.327	.315	.296	.225
Sand (mass/mass) :	.248	.235	.254	.275
Soil Eros Factor K :	.381			
pH :	8.200	7.900	7.900	7.900
CEC (meg/100g) :	2.501	.710	.410	.407

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : MONTELL
STATE / ID : TX / 0213
MINERALOGY : MONTMORILLONITIC
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon	1	2	3
Depth (cm)	20.320	76.200	152.000
Texture **	C	C	C
Eff Sat Cond (cm/hr)	.053	.018	.008
Porosity (cc/cc)	.557	.479	.442
F.Cap. W.C.(vol/vol)	.401	.407	.359
Wilt. Point(vol/vol)	.238	.266	.288
Organic Matter (%)	2.000	.250	.031
Clay (mass/mass)	.460	.460	.475
Silt (mass/mass)	.360	.360	.331
Sand (mass/mass)	.180	.180	.194
Soil Eros Factor K	.344		
pH	7.900	7.900	7.900
CEC (meg/100g)	4.966	1.125	.497

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : DELMITA
STATE / ID : TX / 0340
MINERALOGY : MIXED
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon :	1	2	3
Depth (cm) :	35.560	76.200	152.000
Texture ** :	FSL	SCL	CEM
Eff Sat Cond (cm/hr):	2.782	2.782	6.335
Porosity (cc/cc) :	.382	.388	.320
F.Cap. W.C.(vol/vol):	.256	.263	.098
Wilt. Point(vol/vol):	.084	.161	.001
Organic Matter (%) :	.750	.094	.012
Clay (mass/mass) :	.115	.240	.000
Silt (mass/mass) :	.107	.107	.000
Sand (mass/mass) :	.778	.653	1.000
Soil Eros Factor K :	.393		
pH :	7.200	7.200	.000
CEC (meg/100g) :	1.921	.413	.044

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : RANDADO
STATE / ID : TX / 0357
MINERALOGY : MIXED
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm) : 88.90

Number of Horizons : 3

Horizon	:	1	2	3
Depth (cm)	:	20.320	40.640	88.900
Texture **	:	FSL	FSL	CEM
Eff Sat Cond (cm/hr)	:	2.782	2.782	9.078
Porosity (cc/cc)	:	.431	.391	.350
F.Cap. W.C.(vol/vol)	:	.233	.255	.099
Wilt. Point(vol/vol)	:	.081	.121	.001
Organic Matter (%)	:	1.000	.125	.016
Clay (mass/mass)	:	.130	.210	.000
Silt (mass/mass)	:	.129	.173	.000
Sand (mass/mass)	:	.741	.617	1.000
Soil Eros Factor K	:	.394		
pH	:	7.200	7.200	.000
CEC (meg/100g)	:	2.364	.448	.051

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME	:	SARITA
STATE / ID	:	TX / 0039
MINERALOGY	:	MIXED
HYDROLOGIC GROUP	:	A
ROOT ZONE DEPTH (cm)	:	152.00

Number of Horizons	:	2	
Horizon	:	1	2
Depth (cm)	:	121.920	152.000
Texture **	:	FS	SCL
Eff Sat Cond (cm/hr)	:	27.824	8.799
Porosity (cc/cc)	:	.323	.350
F.Cap. W.C.(vol/vol)	:	.214	.255
Wilt. Point(vol/vol)	:	.058	.164
Organic Matter (%)	:	1.000	.125
Clay (mass/mass)	:	.070	.230
Silt (mass/mass)	:	.093	.070
Sand (mass/mass)	:	.837	.700
Soil Eros Factor K	:	.410	
pH	:	6.700	7.000
CEC (meg/100g)	:	3.222	.608

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : BRENNAN
STATE / ID : TX / 0235
MINERALOGY : MIXED
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 2

Horizon	:	1	2
Depth (cm)	:	30.480	152.000
Texture **	:	FSL	SCL
Eff Sat Cond (cm/hr)	:	8.799	2.782
Porosity (cc/cc)	:	.379	.359
F.Cap. W.C.(vol/vol)	:	.237	.265
Wilt. Point(vol/vol)	:	.093	.164
Organic Matter (%)	:	1.000	.125
Clay (mass/mass)	:	.130	.240
Silt (mass/mass)	:	.132	.152
Sand (mass/mass)	:	.738	.608
Soil Eros Factor K	:	.395	
pH	:	7.200	7.900
CEC (meg/100g)	:	2.502	.562

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : HIDALGO
STATE / ID : TX / 0226
MINERALOGY : MIXED
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon	:	1	2	3
Depth (cm)	:	43.180	71.120	152.000
Texture **	:	FSL	SCL	CL
Eff Sat Cond (cm/hr)	:	2.782	2.782	2.782
Porosity (cc/cc)	:	.421	.401	.375
F.Cap. W.C.(vol/vol)	:	.257	.289	.300
Wilt. Point(vol/vol)	:	.124	.175	.187
Organic Matter (%)	:	2.000	.250	.031
Clay (mass/mass)	:	.175	.270	.290
Silt (mass/mass)	:	.177	.217	.266
Sand (mass/mass)	:	.648	.513	.444
Soil Eros Factor K	:	.356		
pH	:	8.150	8.150	8.150
CEC (meg/100g)	:	5.236	.922	.261

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : MCALLEN
STATE / ID : TX / 0468
MINERALOGY : MIXED
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 2

Horizon	1	2
Depth (cm)	35.560	152.000
Texture **	FSL	SCL
Eff Sat Cond (cm/hr)	2.782	2.782
Porosity (cc/cc)	.401	.368
F.Cap. W.C.(vol/vol)	.255	.284
Wilt. Point(vol/vol)	.135	.178
Organic Matter (%)	.750	.094
Clay (mass/mass)	.195	.265
Silt (mass/mass)	.173	.227
Sand (mass/mass)	.632	.508
Soil Eros Factor K	.391	
pH	8.150	8.150
CEC (meg/100g)	1.961	.466

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : CHANEY
STATE / ID : TX / 0215
MINERALOGY : MIXED
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 4

Horizon	1	2	3	4
Depth (cm)	35.560	86.360	132.080	152.000
Texture **	LS	C	SC	C
Eff Sat Cond (cm/hr)	8.799	.508	.508	.508
Porosity (cc/cc)	.379	.428	.370	.365
F.Cap. W.C.(vol/vol)	.249	.371	.301	.310
Wilt. Point(vol/vol)	.069	.250	.214	.216
Organic Matter (%)	1.000	.125	.016	.002
Clay (mass/mass)	.100	.425	.325	.325
Silt (mass/mass)	.126	.166	.134	.169
Sand (mass/mass)	.774	.409	.541	.506
Soil Eros Factor K	.407			
pH	6.450	6.450	7.000	7.000
CEC (meg/100g)	2.535	.611	.220	.170

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : DUFFAU
STATE / ID : TX / 0261
MINERALOGY : SILICEOUS
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 2

Horizon	:	1	2
Depth (cm)	:	25.400	152.000
Texture **	:	FSL	SCL
Eff Sat Cond (cm/hr)	:	8.799	2.782
Porosity (cc/cc)	:	.395	.364
F.Cap. W.C.(vol/vol)	:	.233	.282
Wilt. Point(vol/vol)	:	.083	.188
Organic Matter (%)	:	1.000	.125
Clay (mass/mass)	:	.115	.275
Silt (mass/mass)	:	.231	.162
Sand (mass/mass)	:	.654	.563
Soil Eros Factor K	:	.431	
pH	:	6.950	6.450
CEC (meg/100g)	:	2.415	.576

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : WINDTHORST
STATE / ID : TX / 0265
MINERALOGY : MIXED
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon	:	1	2	3
Depth (cm)	:	25.400	96.520	152.000
Texture **	:	FSL	C	SCL
Eff Sat Cond (cm/hr)	:	2.782	.880	.880
Porosity (cc/cc)	:	.401	.434	.378
F.Cap. W.C.(vol/vol)	:	.233	.363	.308
Wilt. Point(vol/vol)	:	.083	.254	.197
Organic Matter (%)	:	1.000	.125	.016
Clay (mass/mass)	:	.115	.425	.300
Silt (mass/mass)	:	.269	.226	.288
Sand (mass/mass)	:	.616	.349	.412
Soil Eros Factor K	:	.437		
pH	:	6.450	6.450	7.000
CEC (meg/100g)	:	2.415	.611	.210

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : AUBREY
STATE / ID : TX / 0496
MINERALOGY : MIXED
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon :	1	2	3
Depth (cm) :	15.240	68.580	152.000
Texture ** :	FSL	C	WB
Eff Sat Cond (cm/hr):	8.799	.278	6.335
Porosity (cc/cc) :	.398	.448	.320
F.Cap. W.C.(vol/vol):	.207	.390	.098
Wilt. Point(vol/vol):	.063	.288	.001
Organic Matter (%) :	.000	.000	.000
Clay (mass/mass) :	.100	.500	.000
Silt (mass/mass) :	.196	.132	.000
Sand (mass/mass) :	.704	.368	1.000
Soil Eros Factor K :	.437		
pH :	6.450	4.800	.000
CEC (meg/100g) :	.050	.250	.000

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : CALLISBURG
STATE / ID : TX / 0075
MINERALOGY : MIXED
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon :	1	2	3
Depth (cm) :	15.240	48.260	152.000
Texture ** :	FSL	SCL	SC
Eff Sat Cond (cm/hr):	2.782	.880	.880
Porosity (cc/cc) :	.437	.424	.394
F.Cap. W.C.(vol/vol):	.231	.347	.351
Wilt. Point(vol/vol):	.092	.240	.263
Organic Matter (%) :	1.000	.125	.016
Clay (mass/mass) :	.140	.400	.425
Silt (mass/mass) :	.244	.189	.189
Sand (mass/mass) :	.616	.411	.386
Soil Eros Factor K :	.424		
pH :	6.450	6.200	6.450
CEC (meg/100g) :	2.269	.546	.269

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : CROSSTELL
STATE / ID : TX / 0453
MINERALOGY : MONTMORILLONITIC
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon :	1	2	3
Depth (cm) :	12.700	116.840	152.000
Texture ** :	FSL	C	
Eff Sat Cond (cm/hr):	2.782	.003	.003
Porosity (cc/cc) :	.470	.437	.434
F.Cap. W.C.(vol/vol):	.234	.361	.360
Wilt. Point(vol/vol):	.070	.310	.309
Organic Matter (%) :	1.000	.125	.016
Clay (mass/mass) :	.100	.500	.500
Silt (mass/mass) :	.302	.170	.131
Sand (mass/mass) :	.598	.330	.369
Soil Eros Factor K :	.446		
pH :	6.700	6.450	7.500
CEC (meg/100g) :	2.241	.805	.461

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : ALEDO
STATE / ID : TX / 0114
MINERALOGY : CARBONATIC
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm) : 50.80

Number of Horizons : 3

Horizon :	1	2	3
Depth (cm) :	10.160	40.640	50.800
Texture ** :	CL	CL	WB
Eff Sat Cond (cm/hr) :	2.782	2.782	9.078
Porosity (cc/cc) :	.443	.402	.350
F.Cap. W.C.(vol/vol) :	.298	.288	.091
Wilt. Point(vol/vol) :	.131	.088	.001
Organic Matter (%) :	.000	.000	.000
Clay (mass/mass) :	.275	.275	.000
Silt (mass/mass) :	.306	.233	.000
Sand (mass/mass) :	.419	.492	1.000
Soil Eros Factor K :	.410		
pH :	8.150	8.150	.000
CEC (meg/100g) :	.110	.110	.000

** LEGEND **

C = CLAY	S = SAND
CL = CLAY LOAM	SC = SANDY CLAY
COS = COARSE SAND	SCL = SANDY CLAY LOAM
COSL = COARSE SANDY LOAM	SI = SILT
FS = FINE SAND	SIC = SILTY CLAY
FSL = FINE SANDY LOAM	SICL = SILTY CLAY LOAM
L = LOAM	SIL = SILT LOAM
LCOS = LOAMY COARSE SAND	SL = SANDY LOAM
LFS = LOAMY FINE SAND	VFS = VERY FINE SAND
LS = LOAMY SAND	VFSL = VERY FINE SANDY LOAM
LVFS = LOAMY VERY FINE SAND	

GLMSOIL 8-13-1994

SOIL SERIES NAME : SLIDELL
STATE / ID : TX / 0485
MINERALOGY : MONTMORILLONITIC
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 2

Horizon	:	1	2
Depth (cm)	:	124.460	152.000
Texture **	:	SIC	SIC
Eff Sat Cond (cm/hr)	:	.009	.004
Porosity (cc/cc)	:	.489	.446
F.Cap. W.C.(vol/vol)	:	.408	.360
Wilt. Point(vol/vol)	:	.302	.319
Organic Matter (%)	:	2.500	.313
Clay (mass/mass)	:	.500	.500
Silt (mass/mass)	:	.299	.247
Sand (mass/mass)	:	.201	.253
Soil Eros Factor K	:	.304	
pH	:	7.900	7.900
CEC (meg/100g)	:	8.430	1.638

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : TOPSEY
STATE / ID : TX / 0942
MINERALOGY : CARBONATIC
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm) : 152.00

Number of Horizons : 5

Horizon	:	1	2	3	4	5
Depth (cm)	:	20.320	35.560	48.260	71.120	152.000
Texture **	:	L	L	L	SIL	SICL
Eff Sat Cond (cm/hr)	:	2.782	2.782	2.782	2.782	.880
Porosity (cc/cc)	:	.498	.420	.410	.401	.395
F.Cap. W.C.(vol/vol)	:	.315	.308	.301	.306	.371
Wilt. Point(vol/vol)	:	.153	.160	.129	.164	.250
Organic Matter (%)	:	2.500	.313	.039	.005	.001
Clay (mass/mass)	:	.275	.275	.275	.275	.425
Silt (mass/mass)	:	.390	.406	.332	.317	.317
Sand (mass/mass)	:	.335	.319	.393	.408	.258
Soil Eros Factor K	:	.348				
pH	:	8.150	8.150	8.150	8.150	8.150
CEC (meg/100g)	:	5.857	.952	.224	.126	.172

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : CROCKETT
STATE / ID : TX / 0318
MINERALOGY : MONTMORILLONITIC
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 5

Horizon	:	1	2	3	4	5
Depth (cm)	:	20.320	40.640	106.680	144.780	152.000
Texture **	:	FSL	C	C	CL	
Eff Sat Cond (cm/hr)	:	2.782	.016	.009	.055	.008
Porosity (cc/cc)	:	.495	.476	.431	.399	.424
F.Cap. W.C.(vol/vol)	:	.243	.415	.351	.356	.359
Wilt. Point(vol/vol)	:	.085	.280	.290	.236	.293
Organic Matter (%)	:	1.250	.156	.020	.002	.000
Clay (mass/mass)	:	.125	.475	.450	.350	.450
Silt (mass/mass)	:	.384	.264	.284	.282	.300
Sand (mass/mass)	:	.491	.261	.266	.368	.250
Soil Eros Factor K	:	.441				
pH	:	6.700	6.450	7.250	7.250	7.250
CEC (meg/100g)	:	2.974	.809	.425	.289	.361

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : HEIDEN
STATE / ID : TX / 0151
MINERALOGY : MONTMORILLONITIC
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon	:	1	2	3
Depth (cm)	:	15.240	45.720	152.000
Texture **	:	C	C	C
Eff Sat Cond (cm/hr)	:	.030	.009	.004
Porosity (cc/cc)	:	.577	.490	.442
F.Cap. W.C.(vol/vol)	:	.398	.404	.363
Wilt. Point(vol/vol)	:	.260	.295	.319
Organic Matter (%)	:	2.500	.313	.039
Clay (mass/mass)	:	.500	.500	.500
Silt (mass/mass)	:	.277	.277	.228
Sand (mass/mass)	:	.223	.223	.272
Soil Eros Factor K	:	.300		
pH	:	8.150	8.150	8.150
CEC (meg/100g)	:	5.897	1.259	.541

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : HOUSTON BLACK
STATE / ID : TX / 0093
MINERALOGY : MONTMORILLONITIC
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon	:	1	2	3
Depth (cm)	:	20.320	96.520	152.000
Texture **	:	C	C	C
Eff Sat Cond (cm/hr)	:	.022	.006	.002
Porosity (cc/cc)	:	.606	.508	.462
F.Cap. W.C.(vol/vol)	:	.406	.415	.378
Wilt. Point(vol/vol)	:	.275	.320	.340
Organic Matter (%)	:	3.000	.375	.047
Clay (mass/mass)	:	.550	.550	.550
Silt (mass/mass)	:	.266	.256	.265
Sand (mass/mass)	:	.184	.194	.185
Soil Eros Factor K	:	.278		
pH	:	7.900	7.900	7.900
CEC (meg/100g)	:	7.337	1.626	.620

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : BURLESON
STATE / ID : TX / 0017
MINERALOGY : MONTMORILLONITIC
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon :	1	2	3
Depth (cm) :	50.800	101.600	152.000
Texture ** :	C	C	C
Eff Sat Cond (cm/hr):	.012	.004	.004
Porosity (cc/cc) :	.523	.446	.446
F.Cap. W.C.(vol/vol):	.408	.365	.364
Wilt. Point(vol/vol):	.235	.316	.305
Organic Matter (%) :	2.000	.250	.031
Clay (mass/mass) :	.500	.500	.500
Silt (mass/mass) :	.310	.295	.278
Sand (mass/mass) :	.190	.205	.222
Soil Eros Factor K :	.330		
pH :	7.000	7.250	7.900
CEC (meg/100g) :	5.710	1.244	.521

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : FRELSBURG
STATE / ID : TX / 0804
MINERALOGY : MONTMORILLONITIC
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 2

Horizon :	1	2
Depth (cm) :	20.320	152.000
Texture ** :	C	C
Eff Sat Cond (cm/hr):	.030	.004
Porosity (cc/cc) :	.588	.458
F.Cap. W.C.(vol/vol):	.403	.368
Wilt. Point(vol/vol):	.270	.330
Organic Matter (%) :	2.500	.313
Clay (mass/mass) :	.525	.525
Silt (mass/mass) :	.282	.282
Sand (mass/mass) :	.193	.193
Soil Eros Factor K :	.298	
pH :	7.900	8.150
CEC (meg/100g) :	6.167	1.509

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : WILSON
STATE / ID : TX / 0298
MINERALOGY : MONTMORILLONITIC
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon :	1	2	3
Depth (cm) :	12.700	81.280	152.000
Texture ** :	SIL	SIC	SIC
Eff Sat Cond (cm/hr):	.880	.041	.008
Porosity (cc/cc) :	.500	.465	.437
F.Cap. W.C.(vol/vol):	.304	.393	.357
Wilt. Point(vol/vol):	.139	.254	.306
Organic Matter (%) :	1.250	.156	.020
Clay (mass/mass) :	.225	.425	.475
Silt (mass/mass) :	.412	.313	.266
Sand (mass/mass) :	.363	.262	.259
Soil Eros Factor K :	.422		
pH :	6.450	7.000	7.500
CEC (meg/100g) :	2.881	.809	.454

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : EDGE
STATE / ID : TX / 1084
MINERALOGY : MIXED
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm) : 152.00

Number of Horizons : 5

Horizon	1	2	3	4	5
Depth (cm)	27.940	73.660	109.220	121.920	152.000
Texture **	FSL	SC	CL	FSL	
Eff Sat Cond (cm/hr)	2.782	.029	.508	.880	.508
Porosity (cc/cc)	.402	.450	.390	.363	.360
F.Cap. W.C.(vol/vol)	.231	.399	.353	.288	.291
Wilt. Point(vol/vol)	.066	.274	.230	.170	.186
Organic Matter (%)	1.000	.125	.016	.002	.000
Clay (mass/mass)	.085	.475	.360	.250	.275
Silt (mass/mass)	.351	.252	.308	.275	.199
Sand (mass/mass)	.564	.273	.332	.475	.526
Soil Eros Factor K	.456				
pH	5.900	5.500	5.500	6.150	6.750
CEC (meg/100g)	2.427	.620	.235	.132	.138

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : PADINA
STATE / ID : TX / 0551
MINERALOGY : SILICEOUS
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon	:	1	2	3
Depth (cm)	:	20.320	124.460	152.000
Texture **	:	FS	FS	SCL
Eff Sat Cond (cm/hr)	:	27.824	27.824	2.782
Porosity (cc/cc)	:	.370	.323	.362
F.Cap. W.C.(vol/vol)	:	.166	.204	.275
Wilt. Point(vol/vol)	:	.044	.049	.180
Organic Matter (%)	:	1.000	.125	.016
Clay (mass/mass)	:	.060	.060	.265
Silt (mass/mass)	:	.083	.083	.139
Sand (mass/mass)	:	.857	.857	.596
Soil Eros Factor K	:	.412		
pH	:	6.450	6.450	5.800
CEC (meg/100g)	:	2.329	.446	.194

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : SILSTID
STATE / ID : TX / 0085
MINERALOGY : SILICEOUS
HYDROLOGIC GROUP : A
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 4

Horizon	1	2	3	4
Depth (cm)	63.500	93.980	132.080	152.000
Texture **	FS	FS	SCL	SCL
Eff Sat Cond (cm/hr)	27.824	27.824	2.782	62.198
Porosity (cc/cc)	.376	.376	.346	.327
F.Cap. W.C.(vol/vol)	.230	.230	.258	.246
Wilt. Point(vol/vol)	.061	.061	.176	.008
Organic Matter (%)	1.000	1.000	.125	.016
Clay (mass/mass)	.075	.075	.250	.000
Silt (mass/mass)	.073	.073	.032	.285
Sand (mass/mass)	.852	.852	.718	.715
Soil Eros Factor K	.392			
pH	6.450	6.450	5.800	.000
CEC (meg/100g)	2.803	3.435	.593	.062

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : GREDGE
STATE / ID : TX / 1044
MINERALOGY : MONTMORILLONITIC
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm) : 152.00

Number of Horizons : 5

Horizon :	1	2	3	4	5
Depth (cm) :	17.780	53.340	101.600	144.780	152.000
Texture ** :	FSL	SC	CL	CL	CL
Eff Sat Cond (cm/hr) :	2.782	.015	.508	.880	.880
Porosity (cc/cc) :	.456	.473	.401	.384	.381
F.Cap. W.C.(vol/vol) :	.231	.412	.332	.310	.299
Wilt. Point(vol/vol) :	.076	.281	.227	.199	.182
Organic Matter (%) :	1.000	.125	.016	.002	.000
Clay (mass/mass) :	.110	.475	.325	.275	.250
Silt (mass/mass) :	.242	.220	.261	.224	.223
Sand (mass/mass) :	.648	.305	.414	.501	.527
Soil Eros Factor K :	.434				
pH :	5.500	5.250	6.150	7.000	7.000
CEC (meg/100g) :	2.322	.734	.313	.227	.201

** LEGEND **

C = CLAY	S = SAND
CL = CLAY LOAM	SC = SANDY CLAY
COS = COARSE SAND	SCL = SANDY CLAY LOAM
COSL = COARSE SANDY LOAM	SI = SILT
FS = FINE SAND	SIC = SILTY CLAY
FSL = FINE SANDY LOAM	SICL = SILTY CLAY LOAM
L = LOAM	SIL = SILT LOAM
LCOS = LOAMY COARSE SAND	SL = SANDY LOAM
LFS = LOAMY FINE SAND	VFS = VERY FINE SAND
LS = LOAMY SAND	VFSL = VERY FINE SANDY LOAM
LVFS = LOAMY VERY FINE SAND	

GLMSOIL 8-13-1994

SOIL SERIES NAME : LUFKIN
STATE / ID : TX / 0302
MINERALOGY : MONTMORILLONITIC
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm) : 152.00

Number of Horizons : 2

Horizon	:	1	2
Depth (cm)	:	20.320	152.000
Texture **	:	FSL	C
Eff Sat Cond (cm/hr)	:	2.782	.021
Porosity (cc/cc)	:	.491	.423
F.Cap. W.C.(vol/vol)	:	.279	.344
Wilt. Point(vol/vol)	:	.123	.282
Organic Matter (%)	:	1.250	.156
Clay (mass/mass)	:	.200	.425
Silt (mass/mass)	:	.330	.278
Sand (mass/mass)	:	.470	.297
Soil Eros Factor K	:	.417	
pH	:	5.800	6.150
CEC (meg/100g)	:	3.034	.884

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : RADER
STATE / ID : TX / 0663
MINERALOGY : MIXED
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 4

Horizon	:	1	2	3	4
Depth (cm)	:	63.500	81.280	132.080	152.000
Texture **	:	FSL	SCL	SC	SCL
Eff Sat Cond (cm/hr)	:	8.799	.880	.034	.508
Porosity (cc/cc)	:	.416	.398	.395	.367
F.Cap. W.C.(vol/vol)	:	.238	.274	.363	.317
Wilt. Point(vol/vol)	:	.091	.157	.269	.232
Organic Matter (%)	:	1.250	.156	.020	.002
Clay (mass/mass)	:	.125	.240	.425	.345
Silt (mass/mass)	:	.279	.219	.199	.149
Sand (mass/mass)	:	.596	.541	.376	.506
Soil Eros Factor K	:	.429			
pH	:	5.500	5.000	5.500	6.450
CEC (meg/100g)	:	3.519	.640	.284	.182

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : CUTHBERT
STATE / ID : TX / 0329
MINERALOGY : MIXED
HYDROLOGIC GROUP : C
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 4

Horizon	1	2	3	4
Depth (cm)	20.320	73.660	86.360	152.000
Texture **	LFS	SCL	SCL	
Eff Sat Cond (cm/hr)	8.799	.880	.880	1.524
Porosity (cc/cc)	.446	.444	.412	.367
F.Cap. W.C.(vol/vol)	.253	.381	.322	.312
Wilt. Point(vol/vol)	.064	.272	.213	.211
Organic Matter (%)	2.000	.250	.031	.004
Clay (mass/mass)	.085	.475	.350	.325
Silt (mass/mass)	.224	.190	.170	.187
Sand (mass/mass)	.691	.335	.480	.488
Soil Eros Factor K	.397			
pH	5.500	4.550	4.550	4.300
CEC (meg/100g)	4.640	.988	.282	.177

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : LILBERT
STATE / ID : TX / 0702
MINERALOGY : SILICEOUS
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 4

Horizon	1	2	3	4
Depth (cm)	20.320	71.120	147.320	152.000
Texture **	LFS	LFS	SCL	SCL
Eff Sat Cond (cm/hr)	27.824	27.824	2.782	.880
Porosity (cc/cc)	.429	.363	.362	.354
F.Cap. W.C.(vol/vol)	.244	.232	.279	.283
Wilt. Point(vol/vol)	.070	.065	.189	.188
Organic Matter (%)	2.000	.250	.031	.004
Clay (mass/mass)	.090	.090	.275	.275
Silt (mass/mass)	.135	.135	.128	.115
Sand (mass/mass)	.775	.775	.597	.610
Soil Eros Factor K	.375			
pH	5.500	5.500	5.250	5.250
CEC (meg/100g)	4.643	.792	.253	.153

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : LAKE CHARLES
STATE / ID : TX / 0020
MINERALOGY : MONTMORILLONITIC
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 2

Horizon	:	1	2
Depth (cm)	:	50.800	152.000
Texture **	:	C	C
Eff Sat Cond (cm/hr)	:	.508	.005
Porosity (cc/cc)	:	.567	.450
F.Cap. W.C.(vol/vol)	:	.378	.357
Wilt. Point(vol/vol)	:	.274	.320
Organic Matter (%)	:	4.000	.500
Clay (mass/mass)	:	.500	.500
Silt (mass/mass)	:	.253	.256
Sand (mass/mass)	:	.247	.244
Soil Eros Factor K	:	.271	
pH	:	6.700	7.500
CEC (meg/100g)	:	11.020	2.217

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : VICTORIA
STATE / ID : TX / 0224
MINERALOGY : MONTMORILLONITIC
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm) : 152.00

Number of Horizons : 2

Horizon	1	2
Depth (cm)	30.480	152.000
Texture **	C	C
Eff Sat Cond (cm/hr)	.026	.004
Porosity (cc/cc)	.506	.446
F.Cap. W.C.(vol/vol)	.408	.369
Wilt. Point(vol/vol)	.284	.337
Organic Matter (%)	2.000	.250
Clay (mass/mass)	.475	.525
Silt (mass/mass)	.222	.194
Sand (mass/mass)	.303	.281
Soil Eros Factor K	.312	
pH	8.150	8.450
CEC (meg/100g)	5.253	1.304

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : BERNARD
STATE / ID : TX / 0021
MINERALOGY : MONTMORILLONITIC
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 2

Horizon	1	2
Depth (cm)	15.240	152.000
Texture **	CL	C
Eff Sat Cond (cm/hr)	.508	.010
Porosity (cc/cc)	.567	.447
F.Cap. W.C.(vol/vol)	.305	.352
Wilt. Point(vol/vol)	.150	.307
Organic Matter (%)	4.000	.500
Clay (mass/mass)	.250	.475
Silt (mass/mass)	.423	.323
Sand (mass/mass)	.327	.202
Soil Eros Factor K	.327	
pH	6.450	6.700
CEC (meg/100g)	8.995	2.106

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : MUSTANG
STATE / ID : TX / 0184
MINERALOGY : MIXED
HYDROLOGIC GROUP : A/D
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 2

Horizon :	1	2
Depth (cm) :	15.240	152.000
Texture ** :	FS	FS
Eff Sat Cond (cm/hr):	27.824	27.824
Porosity (cc/cc) :	.366	.297
F.Cap. W.C.(vol/vol):	.155	.159
Wilt. Point(vol/vol):	.039	.035
Organic Matter (%) :	1.000	.125
Clay (mass/mass) :	.050	.050
Silt (mass/mass) :	.019	.019
Sand (mass/mass) :	.931	.931
Soil Eros Factor K :	.327	
pH :	7.500	7.500
CEC (meg/100g) :	2.224	.456

** LEGEND **

C = CLAY	S = SAND
CL = CLAY LOAM	SC = SANDY CLAY
COS = COARSE SAND	SCL = SANDY CLAY LOAM
COSL = COARSE SANDY LOAM	SI = SILT
FS = FINE SAND	SIC = SILTY CLAY
FSL = FINE SANDY LOAM	SICL = SILTY CLAY LOAM
L = LOAM	SIL = SILT LOAM
LCOS = LOAMY COARSE SAND	SL = SANDY LOAM
LFS = LOAMY FINE SAND	VFS = VERY FINE SAND
LS = LOAMY SAND	VFSL = VERY FINE SANDY LOAM
LVFS = LOAMY VERY FINE SAND	

GLMSOIL 8-13-1994

SOIL SERIES NAME : VESTON
STATE / ID : TX / 0665
MINERALOGY : MIXED
HYDROLOGIC GROUP : D
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 3

Horizon	1	2	3
Depth (cm)	30.480	60.960	152.000
Texture **	L		
Eff Sat Cond (cm/hr)	2.782	2.782	.508
Porosity (cc/cc)	.419	.406	.382
F.Cap. W.C.(vol/vol)	.278	.266	.301
Wilt. Point(vol/vol)	.141	.129	.169
Organic Matter (%)	1.000	.125	.016
Clay (mass/mass)	.210	.195	.250
Silt (mass/mass)	.318	.358	.423
Sand (mass/mass)	.472	.447	.327
Soil Eros Factor K	.419		
pH	7.500	8.450	8.450
CEC (meg/100g)	2.542	.471	.183

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : CONROE
STATE / ID : TX / 0319
MINERALOGY : KAOLINITIC
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm) : 152.00

Number of Horizons : 3

Horizon	:	1	2	3
Depth (cm)	:	63.500	78.740	152.000
Texture **	:	LS	SCL	SC
Eff Sat Cond (cm/hr)	:	8.799	.508	.508
Porosity (cc/cc)	:	.372	.423	.398
F.Cap. W.C.(vol/vol)	:	.234	.311	.322
Wilt. Point(vol/vol)	:	.035	.178	.226
Organic Matter (%)	:	2.000	.250	.031
Clay (mass/mass)	:	.060	.375	.425
Silt (mass/mass)	:	.250	.116	.067
Sand (mass/mass)	:	.690	.509	.508
Soil Eros Factor K	:	.410		
pH	:	5.500	5.000	5.000
CEC (meg/100g)	:	5.536	.867	.160

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

GLMSOIL 8-13-1994

SOIL SERIES NAME : KIRBYVILLE
STATE / ID : TX / 0807
MINERALOGY : SILICEOUS
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm) : 152.00

Number of Horizons : 2

Horizon	:	1	2
Depth (cm)	:	45.720	152.000
Texture **	:	VFSL	SCL
Eff Sat Cond (cm/hr)	:	8.799	2.782
Porosity (cc/cc)	:	.414	.373
F.Cap. W.C. (vol/vol)	:	.233	.283
Wilt. Point (vol/vol)	:	.074	.152
Organic Matter (%)	:	1.000	.125
Clay (mass/mass)	:	.100	.240
Silt (mass/mass)	:	.364	.323
Sand (mass/mass)	:	.536	.437
Soil Eros Factor K	:	.453	
pH	:	5.250	5.000
CEC (meg/100g)	:	2.645	.571

** LEGEND **

C	= CLAY	S	= SAND
CL	= CLAY LOAM	SC	= SANDY CLAY
COS	= COARSE SAND	SCL	= SANDY CLAY LOAM
COSL	= COARSE SANDY LOAM	SI	= SILT
FS	= FINE SAND	SIC	= SILTY CLAY
FSL	= FINE SANDY LOAM	SICL	= SILTY CLAY LOAM
L	= LOAM	SIL	= SILT LOAM
LCOS	= LOAMY COARSE SAND	SL	= SANDY LOAM
LFS	= LOAMY FINE SAND	VFS	= VERY FINE SAND
LS	= LOAMY SAND	VFSL	= VERY FINE SANDY LOAM
LVFS	= LOAMY VERY FINE SAND		

GLMSOIL 8-13-1994

SOIL SERIES NAME : OTANYA
STATE / ID : TX / 0806
MINERALOGY : SILICEOUS
HYDROLOGIC GROUP : B
ROOT ZONE DEPTH (cm): 152.00

Number of Horizons : 4

Horizon	:	1	2	3	4
Depth (cm)	:	22.860	71.120	121.920	152.000
Texture **	:	FSL	SCL	SCL	SCL
Eff Sat Cond (cm/hr)	:	8.799	2.782	.880	.880
Porosity (cc/cc)	:	.437	.399	.374	.367
F.Cap. W.C.(vol/vol)	:	.227	.253	.299	.304
Wilt. Point(vol/vol)	:	.077	.117	.185	.187
Organic Matter (%)	:	1.000	.125	.016	.002
Clay (mass/mass)	:	.115	.185	.290	.290
Silt (mass/mass)	:	.288	.291	.255	.255
Sand (mass/mass)	:	.597	.524	.455	.455
Soil Eros Factor K	:	.440			
pH	:	5.500	5.000	5.000	5.000
CEC (meg/100g)	:	2.386	.468	.201	.153

** LEGEND **

C = CLAY
CL = CLAY LOAM
COS = COARSE SAND
COSL = COARSE SANDY LOAM
FS = FINE SAND
FSL = FINE SANDY LOAM
L = LOAM
LCOS = LOAMY COARSE SAND
LFS = LOAMY FINE SAND
LS = LOAMY SAND
LVFS = LOAMY VERY FINE SAND
S = SAND
SC = SANDY CLAY
SCL = SANDY CLAY LOAM
SI = SILT
SIC = SILTY CLAY
SICL = SILTY CLAY LOAM
SIL = SILT LOAM
SL = SANDY LOAM
VFS = VERY FINE SAND
VFSL = VERY FINE SANDY LOAM

Appendix B - Chapter 5

1.0 Description of Toxicological Information

This chapter summarizes the toxicological information and TxDOT's use patterns for the chemicals evaluated in this EIS. There are nine separate tables. The first table (Table B5-1) lists registration information, active ingredient, signal word, and formulation for each chemical.

Table B5-2 describes the meaning of each signal word and corresponding toxicity category used by the Environmental Protection Agency (EPA) to classify chemicals.

Table B5-3 provides an illustration of relative toxicity levels for some herbicides, insecticides, and other chemicals encountered by humans.

Table B5-4 presents the response from each chemical's manufacturer to TxDOT's request for information regarding inert ingredients. Manufacturers were asked to indicate whether inert ingredients contained in chemicals being evaluated for use were classified in EPA's list 1 (Inerts of Toxicological Concern) or 2 (Potentially Toxic Inerts with High Priority for Testing).

Table B5-5 is TxDOT's Herbicide Summary Application Chart, as found in *Roadside Vegetation Management: A Volume of the Infrastructure Manual* (1993). This table lists the non-experimental herbicides used by TxDOT and the site or pest plant conditions for which they are used. TxDOT application rates are listed as well.

Table B5-6 presents a summary of TxDOT's herbicide use on the ROW. This table includes all herbicides under consideration for use by TxDOT and details the application method used.

Tables B5-7 through B5-14 present specific use information for each herbicide currently used by TxDOT. Targeted plant types, locations, rates, and seasons of use are given.

Tables B5-15 presents a summary of TxDOT's insecticide use on the ROW. Target species and application type are given.

Tables B5-16 through B5-18 present specific use information for each insecticide currently used by TxDOT. Targeted species, application rate, and seasons of use are given.

Table B5-19 presents a summary of TxDOT's herbicide use in 1991 for illustration purposes.

Table B5-1. Technical Characteristics of Chemicals Used by TxDOT

Common Name	Product Name	Signal Word	Registrant	EPA Registration Number	Type of Formulation	Ingredients		
						Type	Name	Composition
Clopyralid*	Transline®	Caution	DowElanco	62719-73	Liquid	Active Inert	Clopyralid ---	40.9% 59.1%
Glyphosate	Rodeo®	Caution	Monsanto Agricultural Company	524-343	Liquid	Active Inert	Glyphosate ---	53.8% 46.2%
Glyphosate	Roundup®	Warning	Monsanto Agricultural Company	524-308-AA	Liquid	Active Inert	Glyphosate ---	41.0% 59.0%
Hexazinone	Velpar L®	Danger	E.I. DuPont De Nemours and Company	352-392	Liquid	Active Inert	Hexazinone ---	25.9% 75.0%
Imazapyr*	Arsenal®	None	American Cyanamid Company	241-273	Liquid	Active Inert	Imazapyr ---	27.6% 72.4%
Metsulfuron methyl	Escort®	None	E.I. DuPont De Nemours and Company	352-439	Dry flowable powder	Active Inert	Metsulfuron methyl ---	60.0% 40.0%
Sulfometuron methyl	Oust®	None	E.I. DuPont De Nemours and Company	352-401	Dry flowable powder	Active Inert	Sulfometuron methyl ---	75.0% 25.0%
Triclopyr*	Pathfinder II®	Danger	DowElanco	464-554	Liquid	Active Inert	Triclopyr ---	61.6% 38.4%
Chlorpyrifos	Dursban®	Warning	DowElanco	62719-11	Liquid	Active Inert	Chlorpyrifos ---	44.9% 55.1%
Diazinon	Diazinon® 4E	Warning	Ciba-Geigy Ltd.	10370-39	Liquid	Active Inert	Diazinon ---	47.5% 52.5%
Fenoxycarb	Logic®	None	Ciba-Geigy Ltd.	100-722	Granules	Active Inert	Fenoxycarb ---	1.0% 99.0%

* Test material
Source: Pesticide labels and Jones, 1992.

Table B5-2. Definition of Chemical Toxicity Categories and Signal Words Used on Labels

Toxicity Category	Signal Word	Hazard Indicator (for rats)				
		Oral LD_{50}	Inhalation LC_{50}	Dermal LD_{50}	Eye Effects	Skin Effects
I. Severe	Danger - poison	From 0-50 mg/kg equivalent human dose: 1 teaspoon or less	From 0-0.2 mg/liter	From 0-200 mg/kg	Corrosive; corneal opacity not reversible within 7 days	Corrosive
II. Moderate	Danger	From 50-500 mg/kg equivalent human dose: 1 teaspoon to 1 ounce	From 0.2-2 mg/liter	From 200-2,000 mg/kg	Corneal opacity reversible within 7 days; irritation persisting for 7 days	Severe irritation at 72 hours
III. Slight	Warning	From 500-5,000 mg/kg equivalent human dose: 1 ounce to 1 pint	From 2-20 mg/liter	From 2,000-20,000 mg/kg	No corneal opacity; irritation reversible within 7 days	Moderate irritation at 72 hours
IV. Very Slight	Caution	Greater than 5,000 mg/kg equivalent human dose: greater than 1 pint	Greater than 20,000 mg/kg	No irritation	No irritation	Mild or slight irritation at 72 hours

Source: Adapted from University of California, 1988, and Maxwell, 1982.

Table B5-3. Acute Toxicity Classification of Selected Chemicals

Herbicide or Other Chemical Substance	Oral LD_{50} for Rats (mg/kg)	Toxicity Category* (label signal words)	Equivalent Human Dose
	0 - 50 (range)	I Severe (Danger - Poison)	1 teaspoon or less
Nicotine	50		
Strychnine	30		
TCDD (a dioxin)	0.1		
Botulinus Toxin	0.00001		
	50 - 500 (range)	II Moderate (Danger)	1 teaspoon to 1 ounce
Caffeine	200		
Diazinon	96		
Chlorpyrifos	82		
	500 - 5,000 (range)	III Slight (Warning)	1 ounce to 1 pint
Glyphosate	4,320		
Clopyralid	4,300		
Triclopyr	4183-4464		
Table Salt	3,750		
Hexazinone	1,690		
	5,000 - 50,000 (range)	IV Very slight (Caution)	More than 1 pint
Sugar	30,000		
Fenoxycarb	16,800		
Ethyl Alcohol	13,700		
Imazapyr	> 5,000		
Sulfometuron Methyl	> 5,000		
Metsulfuron Methyl	> 5,000		

* Categories, signal words, and LD_{50} ranges are based on a classification system used by EPA for labeling pesticides. Adapted from Maxwell (1982).

Table B5-4. Results of TxDOT's Request for Inert Classification

Pesticide Product	Active Ingredient	Inerts in Product Found in EPA Lists 1 or 2?	Respondent
Arsenal	Imazapyr	no	Susan Burkart, Cyanamid
Diazinon 4E	Diazinon	no	Jerry Harrison, Ciba-Geigy
Dursban	Chlorpyrifos	yes; (1 inert in List 2)	Jeffrey Pinkham, DowElanco
Escort	Metsulfuron methyl	no	Darrell Drake, DuPont
Garlon 4	Triclopyr	yes; (1 inert in List 2)	Kent Redding, DowElanco
Logic	Fenoxycarb	no	Jerry Harrison, Ciba-Geigy
Oust	Sulfometuron methyl	no	Darrell Drake, DuPont
Rodeo	Glyphosate	no	Brian Matura, Monsanto
Roundup	Glyphosate	no	Brian Matura, Monsanto
Transline	Clopyralid	no	Kent Redding, DowElanco
Velpar L	Hexazinone	no	Darrell Drake, DuPont

Table B5-5. TxDOT's Herbicide Application Summary Chart

Treatment Area or Pest Plant	Season	Type of Herbicide	Application Rate & Mixture	Nozzle Tip or Boom	Comments
Surfaced shoulders & paved medians	Mar - Oct	Roundup	3 qt./acre	8008	May be sprayed near trees or desired shrubs.
Pavement edge & curbs	Nov - Dec	Velpar L	4 gal./100 gal. water	6508	*Do not* use within 100 feet of trees or desirable shrubs. *Do not* use in picnic or rest areas.
	Mar - Oct	Roundup	3 qt./acre	6508	May be sprayed near trees or desired shrubs.
Guardrail, sign posts, delineator posts	Nov - Dec	Velpar L	4 gal./100 gal. water	2-OC08's 2508	*Do not* use within 100 feet of trees or desirable shrubs. *Do not* use in picnic or rest areas.
	Mar - Oct	Roundup	3 qt./acre (Comp.*) ½ qt./acre (Part.*)	6508 2508	May be sprayed near trees or desired shrubs. *Do not* spray on foliage of ornamentals.
	Year Round	Roundup + Oust	½ qt. + 2 oz./acre (Part.*)	2508	
Tall johnsongrass	May - Oct	Roundup	½ qt./acre	Flex-5 6508 or 2508	*Do not* spray in windy conditions.
	June - July	Roundup + Oust	½ qt. + 2 oz./acre	Flex-5, W-4 Boom, or same as for Roundup alone	Avoid ornamental plants. *Do not* allow spray to drift onto nearby crops.
Tall grass and weeds	May - Oct	Roundup	5 gal./10 gal. water	Ropewick	*Do not* treat when weed foliage is wet. *Do not* allow leakage from ropes over desirable grasses. Travel 2 - 3 mph in thick stands; 4 - 6 mph in thin stands.
Wildoat and jointed goatgrass	Late March	Roundup	1 qt./acre	Flex-5 or W-4 Boom	May be sprayed near trees or desirable shrubs.
Brush species near bridges and fences	Apr - Oct	Velpar L	4 ml./inch of stem diameter 4 gal./100 gal. water	Spotgun Handgun 8008	*Do not* use in picnic or rest areas. *Do not* use within 100 feet of trees or desirable shrubs. Spray around base of brush or trees to kill.
Grass and weeds at stockpiles	Mar - Oct	Velpar L	4 gal./100 gal. water	8008	*Do not* use within 100 feet of trees or desirable shrubs.
Aquatic areas (standing or running water)	May - Oct	Rodeo	6 qt./100 gal water	Handgun 8008	Same precautions as for Roundup.
Field bindweed	Apr - Sept	Escort	1 oz./acre	Flex-5 or W-4 Boom	Spray only when plant is in full bloom.
African rue	Apr - Nov	Escort	3 oz./acre	Flex-5 or W-4 Boom	Spray only when plant is actively growing.
Huisache	June - July	Escort	2 oz./acre	Flex-5 or W-4 Boom	*Do not* spray after July 31.

Source: TxDOT's *Vegetation Management Standards*, 1991.

* Comp. = Complete Vegetation Control
* Part. = Partial Vegetation Control

Table B5-6. Summary of Herbicide Use on TxDOT ROW

Herbicide	ROW Treatment Sites									Target Vegetation					Application Form	Application Methods				Placement	
	Pavement edges, curbs, cracks, and joints	Surfaced shoulders and paved medians	Fixture bases	Bridges and fences	Safety strips	Sightlines and general ROW areas	Drainage channels and culvert headwalls and endwalls	Landscape plantings	Stockpiles	Annual forbs	Perennial forbs	Grasses	Woody plants	Noxious weeds	Spray	Handgun portable hand sprayer	Stump treatment	Truck spray	Ropewick applicator	Foliage	Soil
Clopyralid					X	X				X	X		X		X	X		X		X	
Glyphosate (Rodeo®)							X			X	X	X	X	X	X	X		X		X	
Glyphosate (Roundup®)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	
Hexazinone	X		X		X	X			X	X	X	X	X		X	X		X		X	X
Imazapyr	X								X	X	X	X	X	X	X			X		X	
Metsulfuron methyl					X	X							X	X	X	X		X		X	
Sulfometuron methyl			X		X	X				X	X	X		X	X			X		X	X
Triclopyr					X	X							X		X	X	X				

Sources: Roy Smith, TxDOT, and TxDOT's *Herbicide Operations Manual*.

Table B5-7. TxDOT's Herbicide Use Pattern for Clopyralid

Active Ingredient : Clopyralid *

Product Name : Transline ®

Application Mixture : Aqueous solution

Application Method : Foliar-applied spray

Application Rate : (Test Rate) 5 - 20 oz/acre (.4-1.5 L/ha)

Mode of Action : Auxin-type, selective postemergent

Use Limitations : Avoid use in windy conditions. Avoid drift onto crops.

A Annual forbs
P Perennial forbs
G Grasses
W Woody plants
N Noxious weeds

Sp Spring
Su Summer
F Fall
W Winter

* Test material

Source : Roy Smith, TxDOT, and Transline ® label

Treatment Sites :	**Target Vegetation :**	**Appl. Rate :**	**Seasons of Use :**	**Comments :**
Pavement edges and curbs	----	---	---	---
Surfaced shoulders and paved medians, cracks and joints	---	---	---	---
Fixture bases	---	---	---	---
Bridges and fences	---	---	--	---
Safety strips	---	see above	Sp, su	---
Sightlines and general ROW areas	---	see above	Sp, su	---
Drainage channels, culvert headwalls and endwalls	---	---	---	---
Landscape plantings	---	---	---	---
Stockpiles	---	---	---	---

Table B5-8. TxDOT's Herbicide Use Pattern for Glyphosate (Rodeo®)

Active Ingredient: Glyphosate	
Product Name: Rodeo®	
Application Mixture: Aqueous solution	
Application Method: Foliar-applied spray	
Application Rate: 1 1/2 gal/ 100 gal water or 3qt./acre (7 L/ha)	
Mode of Action: Nonselective postemergent. Not soil-active	
Use Limitations: Avoid ornamental foliage. Avoid windy conditions.	

A Annual forbs
P Perennial forbs
G Grasses
W Woody plants
N Noxious weeds

Sp Spring
Su Summer
F Fall
W Winter

Source: Roy Smith, TxDOT, and Rodeo® label

Treatment Sites:	Target Vegetation:	Appl. Rate:	Seasons of Use:	Comments:
Pavement edges and curb	---	---	---	---
Surfaced shoulders and paved medians, cracks and joints	---	---	---	---
Fixture bases	---	---	---	---
Bridges and fences	---	---	---	---
Safety strips	---	---	---	---
Sightlines and general ROW areas	---	---	---	---
Drainage channels, culvert headwalls and endwalls	APGWN	see above	Su, F	---
Landscape plantings	---	---	---	---
Stockpiles	---	---	---	---

Table B5-9. TxDOT's Herbicide Use Pattern for Glyphosate (Roundup®)

Active Ingredient: Glyphosate

Product name: Roundup®

Application Mixture: Aqueous solution

Application Method: Foliar-applied spray

Application Rate: Varies - see below

Mode of Action: Nonselective postemergent. Not soil-active. Selectivity controlled by application rate.

Use Limitations: May be used near desirable trees and shrubs. Avoid ornamental foliage and windy conditions.

A Annual forbs
P Perennial forbs
G Grasses
W Woody plants
N Noxious weeds

Sp Spring
Su Summer
F Fall
W Winter

Source : Roy Smith, TxDOT, and Roundup® label

Treatment Sites:	Target Vegetation:	Appl. Rate:	Seasons of Use:	Comments:
Pavement edges and curbs	APGWN	3 qt/ acre (7L/ha)	Sp, Su, F	---
Surfaced shoulders and paved medians, cracks and joints	APGWN	3 qt /acre (7L/ha)	Sp, Su, F	---
Fixture bases	APGWN	16oz -3qt / acre (1.2-7L/ha)	Sp, Su, F	---
Bridges and fences	APGWN	16oz-3qt/acre (1.2-7L/ha)	Sp, Su, F	---
Safety strips	APGWN	16oz/acre 1.2L/ha)	Sp, Su, F	---
Sightlines and general ROW areas	APGWN	16oz / acre (1.2L/ha) (Overspray) 33% solution (Ropewick)	Sp, Su, F	Use ropewick applicator Do not treat when foliage is wet. Do not allow leakage from ropes over desirable grasses.
Dry drainage channels, culvert headwalls, and endwalls	APGWN	16oz-3qt/ acre (1.2-7L/ha)	Sp, Su, F	Drainage areas must be dry
Landscape plantings	APGWN	16oz-3qt / acre (1.2L/ha)	Sp, Su, F	Do not allow on ornamental foliage
Stockpiles	APGWN	16oz-3 qt / acre (1.2-7L/ha)	Sp, Su, F	---

Table B5-10. TxDOT's Herbicide Use Pattern for Hexazinone

Active Ingredient : Hexazinone	
Product Name : Velpar L®	
Application Mixture : Aqueous solution	
Application Method : Foliar-applied spray	
Application Rate : Varies - see below	
Mode of Action : Preemergent and postemergent broadspectrum. Nonselective. Contact and systematic	
Use Limitations : Do not use near desired trees and shrubs. Do not use in picnic or safety rest areas. Do not apply to bare soil or slopes or where runoff is likely.	

A Annual forbs
P Perennial forbs
G Grasses
W Woody plants
N Noxious weeds

Sp Spring
Su Summer
F Fall
W Winter

Source : Roy Smith, TxDOT, and Velpar L® label

Treatment Sites :	**Target Vegetation :**	**Appl. Rate :**	**Seasons of Use :**	**Comments :**
Pavement edges and curbs	APGW	4gal/100 gal water (15L/379L water)	F	---
Surfaced shoulders and paved medians, cracks and joints	---	---	---	---
Fixture bases	APGW	4gal/100 gal water (15L/379L water)	F	---
Bridges and fences	---	---	---	---
Safety strips	W	4gal/100 gal water, (15L/379L water) 4ml concentrated material per inch stem diameter	Sp, Su, F	Use as trunk base spray
Sightlines and general ROW areas	W	4gal/100 gal water, (15L/379L water) 4ml concentrated material per inch stem diameter	Sp, Su, F	---
Drainage channels, culvert headwalls and endwalls	---	---	---	---
Landscape plantings	---	---	---	---
Stockpiles	APGW	4gal/100 gal water (15L/379L water)	Sp, Su, F	---

Table B5-11. TxDOT's Herbicide Use Pattern for Imazapyr

Active Ingredient : Imazapyr*

Product Name : Arsenal®

Application Mixture : Aqueous solution

Application Method : Foliar-applied spray

Application Rate : 1 qt/acre (2.3L/ha)

Mode of Action : Preemergent and postemergent broadspectrum.

Use Limitations :

A Annual forbs
P Perennial forbs
G Grasses
W Woody plants
N Noxious weeds

Sp Spring
Su Summer
F Fall
W Winter

* Test material

Source : Roy Smith, TxDOT, and Arsenal® label

Treatment Sites :	Target Vegetation :	Appl. Rate :	Seasons of Use :	Comments :
Pavement edges and curbs	APGWN	1 qt/acre (2.3 L\ha)	Sp, Su, F	---
Surfaced shoulders and paved medians, cracks and joints	---	---	---	---
Fixture bases	---	---		---
Bridges and fences	---	---	---	---
Safety strips	---	---	---	---
Sightlines and general ROW areas	---	---	---	---
Drainage channels, culvert headwalls and endwalls	---	---	---	---
Landscape plantings	---	---	---	---
Stockpiles	APGWN	1 qt/acre (2.3L/ha)	Sp, Su, F	---

Table B5-12. TxDOT's Herbicide Use Pattern for Metsulfuron methyl

Active Ingredient: Metsulfuron methyl	
Product name: Escort®	
Application Mixture: Aqueous suspension	
Application Method: Foliar-applied spray	
Application Rate: Varies - see below	
Mode of Action: Selective preemergent, early postemergent	
Use Limitations:	

A Annual forbs
P Perennial forbs
G Grasses
W Woody plants
N Noxious weeds

Sp Spring
Su Summer
F Fall
W Winter

Source : Roy Smith, TxDOT, and Escort® label

Treatment Sites:	Target Vegetation:	Appl. Rate:	Seasons of Use:	Comments:
Pavement edges and curbs	---	---	---	---
Surfaced shoulders and paved medians, cracks and joints	---	---		---
Fixture bases	---	---	---	---
Bridges and fences	---	---	---	---
Safety strips	WN	1-3oz/acre (70-210g/ha)	Sp, Su, F	Rate used depends on target species
Sightlines and general ROW areas	WN	1-3oz/acre (70-210g/ha)	Sp, Su, F	Rate used depends on target species
Field Bindweed	Field Bindweed	1oz/acre (70g/ha)	Sp, Su	Spray only when plant is in full bloom
African Rue	African Rue	3oz/acre (210 g/ha)	Sp, Su, F	Spray only when plant is actively growing
Huisache	Huisache	2 oz/acre (140g/ha)	Su	Do not spray after July 31

Table B5-13. TxDOT's Herbicide Use Pattern for Sulfometuron methyl

Active Ingredient : Sulfometuron methyl

Product Name : Oust®

Application Mixture : Aqueous suspension

Application Method : Foliar-applied spray

Application Rate : 2oz/acre (140 g/ha)

Mode of Action : Preemergent, postemergent nonselective. Selectivity controlled by application rate.

Use Limitations : Avoid ornamental foliage, crop areas, fruit trees. Do not use mixed with Roundup® until wildflowers have set seed. Do not use before bermudagrass is actively growing.

A	Annual forbs	Sp	Spring
P	Perennial forbs	Su	Summer
G	Grasses	F	Fall
W	Woody plants	W	Winter
N	Noxious weeds		

Source : Roy Smith, TxDOT, and Oust® label

Treatment Sites :	Target Vegetation :	Appl. Rate :	Seasons of Use :	Comments :
Pavement edges and curbs	---	---	---	---
Surfaced shoulders and paved medians, cracks and joints	---	---	---	---
Fixture bases	APGN	see above	Sp, Su, F, W	Used with .5 qt/ac (1.1 L\ha) Roundup®
Bridges and fences	---	---	---	---
Safety strips	APGN	see above	Su Not after July 31st	Used with .5 qt/ac (1.1 L\ha) Roundup®
Sightlines and general ROW areas	APGN	see above	Su Not after July 31st	Used with .5 qt/ac (1.1 L\ha) Roundup®
Drainage channels, culvert headwalls and endwalls	---	---	---	---
Landscape plantings	---	---	---	---
Stockpiles	---	---	---	---

Table B5-14. TxDOT's Herbicide Use Pattern for Triclopyr

Active Ingredient: Triclopyr*	
Product Name: Pathfinder II®	
Application Mixture: Ester applied in oil	
Application Method: Stem-base spray	
Application Rate: 2 1/4qt - 4 1/2qt/acre- (5.3-10.5 L/ha)	
Mode of Action: Auxin-type selective	
Use Limitations:	

A Annual forbs
P Perennial forbs
G Grasses
W Woody plants
N Noxious weeds

Sp Spring
Su Summer
F Fall
W Winter

* Test material

Note: Pathfinder®, a spray-ready solution, may be used in the place of Garlon 4®

Source : Roy Smith, TxDOT, Garlon 4® and Pathfinder® label

Treatment Sites:	Target Vegetation:	Appl. Rate:	Seasons of Use:	Comments:
Pavement edges and curbs	---	---	---	---
Surfaced shoulders and paved medians, cracks and joints	---	---	---	---
Fixture bases	---	---	---	---
Bridges and fences	---	---	---	---
Safety strips	W	see above	Sp, Su, W, F	Low volume basal spray
Sightlines and general ROW areas	W	see above	W	Low volume basal spray
Drainage channels, culvert headwalls, and endwalls	---	---	---	---
Landscape plantings	---	---	---	---
Stockpiles	---	---	---	---

Table B5-15. Summary of Insecticide Use on TxDOT ROW

Insecticide	ROW Treatment Site		Target Insects	Application Mixture		Spot Application Method		Mode of Action	
	Safety rest areas	Electric equipment boxes	Ants and other stinging insects	Spray applied to individual mounds	Granules	Handgun	Manual distribution	Contact	Bait
Chlorpyrifos	X		X	X		X		X	
Diazinon	X	X	X	X		X		X	
Fenoxycarb	X		X		X		X		X

Source: Roy Smith, TxDOT.

Table B5-16. TxDOT's Insecticide Use Pattern for Chlorpyrifos

Active Ingredient : Chlorpyrifos	
Product Name : Dursban® Turf Insecticide	
Application Mixture : Aqueous or oil-based solution	
Application Method : Direct spraying of ant mounds	
Application Rate : 1 fl oz/4 gal/4 mounds or 1qt/acre (2.3 L/ha)	
Mode of Action : Organophosphate. Action on contact.	
Use Limitations : Follow label recommendations.	

Sp Spring
Su Summer
F Fall
W Winter

Source : Roy Smith, TxDOT, Dursban® 4E label

Treatment Sites :	**Target Vegetation :**	**Appl. Rate :**	**Seasons of Use :**	**Comments :**
Safety rest areas, lawns, rights-of-way	ants	see above	Sp, Su, F	---
Electrical equipment boxes	--	--	--	---

Table B5-17. TxDOT's Insecticide Use Pattern for Diazinon

Active Ingredient : Diazinon
Product Name : Diazinon® 4E
Application Mixture : Aqueous solution
Application Method : Direct spraying of ant mounds
Application Rate : 2-3 fl oz/1 gal/spray mounds to wet, not drench
Mode of Action : Organophosphate. Action on contact.
Use Limitations : Follow label recommendations

Sp Spring
Su Summer
F Fall
W Winter

Source : Roy Smith, TxDOT, and Diazinon® label

Treatment Sites :	Target Vegetation :	Appl. Rate :	Seasons of Use :	Comments :
Safety rest areas, lawns, rights-of-way	ants	see above	Sp, Su, F	---
Electrical equipment boxes	ants	see above	Sp, Su, F	---

Table B5-18. TxDOT's Insecticide Use Pattern for Fenoxycarb

Active Ingredient : Fenoxycarb
Product Name : Logic®
Application Mixture : Granules
Application Method : Broadcast
Application Rate : 1-1.5 lb/acre (1.1-1.7 kg/ha)
Mode of Action : Carbamate. Bait insecticide.
Use Limitations : Any infested area. Follow label recommendations

Sp Spring
Su Summer
F Fall
W Winter

Source : Roy Smith, TxDOT, Logic® label

Treatment Sites :	Target Vegetation :	Appl. Rate :	Seasons of Use :	Comments :
Safety rest areas, picnic areas, lawns, ROWs	ants	see above	Sp	---
Electrical equipment boxes	---	---	---	---

Table B5-19. 1991 Herbicide Usage by TxDOT Districts

District	Glyphosate (Rodeo®)	Glyphosate (Roundup®)	Hexazinone	Metsulfuron Methyl	Sulfometuron Methyl
1		X			X
2	X	X	(X)		X
3		X	X		
4		X		X	X
5	X	X	X	X	X
6		X	(X)	X	
7		X		X	X
8	X	X	X		X
9		X			X
10	X	X			X
11	X	X			X
12	X	X	(X)		X
13	X	X	(X)	X	X
14	X	X	(X)		X
15	X	X	X		X
16	X	X	X		X
17	X	X	X		X
18	X	X	(X)		X
19	X	X	X		X
20	X	X	X		X
21	X	X	X	X	X
23		X			X
24	X	X	(X)		X
25		X	X	X	X

Source : Roy Smith, TxDOT (X) - Suspended use in 1992

Appendix B - Chapter 6

Draft EIS

Pest Management Program

This report outlines a discussion of the costs and benefits associated with the use of herbicides in TxDOT's vegetation management program. It is not the author's intention to develop an exhaustive list of, or to estimate every relevant cost and benefit. Data limitations render this impossible. It is the author's intention to outline some of the costs and benefits which could be relevant when investigating the option of chemical treatment.

Results from this investigation suggest that movement away from the use of chemical treatments would involve significant costs. One of these is the increased maintenance costs stemming from more frequent asphalt replacement. A second, more indirect cost, is the loss of recycling savings as weed-infested asphalt cannot be recycled.

1.0 Use of Chemical Treatments

1.1 Herbicide Use In The United States

Surveys performed by the Transportation Research Board of the National Research Council suggest that herbicide use is increasing. Twenty-three of thirty-seven states note their herbicide use has increased in the last ten years. Twelve states note their use of herbicides has remained fairly constant, while only three states note decreased use. Respondents to the survey cite cost savings, reduction in labor and equipment, more natural appearance (compared with mowing), and more effective chemicals as reasons for increased chemical use (Burkkhardt, 1988).

1.2 Summary of Herbicide Use by TxDOT

Chemical treatments applied to relatively limited areas make up one component of TxDOT's vegetation management program. Table B6-1 summarizes the extent of use of chemical treatments. Data concerning expenditures on chemical treatments are divided into three categories:

- Edge treatments: Control of vegetation growth along pavement edges, curbs, shoulders, or islands;
- Overspray treatments: Control of stands of undesirable vegetation growth by overspraying the rights-of-way (ROW) or drainage channels; and

- Spot treatments: Control of vegetation growth around culvert headwalls, signs, mailboxes, delineators, riprap, and guardrails.

Reported figures will be divided into the above categories where adequate data renders this possible.

Table B6-1. TxDOT's Use of Chemicals

Activity	Use in 1990	Use in 1991
Control of pavement edges, curbs, shoulders[1]	10563 ha 26,100 acres	20676 ha 51,090 acres
Overspraying ROWs or drainage channels	58669 ha 144,971 acres	73950 ha 182,730 acres
Spot control around signs, guardrails, and culvert headwalls	30098 ha 74,371 acres	157113 ha 74,000 acres

Source: Personal Correspondence, Roy L. Smith, TxDOT.

Estimates of the total acreage managed by TxDOT in 1990 and 1991 are not available; therefore, the above figures cannot be reported on a percentage of total acreage basis. The limited acreage under chemical treatment is apparent when compared to mowed areas of 1,965,424 acres in 1990, and 2,144,262 acres in 1991.

2.0 A Framework for Investigating the Advantages of Chemical Treatment

The importance or value of chemical treatment clearly depends on the ability to substitute from chemical use to an alternative nonchemical treatment. Substitution of treatments depends on the specific pest management need under consideration.

In some ROW treatment sites, mowing and manual techniques offer a reasonable substitute for chemical treatment. In some of these sites, the treatment substitution can generate significantly higher management costs. In other ROW treatment sites (which have different vegetation management needs), no effective nonchemical methods have been identified. This is especially true for controlling vegetation growth in pavement cracks, joints, and edges. Vegetative growth in pavement destroys the integrity of the

[1] The extent of use of chemicals for control of pavement edges, cracks, etc. was reported in linear miles. For conversion to acres, the treatment area was assumed to average there feet in width.

travel surface and threatens highway safety. For these particular situations, the only alternative to chemical treatment is no treatment, which would compromise highway safety.

The above discussion suggests that there could be two situations for which the relative importance of chemical treatments must be investigated.

I. Is it advantageous to use chemical treatment as a supplement to or substitute for mowing and manual methods in ROW treatment sites where these nonchemical methods would be effective?

II. Is it advantageous to use chemical treatments to control vegetation in treatment sites where nonchemical alternatives have not proven to be effective, such as in pavement edges, joints, and cracks?

The first situation will be addressed briefly below. The second situation will be discussed in more detail.

2.1 Benefits of Chemical Use as a Supplement to or Substitute for Mowing and Manual Techniques

In some cases, herbicide use may reduce or replace the need for mechanical mowing and manual techniques. Dr. Jesse Buffington analyzed the effect of herbicide overspraying for a period of three to four years in 13 TxDOT districts (Buffington, 1987). Dr. Buffington concludes that mowing costs would be related to herbicide expenditures. Specifically, the use of overspraying to control johnsongrass and other pest plants leads to a decrease in mowing costs. More importantly, the decrease in mowing costs could not be offset by an increase in herbicide expenditures. Thus, the use of herbicides as a supplemental treatment actually decreases total costs. Dr. Buffington estimated districts using this treatment could save from $1.34 to $12.82 per acre of vegetation. Personnel in the districts studied were pleased with the results of overspray treatments.

In 1988, the California Department of Transportation suspended chemical use in District 1 pending further study. A study was performed to analyze the resulting changes in vegetation management costs (Jones and Stokes Associates, 1991). The authors concede that the study has several important shortcomings: first, only one fiscal year had elapsed since suspension of chemical use. Second, pre- and post-suspension study periods did not involve the same level of vegetation management, and estimates were formulated to establish the costs of the unmet needs. Third, there was some inaccuracy in the data. Despite the shortcomings of the report, calculations suggest that a no-chemical program would be less cost-effective than a chemical-available program in the long term.

The findings of the Buffington and Caltrans studies appear to be supported when looking at state survey responses. A survey performed by the Roadside Maintenance Committee of the Transportation Research Board in 1987 questioned states about their use of mowing and herbicides (Roadside Maintenance Committee, 1987). Several states claimed a move toward chemical treatment, many citing cost-effectiveness as the reason. One state claimed chemical use had replaced all manual techniques. Many states claimed that herbicide use had replaced mowing to some extent.

The issue of cost comparisons for alternative treatments will not be addressed further in this study. An investigator must have access to a rich data set, especially when data is compromised as in the Caltrans study. Data constraints prevent an in-depth investigation. However, some of the following discussion could apply to this case.

2.2 Costs and Benefits of Using Chemical Treatments to Meet Vegetation Management Needs for Which Nonchemical Alternatives Would Not Be Effective

As mentioned above, in treatment sites such as pavement edges, cracks, and joints, chemical treatment is the only treatment which has proved to be effective in meeting vegetation management needs. In this case, the only reasonable alternative for comparison purposes is no treatment. The remainder of the study investigates the following:

- Direct costs of chemical use for the stated purpose;
- Indirect benefits accrued from chemical use for the stated purpose; and
- Indirect costs that may possibly be incurred from chemical use for the stated purpose and from use in general.

Some of the discussion below relates specifically to chemical treatment used to control vegetation growth in pavement cracks, joints, etc. Other discussions apply to the general use of chemical treatment. This distinction will be made where necessary.

3.0 Direct Costs Related to Chemical Treatments

3.1 Summary of Expenditures

Tables B6-2 and B6-3 report expenditures for these three treatment activities on a per-acre basis for 1990 and 1991.

Table B6-2. Expenditures for Chemical Treatment, 1990 per hectare (per acre)

Activity	Total Costs	Labor Costs	Material Costs	Equip. Costs
Control of pavement edges, curbs, and shoulders	$30.93 $76.43	$6.85 $16.93	$19.04 $47.05	$5.04 $12.45
Overspraying ROWs or drainage channels	$6.73 $16.62	$1.32 $ 3.25	$4.37 $10.81	$1.04 $ 2.56
Spot control around signs, guardrails, and culvert headwalls	$17.99 $44.45	$5.54 $13.69	$8.87 $21.92	$3.58 $ 8.84

Source: Personal Correspondence, Roy L. Smith, TxDOT.

Table B6-3. Expenditures For Chemical Treatment, 1991 per hectare (per acre)

Activity	Total Costs	Labor Costs	Material Costs	Equip. Costs
Control of pavement edges, curbs, and shoulders	$18.03 $44.54	$4.42 $10.92	$10.55 $26.07	$3.06 $ 7.55
Overspraying rights-of way or drainage channels	$6.71 $16.57	$1.32 $ 3.26	$4.38 $10.82	$1.01 $ 2.49
Spot control around signs, guardrails, and culvert headwalls	$20.06 $50.00	$6.08 $15.02	$9.83 $24.28	$4.15 $10.28

Source: Personal Correspondence, Roy L. Smith, TxDOT.

Note that a large portion of the costs stem from the purchase of the chemical materials. Cost of mowing on a per-acre basis was $13.60 in 1990 and $13.71 in 1991. These cost figures would not be an accurate estimate of the costs associated with using mowing as opposed to chemical control of vegetation, however, as the two methods meet different needs. It is not possible to detail the labor, equipment, or material costs per acre since a majority of mowing work is sub-contracted and this information is not reported.

3.2 Liability Costs Associated With Chemical Treatment

Any vegetation management program involves liability risks and potential costs. The data shown in the following table were claims to carriers which represent approximately 80% of TxDOT's liability insurance costs (Smith, Sims Memo, 1992). Note that these liability costs are direct costs, and do not include indirect costs such as loss of equipment use, loss of employee productivity, lost production time, investigative costs, and so on. Thus, the real economic costs associated with damage or injury would be higher than reported in Table B6-4.

The available TxDOT claim data were not divided into the type of chemical treatment activity as were the previous data. Per-acre figures could be calculated by dividing total liability costs by the total number of chemically-treated acres. The costs per acre may actually vary from treatment activity to treatment activity, but the nature of the liability claims does not suggest that this should be the case.

Table B6-4. Chemical and Mowing Treatment Liability Costs, 1989, 1990, 1991

Year	Chemical Total Cost	Chemical Cost/Acre	Mowing Total Cost	Mowing Cost/Acre
1989	$6375	N/A	$5275	N/A
1990	$ 441	$.002	$20,918	$.011
1991	$ 900	$.003	$12,074	$.006

Source: Total costs calculated from personal correspondence, Roy L. Smith, TxDOT.

These figures are worthy of some comment. In 1989, two incidents of vehicular collision produced 100% of the liability costs. In 1990, $375 resulted from two incidents of vehicular collision, with the remaining cost resulting from a thrown tire. In 1991, no vehicular collisions were reported. The liability costs resulted from overspray damage to trees and crops, other property damage, and one employee injury. The low per-acre costs for herbicide treatment seem even less significant when compared to the per-acre liability costs for mowing. In 1990, mowing liability costs per-acre were $.011, almost six times the per-acre costs for chemical treatment in 1990. In 1991, mowing liability costs per-acre were $.006, almost double the corresponding per-acre liability costs for chemical treatments.

4.0 Indirect Benefits Accrued from Use of Chemical Programs

4.1 Decreased Maintenance and Increased Life of Pavement

Herbicides' ability to deter weed encroachment is highly valued by TxDOT. Weed encroachment is the growth of weeds through or onto the pavement. Encroachment accelerates pavement deterioration and ultimately requires complete replacement of the asphalt. As mentioned above, there were no nonchemical treatments effective in preventing weed encroachment, as nonchemical techniques do not prevent germination of vegetation in the pavement. Traffic may minimally temper the rate of weed encroachment. As a road shows signs of increased encroachment, however, traffic tends to move closer to the center line. Therefore, traffic does not effectively control weed encroachment.

When considering the costs and benefits of using chemical treatments, the lower maintenance and asphalt replacement costs weigh heavily in the case favoring chemical use. The table below illustrates the significant costs TxDOT would incur if chemical treatment were not used to prevent weed encroachment. It could be assumed that in the absence of chemical treatment, weed encroachment will require pavement replacement on an average of every four years. Note that replacement rates may be significantly higher for regions of Texas in which climate conditions cause rapid plant growth. Replacement rates for roadways under chemical treatment average once every twenty years.

Road replacement involves two stages, the complete replacement or in-place repair of the base, and the laying of a new hot mix. Cost estimates for base replacement, base repair, and laying the hot mix are provided in Table B6-5. The costs are offered on a per-acre basis, and thus must be multiplied by the number of acres of asphalt to be replaced in order to generate the full cost of the asphalt replacement activity.

Table B6-5. Pavement Replacement Costs

Activity	Cost/yard^2	Cost/acre
Complete replacement of base	\$4.40	\$21,296
In-place repair of base	\$2.06	\$9,975
Lay new hot mix foundation	\$2.60	\$12,589

Source: Personal Correspondence, John Bohuslav, TxDOT.

Simply dividing these costs by four gives approximate annual per-acre cost of asphalt replacement. These costs must be compared to the costs related to a twenty-year asphalt replacement rate.

It has been suggested that chemicals be used only for pre-surface treatment, the practice of treating the ground surface with herbicides before the pavement is laid. While this method may seem logical and effective in deterring weed encroachment, it may come from a different direction, plants may grow under the pavement from the ROW to the pavement rather than straight up and through the asphalt from the treated surface. Plants also arise from seeds in surface cracks.

4.2 Recycling Savings

Currently, Texas is legally required to recycle asphalt, and estimates show the savings could be significant. Joe Button of the Texas Transportation Institute suggests savings range from $0.63 to $2.50 a square yard, or $3,050 to $12,100 per acre. When asphalt must be replaced due to weed encroachment, however, the removed asphalt is not recyclable. This loss of recycling savings is another cost to be considered in the economic evaluation of chemical use.

It is also important to realize that the weed-infested asphalt requires adequate disposal, typically shipping to disposal sites licensed to accept asphalt. These shipping costs likely would be significant. Thus, the costs involved with losing the salvage value of the asphalt also must include the costs involved with transport and disposal of the nonrecyclable asphalt.

5.0 Potential Indirect Environmental Costs to Be Further Investigated

5.1 Environmental Concerns Associated With Chemical Use

Environmental concerns regarding chemical use may be categorized as follows:

- Concern for human health and safety, specifically, concern about exposure to pesticides.
- Concern for vegetation that could be damaged by chemical use, including endangered or threatened species.
- Concern for water and aquatic resource quality.
- Concern for soil quality.
- Concern for air quality.
- Concern for fish and wildlife.

Valid concerns in these areas must be considered costs of chemical treatment and must be weighed against the benefits discussed in this report.

6.0 SUMMARY

The goal of this report is to outline some of the costs and benefits associated with the use of chemical treatment. It is not the intention of the author to generate a conclusion regarding the justiciability of the use of chemicals. The benefits from chemical use appear to be significant. If chemical treatment is suspended, TxDOT must pay the costs associated with a rapid rate of road replacement. More subtle costs must be considered as well. For example, TxDOT would not benefit from the cost savings from asphalt recycling, and disposal of the nonreusable asphalt would be costly. TxDOT must consider direct economic costs as well as the potential for environmental harm when evaluating the impacts of chemical use.

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Appendix B - Chapter 7

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Pest Management Program

Appendix B - Chapter Seven — Hazardous Material and Waste

1.0 Federal Laws and Regulations

1.1 The Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) is the federal law governing pesticides. FIFRA regulates:

- pesticide registration and labeling;
- protection of trade secrets and confidential data;
- pesticide suspension and cancellation;
- designation and use of restricted-use pesticides;
- standards for pesticide applicator certification;
- pesticide storage, disposal, and transportation; and
- penalties for pesticide misuse.

The Environmental Protection Agency (EPA) is responsible for administering and enforcing FIFRA, and is the federal agency responsible for regulating pesticides. Regulations for implementing FIFRA are contained in 40 CFR 150-189.

1.2 The Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) regulates the generation, treatment, storage, transportation, and disposal of solid wastes. RCRA defines which solid wastes are hazardous and specifies handling procedures for hazardous wastes.

Discarding pesticides, unrinsed pesticide containers, pesticide rinsewater, and soil contaminated by pesticide is regulated by RCRA's hazardous waste provisions. Pesticide waste may be stored for a maximum of 270 days (9 months), and then must be shipped offsite by a permitted hauler to an approved disposal facility. All shipping and transportation procedures must conform with federal and state transportation department regulations for hazardous waste. (49 CFR 177)

Pesticide users would exempt from RCRA requirements if pesticides, containers, and rinsewater are handled in accordance with FIFRA regulations.

1.3 Other Federal Laws and Regulations

Other federal agencies, such as the U.S. Fish and Wildlife Service, monitor the environment for the presence of pesticides and other toxic substances. These agencies may request EPA to restrict or modify certain uses of pesticides, but do not regulate pesticides independently.

2.0 Texas State Laws and Regulations

2.1 Texas Department of Agriculture Regulations

While the users in all states must comply with FIFRA, each state may pass additional laws regulating pesticide use. Because Texas requirements are both more comprehensive and more stringent than the FIFRA provisions listed above, the remainder of this appendix will focus on Texas laws and regulations. Texas laws regulating pesticide use are included in the Texas Agriculture Code, Chapters 75 and 76, and Texas Pesticide Regulations, Chapters 7.1 - 7.41.

The Texas Department of Agriculture (TDA) is the lead agency for enforcing Texas pesticide laws and regulations and in regulating pesticide use and application. TDA's responsibilities are:

- to register pesticides for use in Texas;
- to protect trade secrets and confidential data submitted by registrants;
- to suspend or cancel registrations for the use of pesticides;
- to designate restricted-use pesticides in addition to those designated by EPA and regulate their use;
- to develop standards for pesticide applicator licensing;
- to regulate pesticide storage, disposal, and transportation; and
- to establish penalties for pesticide misuse.

2.1.1 Pesticide Registration

Manufacturers must register a pesticide with TDA before it is distributed, transported, or used in the state. Information required for pesticide registration is as follows (TDA, 1989, 1990):

- the name of the pesticide;
- the name and address of the applicant, and the name and address of the person whose name shall appear on the pesticide label if not the applicant's;

- a complete copy of all labeling to accompany the pesticide and a statement of all claims to be made for it, including the directions for use;
- the use classification, whether for restricted or general use, as provided by Federal Insecticide, Fungicide, and Rodenticide Act, as amended, or by a rule adopted under that Act;
- a partial list of dealers who could be distributing the pesticide and from whom samples of the product may be obtained;
- the location of the lot or batch number on the container of the pesticide;
- a material safety data sheet (MSDS) which complies with the provisions set forth in 29 Code of Federal Regulations, Subsection 1910.1200(g).

Each brand name and formulation of a pesticide must be registered as a separate product. Also, the registration period for each pesticide ends on December 31. It is a violation to continue to distribute a pesticide for which a renewal application has not been received after December 31 of the year of current registration (TDA, 1990).

2.1.2 Pesticide Labeling

Pesticide labels are legal documents. Proposed labels are submitted to EPA by pesticide registrants as part of the registration process. Under TDA regulations, each pesticide distributed in the state shall bear a label containing the following information (TDA, 1989 and 1990):

- the name, brand, or trademark under which the pesticide is distributed;
- an ingredient statement
- the accepted common name and/or chemical name of all active ingredients are named;
- the percentage by weight of each active ingredient and the percentage by weight of inert ingredients is listed;
- a trademark or trade name may not be used as the name of an ingredient unless it has become the common name;
- numbers or other symbols to identify the manufacturer's lot and batch stamped on the pesticide container any place where they can be readily seen; it is unlawful to have more than one lot or batch number on the container of the pesticide;
- it shall be unlawful to sell custom mixes without identifying the purchases on the label; and
- all labels shall be printed with a non-smearing, permanent substance.
- the sliding scale methods of expressing percentages shall not be used (example: active ingredient name - 6.0%-8.0%).

- complete directions for all uses of the pesticide shown on the label which are necessary for effecting the purpose for which the product is intended, including, but not limited to: application and dilution rates, proper mixing procedures; methods of application; limitations of application; reentry requirements and preharvest intervals consistent with federal regulations, and clean-up, storage, and disposal instructions;
- the net weight or measure of the contents;
- appropriate warnings, symbols, symptoms of poisoning, antidotes, treatments, or procedures to take in case of overexposure and other cautionary statements as required by FIFRA, based on the product's toxicity and use classification;
- should the pesticide contain arsenic, the percentage of total water-soluble arsenic;
- the name and address of the manufacturer, registrant, distributor, or person for whom the pesticide was manufactured;
- numbers of other symbols to identify the lot or batch of the manufacturer;
- clear display of appropriate warnings, symbols, and cautionary statements commensurate with the toxicity or use classification of the pesticide;
- the use classification for which it is registered, stated as:
  - restricted use;
  - general use; or
  - unclassified, for which no statement is required.

2.1.3 Denial or Cancellation of Registration

TDA may conduct a hearing on denial or cancellation of registration should it have reason to believe that any use of a registered pesticide is in violation of a provision of this chapter or is dangerous or harmful. After opportunity at the hearing for presentation of evidence by interested parties, the department may deny or cancel the registration of the pesticide if the department finds that the pesticide poses an unacceptable risk to humans or the environment (TDA, 1989).

2.1.4 Pesticide Applicator and Advisor Licensing and Training

TDA requires all pesticide applicators other than residential property owners treating their own property to be licensed. The licensure exam covers labels and labeling comprehension, safety, environment, pests, pesticides, equipment, application techniques, pesticide laws and regulations and topics as necessary for the specific applicator's category. A licensed applicator may renew the license annually through the accumulation of continuing education credits and payment of the annual license renewal fees. TDA determines when pesticide technology has progressed such that license renewal requires a new training program and reexamination. TxDOT's applicators would be licensed in the ROW pest control category. Training, however, is not a part of the TDA licensure process.

TxDOT's pesticide advisors and applicators are trained and licensed in the noncomerical category.

TxDOT hosts TDA-approved training programs to prepare personnel for initial licensure and provides licensed personnel with opportunities to earn continuing education credits. Continuing education is the responsibility of the employer, and includes instruction in one or more of the following categories:

- label and labeling comprehension;
- safety factors;
- environmental consequences;
- pest features;
- integrated pest management strategies;
- pesticide factors;
- equipment characteristics;
- application techniques;
- laws and regulations; or
- business ethics.

2.1.5 Restricted-Use and State-Limited-Use Pesticides

EPA and TDA classify pesticides as suitable for general or restricted use. TDA classifies all EPA-designated restricted-use pesticides as state-limited-use in Texas. Additional chemicals may be designated state-limited by TDA, which means their use is restricted in all or part of the state, based on potential hazards to applicators, the public, or the environment.

Only licensed commercial applicators may use a restricted-use or state-limited-use pesticide (TDA, 1990). TxDOT uses no state-limited or restricted pesticides.

2.1.6 Pesticide Use Reporting

Records on pesticide use must be kept for two years.

2.1.7 Storage and Disposal of Pesticides

The TDA has established the following regulations for the storage and disposal of pesticides (TDA, 1990):

- no person may dispose of, discard, or store any pesticide or pesticide container in a manner that may cause or result in injury to humans, vegetation, crops, livestock, wildlife, pollinating insects, or pollution of any water supply or waterway;

- pesticides intended for distribution or sale must be displayed or stored within an enclosed building or fenced area, and may not be displayed on sidewalks, parking lots, or similar open areas without surveillance;
- pesticides in leaking, broken, corroded, or otherwise unsafe containers, or with illegible labels shall not be displayed or offered for sale. Such containers should be handled in a manner to prevent environmental contamination prior to proper disposal or return to manufacturer;
- pesticide containers, concentrates, spray mixes, container rinsates, and/or spray system rinsates that will be discarded shall be disposed of in accordance with pesticide label directions or in accordance with the provisions of the Texas Solid Waste Disposal Act (Texas Civil Statutes Article 4477-7);
- the applicator, the owner of the pesticide, and/or the person in control of the mixing site, shall be jointly and severally liable for proper storage and disposal of pesticide containers and contents. It will be acceptable for any one of the parties involved to assume liability for compliance; and
- all pesticide dealers shall have a list of poison control centers in the state to contact in the case of pesticide poisoning.

2.1.8 Penalties for Pesticide Misuse

Penalties for misuse of pesticides by commercial applicators under FIFRA may be a civil penalty up to $5,000.00. Intentional violation of FIFRA is a misdemeanor punishable by imprisonment up to one year or fines of up to $25,000.00 (Texas Agricultural Extension Service, undated).

The Texas Pesticide Law classifies a first offense as a Class C misdemeanor, or, in the event of a previous conviction, a Class B misdemeanor. The administrative penalty may not exceed $2,000.00 for each violation, provided that the total penalty shall not exceed $4,000.00 for all violations related to a single incident. Each violation is a separate offense (TDA, 1989).

Violation of any provision of the Texas Herbicide Law is a misdemeanor punishable by not less than $2,000.00 or imprisonment up to 30 days, or both (TDA, 1989).

2.1.9 Reentry Intervals

Pesticides used along the ROW by TxDOT require no reentry intervals.

2.1.10 Role of the Structural Pest Control Board

The Structural Pest Control Board (SPCB) has jurisdiction over the training, licensing, and regulation of commercial and noncommercial applicators of insecticides in or near residential or commercial structures in urban areas. The SPCB also is responsible for regulating herbicide use within cities; however, SPCB has delegated the responsibility to TDA to regulate TxDOT use of both herbicides and insecticides outside of the structure.

All pesticide applications inside TxDOT structures are undertaken by contractors to TxDOT who are regulated by SPCB.

2.1.11 Other State Agencies

Memoranda of Understanding (MOUs) have been implemented between TxDOT and the Texas Natural Resource Conservation Commission, Texas Parks and Wildlife Department, Corps of Engineers, the U.S. Fisheries and Wildlife Service, Texas Department of Agriculture, and the Structural Pest Control Board. MOUs are pending with other state and federal agencies. The intent of the MOUs is to initiate communication between agencies. MOUs encourage agencies to comment on issues of natural interest in the programs or initiatives of other agencies. These MOUs update the previous TRACTs system.

2.2 Other Laws and Regulations Applicable to TxDOT Program

2.2.1 The Federal Endangered Species Act

The Federal Endangered Species Act (ESA) (16 USC 1361 et seq.) is the federal law governing the protection of fish, wildlife, and plant species in danger of or threatened with extinction. Section 9 of the ESA, which applies to all persons (including any officer, employee, agent, or department of the state government), prohibits the taking of any fish or wildlife species listed under Section 4 of the ESA as endangered (16 USC 1538). The ESA also provides for regulations which have been enacted to prohibit the taking of any fish or wildlife species listed under Section 4 of the ESA as threatened (16 USC 1538, 50 CFR 17.31).

The ESA broadly defines the term"take" to include harassment (act or lack of action which creates the likelihood of injury to wildlife, including significantly disrupting normal behavior patterns), harm (act which kills or injures wildlife, including significant habitat modification or degradation), pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collection, or any attempt to engage in such conduct (16 USC 1532, 50 CFR 17.3). The use of herbicides which harm endangered species or destroy valuable habitat would be included in the definition of "take."

Under Section 10 of the ESA, the U.S. Fish and Wildlife Service or National Marine Fisheries Service may issue an "incidental take permit" for any taking which is incidental to, and not for the purpose of, carrying out an otherwise lawful activity that would otherwise violate Section 9 of the ESA (16 USC 1539, 50 CFR 17.22, 17.32).

With the application for an incidental take permit, the applicant must submit a conservation plan that specifies impacts likely to result from taking, mitigation measures to minimize those impacts, funding for mitigation, and a description of project alternatives analyzed (16 USC 1539).

2.2.2 Endangered & Threatened Wildlife and Plants

The Natural Heritage Program of the Texas Parks and Wildlife Department was established to manage, preserve, and protect the state's nongame wildlife species. The department is responsible for reviewing species for endangered or threatened status, monitoring their status, and restoring populations.

The Endangered Species Act (ESA) of 1973 provides the criteria for determining endangered plant and animal species. Section 7 requires each federal agency to ensure its actions that authorize, permit , or fund a project, do not jeopardize the continued existence of any threatened or endangered species. The habitat for these species is not to be adversely modified.

3.0 Hazardous Waste Recycling

From the practice of chemical application in pest management, TxDOT becomes a generator of the hazardous waste who causes the pesticide waste (outdated or damaged product) to become subject to state regulation. If unused or leftover pesticide materials cannot be legally applied in a manner consistent with the pesticide label use instructions, then the material would be a waste.

TxDOT is financially and legally responsible for proper management and disposal of its waste. If disposal practices lead to environmental contamination, site cleanup could be very costly. Therefore, waste reduction practices may help reduce the chance of property becoming a hazardous waste site, and also reduce the effect of hazardous waste regulations on operation. In essence, less waste results in less regulation and lower cost.

Some ideas for reducing and managing some common pesticide wastes are described below:

3.1 Pesticide Formulation (including unwanted, unusable, suspended, or canceled pesticides).

- Pesticides should be used for their intended purpose and disposed of only as a last resort. If you have excess product that could still be used according to the pesticide registration, try to find a legitimate user for the product.

- Check with the TDA for a definitive answer about authorized usage of the product. Their answer would help you to determine if the pesticide is a "waste."
- Select the least hazardous option for each pest management situation, and avoid using formulations that could be designated as "hazardous waste."
- Before buying quantities of pesticide, accurately calculate your volume needs, and buy only the amount needed.
- Routinely check inventory and rotate your stock so that the oldest material is used first.
- Provide adequate storage conditions such as temperature and moisture controls in order to avoid damage to the product. Store dry formulations such as wettable powders or dusts above liquids and store containers off of the floor and on pallets.

Storage areas should also be: curbed, totally sealed (concrete pad) containment areas sloped to a sealed sump to assist in recovery of any spilled material; secured against unauthorized entry and identified with appropriate warning signs.

Residue spray solution is the leftover tank contents at completion of job and residue from cleaning the interior of tank and plumbing.

3.2 Waste Volume

Agricultural surveys point out that this waste stream represents approximately 70% of the total agrichemical waste volume. This waste could be eliminated using the following practices:

- Sequence applications to minimize change-overs from one spray solution to another.
- Dedicate equipment to compatible spray activities in order to reduce cleaning needs.
- Mix only what is needed, and calibrate your equipment to achieve precise application of the entire spray mixture.

If spray solution is left over and cannot be applied to the target field, save it for future application or for make-up solution for the next batch. It is very important to record the kind and amount of residual material and the date it is stored for future use. Careful record keeping could help make sure the material is used in a time frame and for a purpose where the material would be most effective. Materials should not be stored indefinitely as an alternative to disposal, because they could be designated as regulated hazardous waste.

3.3 Use of Equipment Modifications and Source Reduction Practices to Reduce Waste Volumes

- Use an injection pump system for metering pesticide into the boom or lines. With the formulation and water held separately, the normal mixing operation and volume of spray solution mixture would be eliminated. Injection systems offer improved accuracy in application and help reduce the amount of rinsate that is generated.
- Ultra-low-volume (ULV) applications (undiluted formulation) also eliminate mixing and spray solution volumes. Be sure to carefully review use instructions. Very few label directions allow for ULV application.
- If possible, the application equipment interior (tank, pump, spray lines) should be cleaned in the field where the rinsate could be applied to the target field per label instructions. Include a small onboard saddle tank or nurse tank for carrying clean washwater to the application site.

3.4 Washwater from Rinsing and Cleaning Spray Equipment Exterior

- Use high-pressure, low volume cleaning equipment . Cleaning of the equipment exterior should ideally be done at a mixing-loading/cleaning station designed to collect washwater for reuse. Washwater containment makes sense economically. Proper containment could reduce costs of product loss, and reduce liability claims from environmental contamination.
- The washwater management facility should include a curbed concrete pad that is sloped to a sealed sump. Sump contents could be pumped into temporary holding tanks and the washwater reused as make-up for the next spray solution of the same pesticide. The more washwater that could be reused, the less waste volume there would be to deal with. If necessary, segregate washwater resulting from different spray mixtures in order to avoid accidental crop damage or other problems which could result from cross-contamination of the collected washwater.

3.5 Empty Pesticide Containers

- Never abandon empty, uncleaned pesticide containers or accumulate them where unauthorized persons have access to them. These containers could be dangerous to people, pets, livestock, wildlife, and the environment.
- Liquid containers should be triple-rinsed after emptying. Many fiber containers have plastic linings, and these also can be triple-rinsed. All rinsate should be added to the sprayer during the mixing procedure and applied to the target area in a manner consistent with the pesticide label directions.
- Paper containers should be thoroughly emptied by shaking and striking the package over the spray tank opening. Burning of pesticide containers can

produce highly toxic fumes, and such burning is prohibited by state air quality regulations. Be sure that containers are thoroughly emptied before attempting to burn them. Burning should never be done when it affects people, animals, occupied buildings, or public roads.

- The economic benefits of triple rinsing and cleaning of pesticide containers could be significant. For example, laboratory tests show that a drum that has been drained, but not rinsed, would still contain measurable amounts of pesticide. A five gallon container may still hold about six ounces and a 55-gallon drum could still hold about 32 ounces of pesticide product.

3.6 Spill Cleanup Residues

3.6.1 Spill Response

Before responding to a pesticide spill or accident, be sure you are wearing adequate protective clothing.

1) Stop the leak or flow,

2) Contain the spillage. Powder spills would be covered with plastic and/or dampened, if necessary, to prevent drift.

3) Pick up spills with absorbent material such as wood shavings, kitty litter, etc. Put the contaminated debris in secure nonleaking containers for disposal. Alternatively, the debris could possibly be used for its original intended purpose. (For example, if the pesticide that was spilled is intended for application to soil.) Check with TDA for a definitive answer about authorized usage of the pesticide. If debris is a hazardous waste, the Dangerous Waste Regulations would apply when the volume of waste exceeds 220 pounds.

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