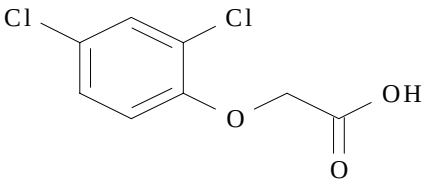
Appendix B

Supplemental Fate Information

There are a total of 9 PC codes: 03001 for 2,4-dichlorophenoxyacetic acid (2,4-D); 030019 for Dimethylamine Salt of 2,4-D (DMA); 030063 for 2-Ethylhexyl Ester of 2,4-D (2-EHE); 030053 for Butoxyethyl Ester of 2,4-D (BEE); 030035 for Triisopropylamine Salt of 2,4-D (TIPA); 030025 for Isopropylamine Salt of 2,4-D (IPA); 030016 for Diethanolamine Salt of 2,4-D (DEA); 030004 for Sodium Salt of 2,4-D (NA); and 030066 for Isopropyl Ester of 2,4-D (IPE). The chemical structure of each form of 2,4-D are listed below.

PC 0300001 (2,4-D)
2,4-dichlorophenoxyacetic acid

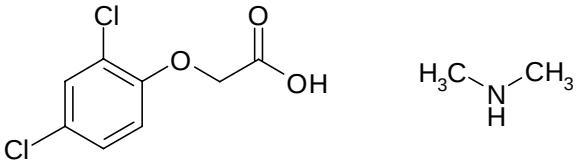


For Sodium Salt, "Na" replaces "H".

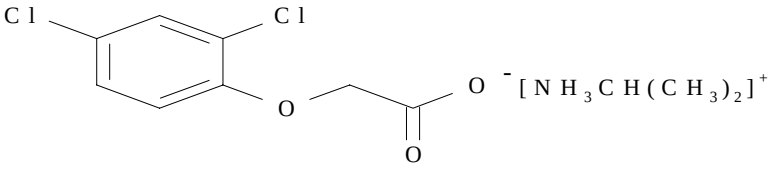
030004 (Na)
Sodium Salt of 2,4-D

Amine Salts

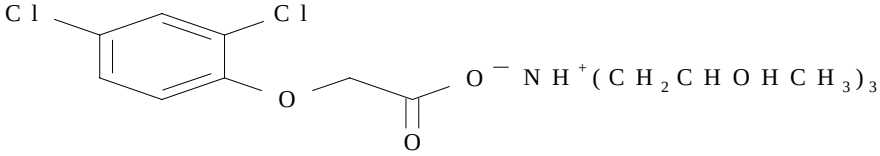
PC 030019 (DMA)
Dimethylamine Salt of 2,4-D



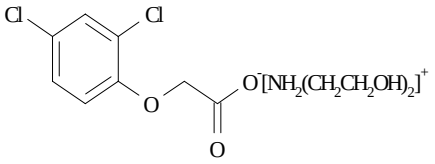
PC 030025 (IPA)
Isopropylamine Salt of 2,4-D



PC 030035 (TIPA)
Triisopropanolamine Salt of 2,4-D

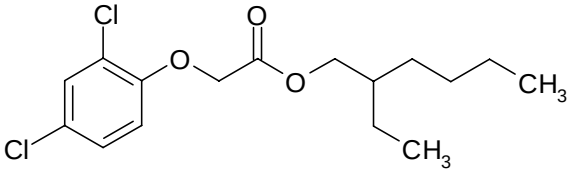


PC 030016 (DEA)
Diethanolamine Salt of 2,4-D

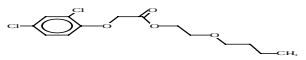


Esters

PC 030063 (2-EHE)
2-Ethylhexyl Ester of 2,4-D

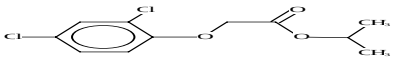


PC 030053 (BEE)
Butoxyethyl Ester of 2,4-D



MolWt: 321.20 C14 H18 Cl2 O4
001929-73-3 2,4-D, butoxyethyl ester

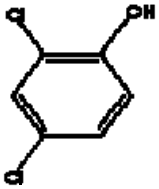
PC 030066 (IPE)
Isopropyl Ester of 2,4-D



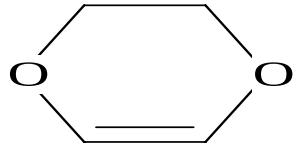
MolWt: 263.12 C11 H12 Cl2 O3
000094-11-1 2,4-D, isopropyl ester

The chemical structures of degradation products formed in the environmental fate studies are listed below.

2,4-DCP (2,4-Dichlorophenol)

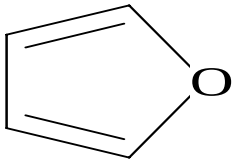


CDD; dioxin



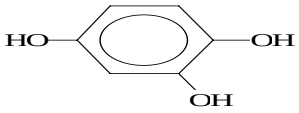
MolWt: 86.09 C4 H6 O2
000543-75-9 1,4-DIOXIN, 2,3-DIHYDRO-

CDF; furan



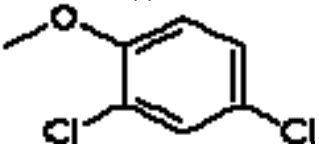
MolWt: 68.08 C4 H4 O1
000110-00-9 Furan

1,2,4-benezenetriol

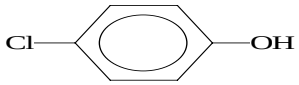


MolWt: 126.11 C6 H6 O3
000533-73-3 1,2,4-Benzenetriol

2,4-DCA (dichloroanisol)

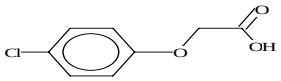


4-chlorophenol



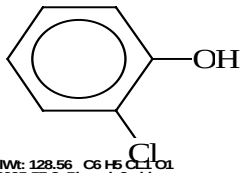
MolWt: 128.56 C6 H5 Cl1 O1
000106-48-9 Phenol, 4-chloro-

4-chlorophenoxyacetic acid



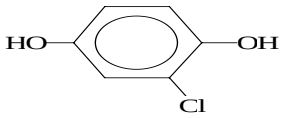
MolWt: 186.60 C8 H7 Cl1 O3
000122-88-3 Acetic acid, (4-chlorophenoxy)-

2-chlorophenol



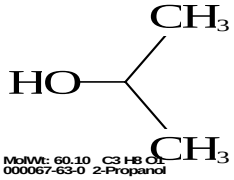
MolWt: 128.56 C6 H5 Cl1 O1
000095-57-8 Phenol, 2-chloro-

Chlorohydroquinone (CHQ)



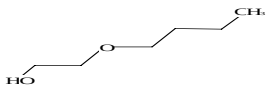
MolWt: 144.56 C6 H5 Cl1 O2
000615-67-8 1,4-Benzenediol, 2-chloro-

Isopropanol



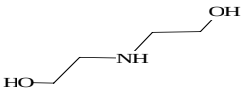
MolWt: 60.10 C3 H8 O1
000067-63-0 2-Propanol

2-butoxyethanol



MolWt: 118.18 C6 H14 O2
000111-76-2 Ethanol, 2-butoxy-

diethanolamine



MolWt: 105.14 C4 H11 N1 O2
000111-42-2 Ethanol, 2,2'-iminobis-

dimethylamine

MolWt: 45.08 C2 H7 N1
000124-40-3 Methanamine, N-methyl-

The physical, chemical properties and environmental fate study summaries are presented below for each of the 2,4-D form considered in this assessment.

2,4-D

Physical and Chemical Properties

Common name:	2,4-D
Chemical name:	2,4-Dichlorophenoxy Acetic Acid
Molecular formula:	$C_8H_6Cl_2O_3$
CAS Number:	94-75-7
Molecular weight:	221.0
Physical state:	colorless crystals
Melting point:	138 ^oC
Vapor pressure (20^{o}C):	1.4 x 10^{-7} mm Hg @25 ^{o}C
Henry's Law:	1.02 x 10^{-8} atm-m^3/mol
Solubility (25^{o}C):	569 mg/L @ 20^{o}C
Log K_{ow}:	2.81

- **Abiotic hydrolysis study (MRID 41007301)**

Radiolabeled 2,4-D acid, at 21 μg/ml, was stable ($t_{1/2}$ 1 to 2 years) in pH 5, 7, and 9 buffer solutions. The reported data indicate 2,4-D should not hydrolyze under normal environmental conditions.

- **Photodegradation in water study (MRID 41125306)**

Radiolabeled 2,4-D, at 5.00 μg/ml, had a first-order half-life of 12.98 calendar days or 7.57 days of constant light in pH 7 buffer solution. Major photodegradates were identified as 1,2,4-benzenetriol (37% of applied) and CO_2 (25% of applied). Many unidentified non-polar and polar degradates (<10% of applied) also were separated by TLC.

- **Photodegradation on soil study (MRID 41125305)**

Radiolabeled 2,4-D, 4.31 μg/g, in sterile, loam had an extrapolated photolysis half-life of 68 calendar days. The major photodegradate was identified as CO_2 (5% of applied). Many unidentified degradates (<10% of applied) also were separated by TLC.

- **Aerobic soil metabolism study (MRID 43167501, Accession No. 00116625**)

Radiolabeled 2,4-D, at 5 μg/g, in a Catlin silty clay loam had a first-order half-life of 1.7 days. Soil degradates were identified as 2,4-dichlorophenol (2,4-DCP) (3.5% of applied at 2 days post-treatment) and 2,4-DCA (2.5 to 2.8% of applied at Day 9 to 1.4 to 1.6% at Day 16). Unidentified extractable residues (several HPLC peaks) were also detected (<0.8% of applied at Day 16). Radiolabeled residues were detected (45 to 60% of applied at Day 5) in non-labile soil organic matter. Radiolabeled residues in the fulvic acid fraction was identified as 2,4-D. Volatile degradates were identified as [^{14}C]-CO_2 (50% of applied at Day 16) and organic volatiles in foam plug trap (0.3% of applied at Day 16). Radiolabeled residue in the foam plug was identified as 2,4-DCA. The reported data indicate that 2,4-D rapidly degrades in aerobic mineral soil.

- **Aerobic aquatic metabolism (MRID 42045301**, **42979201**, **44188601**)

Radiolabeled 2,4-D, at 4.63 μg/g, had a first-order degradation half-life of 15 days (R^2=0.7318) in a sediment and water system. Soluble degradates were identified as chlorohydroquinone (CHQ)(0.76 ppm) and 2,4-dichlorophenol (2,4-DP) (0.23 ppm). The major volatile degradate was identified as CO_2. Radolabeled residues were also found in nonlabile organic matter fractions. The reported data suggest 2,4-D acid should not persist in aerobic aquatic environments.

Radiolabeled 2,4-D, at 5 μg/ml, had a Monod-growth-type kinetic model half-life of 4.5 days in anaerobic sediment- aerobic water system. The DT_{50} of 2,4-D was estimated at 28.5 days. The degradates of [^{14}C]-2,4-D in sediment and water were 2,4-dichlorophenol (2,4-DCP) [1.25% of applied] , 4-chlorophenoxyacetic acid (4-CPA)(1.61% of applied), and 4-chlorophenol (4-CPP) (1.13% of applied). An unknown degradate (separate HPLC peak) also was detected (1.58% of applied at Day 46) in water samples at 35 days post-treatment. Additional unknowns (several small HPLC peaks) were also detected (4.02% of applied immediately post-treatment). The major volatile degradate was tentatively identified as CO_2 (64% of applied at 46 days post-treatment). Unidentified sediment bound residues accounted for 17% of applied [^{14}C]-2,4-D at 46 days post-treatment.

The degradation of 2,4-D acid under aerobic aquatic conditions was studied in sediment and lake water collected from Lake Mendota, Madison, Wisconsin 2,4-D was stable during a 30 day study. Due to the lack of degradation observed in the system a half-life could not be determined. Aerobic conditions were demonstrated during the course of the study through collection of pH, Eh, and dissolved oxygen content. Eh values decreased from a high of 367 mV at day 0 to a low of 88.1 mV at day 30, while dissolved oxygen fluctuated from a high of 9.7 to a low of 2.1 with no clear trend, and pH ranged from 7.77 at day 0 to 9.06 at day 30. Also, microbial analysis indicated that aerobic micro-organisms increased through the course of the study. In the 30 day study 2,4-D was determined to be present in the whole system at 103.0% at day 0 and declined to

97.6% at day 30. Of the parent remaining in the system at day 30, 95.1% was determined to be present in the water phase while 2.5% was present in the sediment. One minor degradate was detected (Region I) at 0.1% of applied at day 30 while a small amount of CO_2 (0.28%) was present at day 30.

- **Anaerobic aquatic metabolism (MRID 43356001, MRID 41557901)**

Radiolabeled 2,4-D, 4.9 μg/ml, degraded with a first-order half-life of 333 days in anaerobic aquatic environments. The major degradate product in soil and water samples was 2,4-DCP (10.6 to 32% applied at 30 day post-treatment). Unidentified radiolabeled residues in sediment and water samples were also detected (7.9% of applied at 35 days). The major volatile degradate in KOH gas traps was tentatively identified as CO_2 (30% of applied at 42 and 365 days post-treatment). The degradates 4 chlorophenol (4-CPA) and 2,4-DCA were also detected (0.7% and 1.9% of applied at 365 days post-treatment) in the polyurethane foam plug. Radiolabeled residues were also detected (40.8% of applied at 240 days post-treatment) in non-labile organic matter fractions. Radiolabeled residue in the fulvic acid fraction was identified as 2,4-D.

- **Unaged Mobility (MRIDS 42045302, 44117901, 44105201; Accession No. 0012937, 00057313**)

The Freundlich coefficient for 2,4-D is 1.27 ml g^{-1} (1/n= 0.827; K_{oc}=58.1) in a clay sediment. The desorption coefficient of 2,4-D is 1.64 ml g^{-1} (1/n=0.74;K_{oc}=78.1).

Nonradiolabeled plus uniformly phenyl ring-labeled [^{14}C]2,4-D, at nominal concentrations of 1.0, 2.5, 5.0 and 10.0 μg/mL, was studied in sandy loam, sand, silty clay loam and loam soil:solution slurries that were equilibrated for 24 hours at 25 ± 1 ^{o}C. Freundlich K_{ads} values were 0.17 for the sandy loam soil, 0.36 for the sand soil, 0.52 for the silty clay loam soil (1.5% O.M.) and 0.28 for the loam soil (0.4% o.m.); corresponding K_{oc} values were 70, 76, 59 and 117 mL/g. Respective 1/N values were 0.68, 0.82, 0.82 and 0.80 for adsorption. Freundlich K_{des} values determined following a 24-hour equilibration period were 0.87 for the sandy loam soil, 1.2 for the sand soil, 2.0 for the silty clay loam soil and 1.6 for the loam soil; corresponding K_{oc} values were 362, 247, 226 and 658 mL/g. Respective 1/N values were 0.73, 0.94, 0.93 and 1.0 for desorption. The reviewer-calculated coefficient of determination (r^2) values for the relationships K_{ads} *vs*. organic matter, K_{ads} *vs*. pH and K_{ads} *vs*. clay content were 0.34, 0.19 and 0.59, respectively.

Carbonyl labeled 2,4-D had Freundlich adsorption coefficient of 0.291 (1/n=1.18; O.M.=1.7%) in a Leon sand, 0.36 (1/n=0.63; O.M.=3.1%) in a Cosad sandy loam, 1.18 (1/n=0.74; O.M.=3.9%) in a Dunkirk silt loam, 2.18 (1/n=0.693; O.M.=5.2%) in a Jefferson clay loam, and 0.943 (1/n=0.94; O.M.=12.4%) in a Rosebury sandy loam. The desorption coefficient of 2,4-D was 0.82 in a Leon sand, 0.517 in Cosad sandy loam, 0.88 in Dunkirk silt loam, 0.66 in a Jefferson clay loam, and 13.3 in a Rosebury sandy loam (**Acc. No 0012937**).

Carbonyl labeled 2,4-D in finely sieved mineral soil had an R_f of 1.00 in Leon sand, 0.77 in a Cosad sandy loam, 0.60 in a Dunkirk silt loam, and 0.41 in a North Bend loam. According to Helling's Mobility Classification, 2,4-D mobility ranged from intermediately mobile (R_f=0.41) to very mobile (R_f=1.00) (**Acc. No. 00057313**).

- **Degradation Product Batch Equilibrium and Soil Colunm Leaching (MRID 44158501 ; Accession No. 00080124)**

Nonradiolabeled plus uniformly phenyl ring-labeled [^{14}C]2,4-DCP, at nominal concentrations of 1.0, 2.5, 5.0 and 10.0 μg/mL, was studied in sandy loam, sand, silty clay loam and loam soil:solution slurries that were equilibrated for 24 hours at 25 ± 1 ^{o}C. Freundlich K_{ads} values were 2.0 for the sandy loam soil (0.4% o.m.), 1.7 for the sand soil, 3.3 for the silty clay loam soil (1.5% o.m.) and 2.9 for the loam soil (0.4% o.m.); corresponding K_{oc} values were 821, 368, 374 and 1204 mL/g. Respective 1/N values were 0.84, 0.91, 0.74 and 0.80 for adsorption. Freundlich K_{des} values determined following a 24-hour equilibration period were 6.3 for the sandy loam soil, 3.8 for the sand soil, 7.1 for the silty clay loam soil and 5.6 for the loam soil; corresponding K_{oc} values were 2625, 813, 807 and 2325 mL/g. Respective 1/N values were 0.89, 0.79, 0.81 and 0.73 for desorption. The reviewer-calculated coefficient of determination (r^2) values for the relationships K_{ads} *vs*. organic matter, K_{ads} *vs*. pH and K_{ads} *vs*. clay content were 0.28, 0.98 and 0.64, respectively.

Isotopically diluted phenyl ring-labeled [^{14}C]2,4-DCA, at nominal concentrations of 0.5, 1.0, 2.5 and 5.0 μg/mL, was studied in sandy loam, sand, silty clay loam and loam soil:solution slurries that were equilibrated for 24 hours at 25 ± 1 ^{o}C. Freundlich K_{ads} values were 1.6 for the sandy loam soil, 2.1 for the sand soil, 5.4 for the silty clay loam soil (1.5% o.m.) and 3.5 for the loam soil (0.4% o.m.); corresponding K_{oc} values were 667, 436, 616 and 1442 mL/g. Respective 1/N values were 0.98, 0.96, 0.81 and 0.85 for adsorption. Freundlich K_{des} values determined following a 24-hour equilibration period were 2.4 for the sandy loam soil, 3.4 for the sand soil, 8.6 for the silty clay loam soil and 4.4 for the loam soil; corresponding K_{oc} values were 996, 721, 975 and 1850 mL/g. Respective 1/N values were 0.65, 0.98, 0.74 and 0.79 for desorption. The reviewer-calculated coefficient of determination (r^2) values for the relationships K_{ads} *vs*. organic matter, K_{ads} *vs*. pH and K_{ads} *vs*. clay content were 0.24, 0.68 and 0.80, respectively.

Radiolabeled aged 2,4-D residues were immobile in a 30 cm column of Lawrenceville silt loam soil. The majority of radioactivity was detected in the surface 5 cm of the soil column and no radioactivity was detected in column leachate fractions.

Amine Salts

The EFED strategy for assessing the environmental fate of 2,4-D amine salts is based on bridging of laboratory fate data from the 2.4-D amine salt to 2,4-D. Dissociation data were required to document the rapid conversion of 2,4-D amine salts to 2,4-D acid. In addition, terrestrial field dissipation studies were required to document environmental fate of 2,4-D amine and 2,4-D under actual use conditions. It is important to note the analytical methods in field dissipation studies were designed to detect only 2,4-D, 2,4-DCP and 2,4-DCA. Therefore, half-life of 2,4-D amine salts could not be determined from the terrestrial, aquatic, and forest field dissipation studies.

2,4-D DMAS

Physical and Chemical Properties

Common name:	2,4-D DMAS
Chemical name:	dimethylamine 2,4-dichlorophenoxyacetate
Molecular formula:	$C_{10}H_{13}Cl_2NO_3$
CAS Number:	2008-39-1
Molecular weight:	266.13
Vapor pressure (20^{o}C):	Dissocaites rapidly to acid
Henry's Law:	Not reported. Dissocaites rapidly to acid
Solubility (25^{o}C):	72.9 g/L @ 20^{o}C
Log K_{ow}:	Not reported. Dissocaites rapidly to acid

- **Dissociation Study (MRID 41308901)**

Analytical grade 2,4-D and 2,4-DMAS, in HPLC grade water had dissociation times of 120 minutes and 1minute, respectively. Complete dissociation was determined through a comparison of theoretical and estimated electrical conductance measurements at infinite dilution. Conductance at infinite dilution` was estimated using the Onsager equation; this equation is linear for fully dissociated compounds or strong electrolytes. 2,4-D DMAS had an estimated and theoretical conductance of 77 μmhos and 73 μmhos, respectively. 2,4-D had an estimated conductance of 379 μmhos and theoretical conductance of 360 μmhos.

- **Batch Equilibrium (Accession No. 00023098)**

The Freundlich adsorption coefficient of 2,4-DMA, at 20 to 50 μg/L, was 0.99 (n=1.00; O.M.=10.5%) in a Melfort loam, 0.45 (n=1.05; O.M.=6.46%) in a Weyburn Oxburn loam, 0.19 (n=1.22; O.M.=4.15) in a Regina heavy clay, 0.53 (n=0.97; O.M.=4.1) in Indian Head loam, and 0.00 in a Asquith sandy loam (O.M.=1.77%).

- **Field Drift Evaluation (Accession No. 235247; Phipps, F.E and Emenegger, no MRID or Accession #; Acc. No. 249863)**

2,4-D DMA (4 lbs ae/gal), at 1 lb/A using a straight stream system or a microfoil boom from a helicopter at a spray height of 100 feet and crosswinds of 4-8 mph, had drifted 400 yards from the application site in Belle Rose, LA. The application of Nalco-Trol, at < 0.5%, reduced drift from a straight stream system. Comparative drift was less with the microfoil boom than with the straight stream system.

DED-WEED 2,4-D Amine SULV, at 0.75 to 2.00 a.i. lb/A as 5 GPA using D-4 and D-8 nozzles at 25 psi at spray heights of 15 to 20 feet and crosswinds of 2 to 13 mph, had drifted 1320 feet downwind at a site in Dallas, OR.

Dimethylamine and Diethylamine salts of 2,4-D (formulated as Estemine, Standard, Ultra-SULV), at 1.9 a.i. lb/A as 5 GPA using D-4-46 for ULV formulations and D10-40 nozzles at 25 psi at spray heights of 10 feet and crosswinds of 2 to 16 mph, had drifted downwind 200 feet at a site in Olathe, KS. Airborne 2,4-D was detected (0.17 to 0.20 mg/filter) 200-feet downwind from the application site.

- **Terrestrial Field Dissipation Studies (MRIDs 4705201;43864002;43831703; 43500301;43470401;43849101;43612101;43592802;43810701;43797902;43872401; 43676803;43872701;43872702;4383301)**

General: In order to address the field behavior of 2,4-D under actual use conditions a total of 15 terrestrial field dissipation studies were conducted using 2,4-D DMAS. Field studies were conducted using 2,4-D DMAS on bareground, pasture, turf, and wheat. In addition, three aquatic field dissipation studies and one forest field dissipation study were conducted using 2,4-D DMAS.

The registrant submitted 15 terrestrial field dissipation studies in CA, CO, NC, ND, NE, OH and TX on bareground plots as well as plots cropped to corn, pasture, turf and wheat. For all studies conducted using 2,4-D DMAS, the first-order 2,4-D half-lives ranged from 1.1 days to 30.5 days with a median half-life of 5.6 days. These half-lives reflect dissipation from the surface soil layer (0 to 6 inches) and do not include residues which have leached below the surface layer. The data indicate a rapid to moderately rapid dissipation rate for 2,4-D acid. The analytical methods in the field studies were not capable of separating and identifying 2,4-D DMAS from 2,4-D acid. Therefore, the half-lives of 2,4-D DMAS can be considered to be equivalent or less than those found for 2,4-D acid. Available data on the solubility and the time for complete dissociation of 2,4-D DMAS indicate it should fully dissociate in soil solution at maximum

application rates (4 lbs/A). At the maximum application rate, the theoretical concentration in soil solution does not exceed the water solubility of 2,4-D DMAS. Dissipation rates for 2,4-D degradation products (2,4-DCP and 2,4-DCA) were not estimated because of their sporadic occurrence patterns in surface soils. The results of the field studies are consistent with half-lives from laboratory studies (**MRIDs 00116625 and 43167501**); 2,4-D half-lives under aerobic conditions ranged from 1.4 days to 12.4 days with a median half-life of 2.9 days.

2,4-D residues were detected below a depth of 18 inches in eleven of the terrestrial field dissipation studies reviewed and was detected below 30 inches in five studies **(MRID 43914701, 43762402, 43831703, 43849101, and 43872702**). Leaching appears to be a route of dissipation when precipitation or irrigation exceed evapotranspiration demands.

The following summary table presents the basic results of the individual field dissipation studies submitted for 2,4-D DMAS and 2,4-D. For a more detailed review of the individual studies the reader is directed to review individual Data Evaluation Records (DER).

MRID #	ST	County	EUP	Form	Use	Single App Rate (lbs ae/A)	No of Apps	Annual App Rate (lbs ae/A)	Surface Soil Half-life (First Application)-Days		Surface Soil Half-life (Second Application)-Days		Surface Soil Half-life (Third Application)-Days		Surface Soil Half-life (Fourth Application)-Days		Maximum Depth of Detection (inches)				Precip + Irrig (in)	Pan Evap (in)
									DMAS	2,4-D	DMAS	2,4-D	DMAS	2,4-D	DMAS	2,4-D	DMAS	2,4-D	2,4-DCP	2,4-DCA		
43705201	CA	Tulare	DMAS	Conc	Bare	2.2	2	4.4	NA	6.8	NA	4.1					NA	12	NA	6	26.8	
43864002	CA	Tulare	DMAS	Conc	Past	2.2	2	4.4	NA	4.1	NA	30.5					NA	12	6	6	56	
43831703	CA	Tulare	DMAS	Conc	Turf	2.2	2	4.4	NA	29.1	NA	8					NA	30	6	6	26.16	
43500301	CO	Eaton	DMAS	Conc	Bare	1.25	2	2.5	NA	5.6	NA	5.1					NA	6	6	NA	14.3	28.3
43470401	CO	Eaton	DMAS	Conc	wheat	1.25	2	2.5	NA	9.4	NA	6.1					NA	18			14.2	27.9
43849101	NE	York	DMAS	Conc	Bare	variable	4	5.5	NA	8.6	NA	3.9	NA	1.1	NA	2.8	NA	48	12	12	31.28	26
43612101	NC	Rowland	DMAS	Conc	Bare	1.25	2	2.5	NA	3.6	NA	3.1					NA	6	6	6	33.7	43.3
43592802	NC	Rowland	DMAS	Conc	wheat	1.25	2	2.5	NA	5.5	NA	2.7					NA	12	6	6	33.7	43.3
43810701	NC	Rowland	DMAS	Conc	Bare	2	2	4	NA	3.4	NA	2.5					NA	12	6	6		
43797902	NC	Rowland	DMAS	Conc	turf	2	2	4	NA	6.4	NA	12.1					NA	6	6	6		
43872401	ND	Northwood	DMAS	Conc	Bare	1.375	2	2.75	NA	7	NA	4.5					NA	24	6	6	16.016	
43676803	TX	Pattison	DMAS	Conc	Past	2	2	4	NA	3.5	NA	10.2					NA	12	6	NA	37.11	
43872701	ND	Northwood	DMAS	Gran	Turf	2.2	2	4.4	NA	10.3	NA	5.1					NA	18	6	6	12.9	
43872702	ND	Northwood	DMAS	Gran	Bare	2.2	2	4.4	NA	16.7	NA	15.2					NA	30	30	18	12.86	
43834301	OH	New Holland	DMAS	Conc	Bare	variable	4	5.5	NA	26	NA	4.4	NA	NA	NA	21	NA	12	6	12	26.6	52

- **Aquatic Field Dissipation Studies (MRID 43908302; 43954701; 43491601; Accession No. 00115741, 00128148, 00043278, 00115748)**

In aquatic field dissipation studies in ND, NC, and LA, 2,4-D acid, at 1.8 to 41.8 lbs ae/A, had an EFED estimated dissipation half lives of 20.7 and 2.7 days in water from the North Carolina pond after the first and second applications, 14 days and 6.1 days in water from a North Dakota pond after the first and second applications, and 1.0 day in water from the Louisiana rice paddy after the single application (**MRID 43908302; 43954701; 43491601)**. The analytical methods in the field studies were not capable of separating and identifying 2,4-D DMAS from 2,4-D acid. Therefore, the half-lives of 2,4-D DMAS can be considered to be equal or less than 2,4-D acid half-lives. Available laboratory data on the solubility and the time for complete dissociation of 2,4-D DMAS indicate it should completely dissociate in aquatic environments. At the maximum application rate, the target concentration in aquatic environments does not exceed the solubility concentration for 2,4-D DMAS Several issues limit interpretation of the aquatic field dissipation data including unreported flow rates through the ponds (if any), frozen storage stability data (none were submitted but surrogate data is available from other field dissipation studies), and low method recoveries for degradation products.

The high application rates result in peak concentrations of 4,800 μg/l at day 1 in the ND pond (application rate of 41.8 lb ae/acre), of 2,800 μg/l on day 0 in the NC pond (application rate of 41.8 lb ae/acre), and of 2,300 μg/l on day 0 in the LA pond (application rate of 1.8 lbs ae/acre). These concentrations are higher than the 2,4-D Maximum Contaminant Level (MCL) of 70 μg/l. 2,4-D concentrations in water did not decrease to below the MCL until after day 30 (1,500 μg/l) at the North Dakota pond, until after day 29 (860 μg/l) at the North Carolina pond, and until after day 3 (390 μg/l) at the Louisiana pond.

North Dakota

2,4-D DMAS (Gordon's Amine 400, 38.6% a.e.), applied twice (31-day interval) as a subsurface injection to a 14-acre pond at a nominal rate of 41.8 lb a.e./A/application, dissipated with registrant-calculated half-lives for 2,4-D acid of 29.5 days ($r^2 = 0.80$) in the sandy loam sediment and 6.5 days ($r^2 = 0.82$) in the pond water following the second application; however, the half-lives are questionable because greater than 50% of the residues dissipated between two sampling intervals (30 and 59 days post-treatment). EFED estimated a half life for 2,4-D acid in the total sediment column after the first application of 17.4 days ($r^2 = 0.56$) and after the second application of 28.8 days ($r^2 = 0.80$). EFED estimated a half life for 2,4-D acid in water after the first application of 14.0 days ($r^2 = 0.85$) and after the second application of 6.1 days ($r^2 = 0.84$). EFED estimates were done using linear regression on log-transformed data.

Following the first application, 2,4-D acid was initially present in the 0- to 5-cm sediment depth at 0.25 ppm, was 1.2 ppm at 14 days post-treatment, and was 0.78 ppm at 30 days (1 day prior to

the second application). In the 5- to 10-cm depth, 2,4-D acid was initially (day 1) present at 0.011 ppm and was 0.12 ppm at 30 days. The parent was present in the 10- to 15-cm depth at 0.027-0.033 ppm from 21 to 30 days post-treatment and in the 15- to 20-cm depth at ≤0.022 ppm from 0 to 30 days. The degradate 2,4-DCP was present in the 0- to 5-cm depth at ≤0.043 ppm at 0-14 days post-treatment and was 0.14 ppm at 21-30 days; 2,4-DCP was only detected once in the 5- to 10-cm depth at 0.025 ppm (one of three replicates) and was not detected below that depth. The degradates 2,4-DCA; 4-CPA; and 4-CP were not detected following the first application.

Following the second application, 2,4-D acid was initially present in the 0- to 5-cm depth at 1.0 ppm, was 1.5-1.6 ppm at 1- 30 days post-treatment, decreased to 0.068 ppm by 59 days (the next sampling interval) and was 0.016 ppm at 180 days. In the 5- to 10-cm depth, 2,4-D acid was present at 0.067-0.10 ppm from 0 to 30 days post-treatment, decreased with variability to 0.015 ppm by 120 days, then was 0.040 ppm at 180 days. The parent was present in the 10- to 15-cm and 15- to 20-cm depths at ≤0.014 ppm and ≤0.048 ppm, respectively, from 0 to 21 days post-treatment. The degradate 2,4-DCP was present in the 0- to 5-cm depth at 0.10-0.19 ppm from 0 to 21 days post-treatment, was a maximum of 0.40 ppm at 30 days, and was 0.14-0.26 ppm from 59 to 180 days. In the 5- to 10-cm depth, 2,4-DCP was detected twice at ≤0.011 ppm from 0 to 30 days post-treatment, was a maximum of 0.22 ppm at 90 days, and was 0.11 ppm at 180 days; 2,4-DCP was not detected below the 5- to 10-cm depth. The degradates 4-CP and 4-CPA were each detected only once in the sediment, at 0.021 ppm (one of three replicates) at 60 days (10- to 15-cm depth) and 21 days post-treatment (5- to 10-cm depth), respectively. The degradate 2,4-DCA was not detected following the second application.

In the pond water following the first application, 2,4-D acid was initially present at 4.7 ppm, was a maximum of 4.8 ppm at 1 day post-treatment, and was 1.2 ppm at 30 days (1 day prior to the second application). The degradate 2,4-DCP was present at 0.004-0.010 ppm from 0 to 30 days post-treatment. The degradate 4-CPA was present at 0.005-0.009 ppm from 0 to 3 days post-treatment.

Following the second application, 2,4_D acid was initially present at 3.1 ppm, was 3.4 ppm at 1 day post-treatment, decreased to 2.1 ppm by 21 days and 1.5 ppm by 30 days, and was last detected at 0.003 ppm at 59 days (the next sampling interval). The degradate 2,4-DCP was present at 0.004 initially and was 0.007-0.010 ppm from 3 to 30 days post-treatment. The minor degradate 4-CPA was present at 0.005-0.008 ppm from 0 to 59 days post-treatment. The degradates 2,4-DCA and 4-CP were not detected at any sampling interval.

North Carolina

Parent 2,4-D DMAS (Weedar® 64, 39.0% a.e.), applied twice (30-day interval) as a subsurface spray to a 2.4-acre pond at a nominal rate of 41.8 lb a.e./A/application, dissipated with registrant-calculated half-lives for 2,4-D acid of 2.0 days ($r^2 = 0.92$) and 2.7 days ($r^2 = 0.98$) in the sandy

loam sediment and water, respectively, following the second application. The parent compound (2,4-D DMAS) converted to the acid equivalent (a.e.), 2,4-D acid, during application, and all half-life calculations are based on the concentration of 2,4-D acid present in the sediment and water. EFED estimated a half life for 2,4-D acid in the total sediment column after the first application of 8.0 days ($r^2 = 0.94$) and after the second application of 15.8 days ($r^2 = 0.46$). EFED estimated a half life for 2,4-D acid in water after the first application of 20.4 days ($r^2 = 0.90$) and after the second application of 2.7 days ($r^2 = 0.98$). EFED estimates were done using linear regression on log-transformed data.

Following the first application, 2,4-D acid was initially present in the 0- to 5-cm sediment depth at 1.1 ppm, was 1.2-1.5 ppm at 1-7 days post-treatment, and decreased to 0.10 ppm by 29 days (1 day prior to the second application). In the 5- to 10-cm depth, 2,4-D acid was initially (day 0) present at 0.95 ppm and decreased with variability to 0.021 ppm by 29 days post-treatment. The parent was present in the 10- to 15-cm and 15- to 20-cm depths at ≤0.035 ppm and ≤0.021 ppm, respectively, from 0 to 29 days post-treatment. The degradate 2,4-DCP was initially (day 0) present in the 0- to 5-cm depth at 0.013 ppm, was a maximum of 0.48 ppm at 14 days post-treatment and was 0.040 at 29 days; 2,4-DCP was detected in the 5- to 10-cm, 10- to 15-cm, and 15- to 20-cm depths at ≤0.027 ppm at 14 and 21 days post-treatment. The degradate 4-CP was present in the 0- to 5-cm depth at 0.010-0.019 ppm from 14 to 29 days post-treatment.

Following the second application, 2,4-D acid was initially present in the 0- to 5-cm sediment depth at 0.62 ppm, was a maximum of 1.8 ppm at 1 day post-treatment, was 0.80 ppm at 3 days, and was last detected at 0.013 ppm at 14 days post-treatment. The parent was initially (day 0) present in the 5- to 10-cm depth at 0.11 ppm, was a maximum of 0.73 ppm at 1 day post-treatment, and was last detected at 0.019 ppm at 7 days. The parent was present in the 10- to 15-cm and 15- to 20-cm depths at ≤0.083 ppm from 0 to 3 days post-treatment and was not detected at any other sampling intervals at those depths. The degradate 2,4-DCP was initially (day 0) present in the 0- to 5-cm depth at 0.044 ppm, was 0.34 ppm at day 1 and 0.14 ppm at 3 days post-treatment, was not detected at 14-57 days, and was last detected at 0.011 ppm at 90 days. 2,4-DCP was present in the 5- to 10-cm depth at 0.17 ppm at 1 day post-treatment and was ≤0.029 ppm at 3-14 days; in the 10- to 15-cm depth, 2,4-DCP was ≤0.038 ppm from 1 to 3 days post-treatment. The degradate 4-CP was initially (day 0) present in the 0- to 5-cm depth at 0.020 ppm, was a maximum of 0.55 ppm at 3 days post-treatment and was last detected at 0.26 ppm at 7 days. 4-CP was present in the 5- to 10-cm depth at 0.047 ppm at 1 day post-treatment and was ≤0.017 ppm at 3-7 days; 4-CP was detected once in the 10- to 15-cm depth at 0.023 ppm (one of three replicates) at day 1. The degradates 2,4-DCA and 4-CPA were not detected in the sediment at any sampling interval or depth.

In the pond water following the first application, 2,4-D acid was initially present at 0.65 ppm, was 2.2 ppm at 3 days post-treatment, and was 0.86 ppm at 29 days. Following the second application, 2,4-D acid was initially present at a maximum of 2.8 ppm, was 1.8 ppm at 3 days and 0.63 ppm at 7 days post-treatment, and was last detected at 0.011 ppm at 21 days. The

degradate 4-CPA was present at 0.003-0.012 ppm from initially following the first application to 14 days following the second application. The minor degradate 2,4-DCP was present at 0.003-0.006 ppm from initially following the first application to 14 days following the second application. The minor degradate 4-CP was present at 0.001-0.003 ppm at 14-21 days following the second application. The degradate 2,4-DCA was not detected at any sampling interval..

Louisiana

2,4-D DMAS, applied at the targeted maximum label rate of 1.5 lb a.e./A, dissipated with a registrant-calculated half-life for 2,4-D acid of 1.1 days ($r^2 = 0.97$) in floodwater and 1.5 days ($r^2 = 0.88$) in soil on a flooded plot of Mowata silt loam soil planted to rice in south central Louisiana in Evangeline Parish.

In the floodwater, 2,4-D acid was initially present at a mean concentration of 1.3717 μg/mL at day 0, decreased to 0.5377 μg/mL by 1 day, and was last detected above the LOQ at 0.1945 μg/mL at 3 days post-treatment. Mean values are registrant-calculated averages of five replicate samples. The degradates 2,4-DCP, 2,4-DCA, 4-CPA, and 4-CP were not detected above the LOQ in any replicate water samples at any sampling intervals.

2,4-D acid was initially present in the 0- to 4-inch soil depth at a concentration of 0.011-0.017 μg/g (two of three replicates) at day 0, was 0.014 μg/g at day 1, and was detected below the LOQ by 3 days post-treatment. 2,4-D acid was detected in the 4- to 8-inch and 8- to 12-inch soil depths at 0.013 μg/g and 0.015-0.016 μg/g (two of three replicates), respectively, at 1 day post-treatment and was detected below the LOQ by 3 days post-treatment. Soil samples were not analyzed for residues of 2,4-D acid below the 0- to 4-inch soil depth at day 0. Total 2,4-D acid residues in all soil depths at 3 days post-treatment were 0.015 μg/g; however, no individual replicate samples were detected above the LOQ. The degradates 2,4-DCP and 2,4-DCA were not detected above the LOQ in any replicate soil samples at any sampling intervals.

2,4-D acid, formulated as Weedar 64 and applied at 20 and 40 lb/A, had a field dissipation half-life of < 3 days in reservoirs at Banks Lake, Washington and Fort Cobb, Oklahoma (**Accession No. 00115741**). The degradate dimethyl-nitrosamine was detected at pretreatment concentrations of 0.2 to 0.4 μg/l and post-treatment concentrations of 0.2 to 1.6 μg/l. The degradate 2,4-DCP was sporadically detected in hydrosoil samples from 7 days to 56 days post-treatment at 0.0078 to 0.0686 μg/g. The concentration of 2,4-DCP in a pretreatment control sample was 0.0114 μg/g. 2,4-D acid residue accumulation was observed < 0.0421 μg/g in carp and largemouth bass. No 2,4-D residues were detected in white suckers.

In the Rock Ranch canal and the Cherry Creek lateral (location unspecified in EFGWB review) amended with 0.433 lbs acid equivalence (ae) and 1.20 lbs ae, respectively, as 2,4-D DMAS, 2,4-D had half-life of < 133 minutes for locations 7 miles downstream from the application site

(**Accession. No. 00128148)**.

In the Guntersville reservoir on the Tennessee River amended with 2,4-D DMAS (4 lb/gal soluble concentrate/liquid) at 20 and 40 lb/A, the water concentration of 2,4-D was 4.8 μg/ml at 8 hours post-treatment and declined to < 0.11 μg/ml at 6 months post-treatment **(Accession No. 00043278**). Sediment concentrations of 2,4-D, at a 5 to 7-foot depth were < 0.37 μg/g at 3 months post-treatment. (Reviewer Note: EFGWB notes that "volatile solids" of sediment bound 2,4-D comprised 2.3 to 9.3% of the 2,4-D.) The concentration of 2,4-D in raw and treated waters from the reservoir was < 5.9 μg/ml.

In two ponds, a bayou, a lagoon, and a lake in LA, 2,4-D DMAS, applied at 1, 4, or 10 lbs/A, had a 2,4-D "residue" dissipation half-life of < 14 days (**Study Accession No. 00115748**). The concentration of 2,4-D residues at 7 days post-treatment ranged from 8 to 999 μg/l and then declined to 1 to 45 μg/l at 28 days post-treatment.

- **Aquatic Dispersion Studies (MRID 45897101)**

General: The 2,4-D Task Force recently submitted two dispersion and dissipation studies for the application of 2,4-D DMAS to control aquatic weeds. Although this study is currently under review in EFED, a study summary of the results is presented for additional information. The analytical methods in the field studies were not capable of separating and identifying 2,4-D DMAS from 2,4-D acid. Therefore, the dispersion and dissipation of 2,4-D DMAS can be considered to be equal or less than those found for 2,4-D acid. Available laboratory data on the solubility and the time for complete dissociation of 2,4-D DMAS indicate it should completely dissociate in aquatic environments. At the maximum application rate, the target 2,4-D DMAS concentration in aquatic environments does not exceed the solubility concentration for 2,4-D DMAS.

Florida

The first study was for the surface application of 2,4-D DMAS to a lake in Lake Woodruff, Florida for the control of water hyacinth. 2,4-D DMAS was surface applied, at a rate of 3.8 lbs ae/acre, to approximately 3.9 acres within an overall water body area of 2200 acres. Water samples were collected along 6 transect lines originating from the edge of the application area and extending up to 1600 meters away from the treated area. Samples were collected from near surface (25 centimeters below surface) and from near the bottom (25 centimeters above bottom when water was 58 inches deep or less, or 48 inches below surface when water was deeper then 58 inches). No sediment or plant samples were analyzed for 2,4-D acid. Residues of 2,4-D acid were analyzed using the RaPID Assay technique and were confirmed in selected samples using

GC/MS. In transect A, the highest 2,4-D concentration was 270 μg/l at 3 hours post-treatment within the application site. Outside the application area, the highest 2,4-D concentration along transect A was at 122 μg/l at Day 3, which is approximately 18.4 meters from the application area. All samples collected along transects B, C, D, E, and F were < 50 μg/l. The furthest point along the transects for 2,4-D detections (LOQ = 1.0 μg/l) was 911 meters from the application site along transect B on Day 5. The study authors calculated a dissipation half life for 2,4-D from the application area of 2.3 days ($r^2 = 0.65$). This half life does not distinguish between degradation, sorption, and transport away from the application area.

Minnesota

In the second dispersion and dissipation study, 2,4-D DMAS was applied by subsurface injection to a water body located in Green Lake, Minnesota for the control of Eurasian watermilfoil. 2,4-D was applied as 2,4-D DMAS by subsurface injection at a rate of 10.8 pounds of acid equivalent per acre-foot (lbs ae/acre-foot) to achieve a target concentration in the application area of 4 parts per million (ppm). 2,4-D DMAS was applied on September 11, 2002 to approximately 4.5 acres with a dense stand of Eurasian watermilfoil. Green Lake is located in Chisago County, Minnesota and is a 1714 acre lake and is reportedly a "low-flow" lake. The study authors report that the location, test site (static to low-flow lake) and application method were chosen because they represent a typical use pattern for 2,4-D DMAS. The highest single concentration detected was 13,193 ug ae/l at one hour after application within the application area. The highest concentration detected outside the application area was 3374 ug ae/l approximately immediately outside the application area. The furthest detection of 2,4-D outside the application area greater than the MCL was on day 11 at 82.3 ug ae/l while the furthest concentration detected above the LOQ was at 1605 meters. The study authors calculated a dissipation half life for 2,4-D from the application area of 3.23 days, however, this half life does not distinguish between degradation, sorption, and transport away from the application area.

- **Forest Field Dissipation Studies (MRID 43954702)**

2,4-D DMAS (Amine 400 2,4-D Weed Killer; 3.8 lb a.e./gal), broadcast applied as a spray (by helicopter) at a nominal rate of 4.0 lb a.e./A onto a forest plot of loam soil planted with fir trees, dissipated with registrant-calculated half-lives for 2,4-D acid of 38.7 days ($r^2 = 0.68$) in exposed soil, 50.8 days ($r^2 = 0.77$) in protected soil, 37.4 days ($r^2 = 0.84$) on foliage, and 65.7 days ($r^2 = 0.84$) on leaf litter. However, the apparent first half-lives occurred between 0 and 1 day post-treatment in the exposed soil, 1 and 3 days in the protected soil, 3 and 7 days on the foliage, and 7 and 14 days on the leaf litter; dissipation was observed to be biphasic in each case. EFED estimated half lives for 2,4-D acid using linear regression of log transformed data (mean concentrations of data from 0 to 6 inches collected through 398 days) of 59 days ($r^2 = 0.74$) in exposed soil, 68 days ($r^2 = 0.63$) in protected soil, 42 days ($r^2 = 0.81$) on foliage, and 72 days ($r^2 = 0.82$) on leaf litter.

The parent compound (2,4-D DMAS) converted to the acid equivalent (a.e.), 2,4-D acid, during application. In the exposed soil, 2,4-D acid (detected as the methyl ester, but reported in acid equivalents) was initially present in the 0- to 6-inch depth at 2.5 ppm, was 1.2 ppm at 1 day post-treatment, was present at 0.17-0.88 ppm from 3 to 120 days (with the exception of 0.086 ppm at 90 days), and was last detected at 0.025 ppm at 181 days. The parent was detected only three times in the 6- to 12-inch depth in one of three replicates each at 0.12 ppm (day 1), 0.11 ppm (7 days) and 0.011 ppm (14 days). The parent was detected only once in the 12- to 18-inch depth at 0.065 ppm (one of three replicates) at 120 days post-treatment. The major degradate 2,4-DCP was initially (day 1) present in the 0- to 6-inch depth at 0.015-0.024 ppm (two of three replicates), was not detected at 3 days, was a maximum of 0.031 ppm at 7 days, and was last detected at 0.017 ppm at 181 days post-treatment. 2,4-DCP was detected once below the LOQ in the 12- to 18-inch depth at 120 days post-treatment and was not detected at any other sampling interval below the 0- to 6-inch depth. The major degradate 2,4-DCA was detected once in the 0- to 6-inch depth at 0.021 ppm at 181 days post-treatment and was not detected at any other sampling interval or depth.

In the protected soil, the parent was initially present in the 0- to 6-inch depth at 0.69 ppm, was a maximum of 1.0 ppm at 1 day post-treatment, was 0.40 ppm at 3 days and 0.23-0.28 ppm from 7 to 14 days, and was last detected at 0.012 ppm (one of three replicates) at 360 days. The parent was detected once in the 6- to 12-inch depth at 0.038 ppm (one of three replicates) at 7 days post-treatment and was not detected at any other sampling interval below the 0- to 6-inch depth. The major degradate 2,4-DCP was detected sporadically in the 0- to 6-inch depth at ≤0.021 ppm from 1 to 181 days post-treatment; 2,4_DCP was not detected below the 0- to 6-inch depth. The major degradate 2,4-DCA was detected sporadically in the 0- to 6-inch depth at ≤0.020 ppm from 14 to 181 days post-treatment and was not detected below that depth.

In the foliage, the parent was initially present 172 ppm, was 110-121 ppm at 1-3 days and 24-51 ppm at 7-30 days, and was 0.22 ppm at 360 days. The major degradate 2,4-DCP was initially (day 0) present at 0.44 ppm, was a maximum of 1.1 ppm at 14 days post-treatment, and was 0.049 ppm at 360 days. The major degradate 2,4-DCA was initially (day 0) present at 0.010-0.011 ppm (two of three replicates), was a maximum of 0.087 ppm at 3 days post-treatment, and was last detected at 0.016 ppm at 59 days.

In the leaf litter, the parent was initially present 27 ppm, was a maximum of 43 ppm at 7 days post-treatment, was 9.5 ppm at 14 days (the next sampling interval) and 7.4-8.9 ppm from 30 to 90 days, and was 0.71 ppm at 360 days. The major degradate 2,4-DCP was initially (day 0) present at 0.59 ppm, was a maximum of 2.8 ppm at 7 days post-treatment, was 0.68-1.0 ppm from 14 to 90 days, and was 0.17 ppm at 360 days. The major degradate 2,4-DCA was present at 0.066-0.15 ppm from 3 to 181 days post-treatment, and was 0.039 ppm at 360 days. Residues of the parent or degradates were not detected in any samples of the pond water or sediment.

- **Field Accumulation in Aquatic Organisms** (**Acc. No. 00115745**)

In the Spring Creek arm of Lake Seminole in Georgia, amended with 2,4-DMAS at 22.5 and 45 kg/ha as Weedar 64, 2,4-D accumulation was not detected in gizzard shad, largemouth bass, redeadr sunfish, flathead catfish, bluegill sunfish, catfish, bowfin, bream, harmouth, and nelam.

Dimethylamine (DMA)

- **Aerobic Soil Metabolism** (Open literature-Smith and Aubin, 1992 J. Agric. Food Chem. 40:2299-2301; Ayanaba, et al. 1973 Soil Sci. Soc. Am. Proc. 37:565-568; Greber, 1973, Handbook of Microbiology. Microbial Products CRC Press; Niimura, et al., 1986 Agric. Biol. Chem. 50: 1447-1443)

Dimethylamine was rapidly degraded (DT_{50}= 4 to 14 days) in acid and near-neutral moist soils. However, DMA was persistent in air-dried mineral soils. The major degradate of DMA was CO_2. Dimethylnitrosamine (DMNA) was also identified as degradate of DMA. This degradation product was detected in soils with high concentrations of DMA and nitrite-N. The degradate DMNA degraded rapidly (DT_{50} 6 to 15 days) in soil. The mechanism of DMA degradation appears to be controlled by microbial-mediated deamination, beta-oxidation of carboxylic acids and oxidative mineralization through the Krebs cycle.

- **Aerobic Aquatic (MRID 43779601)**

Radiolabeled [^{14}C]dimethylamine, at a nominal application rate of 10 ppm, degraded with a registrant-calculated half-life of 2.8 days (r^2 = 0.99) in aerobic flooded silt loam sediment that was incubated in darkness at 25 ± 1 ^{o}C for up to 14 days. All data, designated as percent of the applied radioactivity, represent percentages of the nominal application. Based on HPLC analysis, the parent compound was initially detected in the total sediment/water system at 88.2% of the applied radioactivity, decreased to 45.9% of the applied by 2 days post-treatment and 37.7% of the applied by 3 days, and was last detected at 13.4-15.9% of the applied at 7 days post-treatment. In the water phase, the parent was initially present at 11.3% of the applied radioactivity, decreased to 4.7% by 2 days post-treatment and was last detected at 3.6% at 3 days. The minor degradate monomethylamine was present at a maximum of 0.73% of the applied radioactivity at 1 day post-treatment. In the sediment, extractable parent compound initially present at 76.9% of the applied radioactivity, decreased to 34.2% by 3 days and was last detected at 13.4-15.9% at 7 days. The minor degradate monomethylamine was a maximum of 5.3% of the applied radioactivity at day 0. Nonextractable [^{14}C]residues were a maximum of 41.0% of the applied radioactivity at 5 days post-treatment. [^{14}C]Residues associated with humic acid, fulvic acid and humin fractions (day 5) were 3.1%, 4.0% and 5.1% of the applied,

respectively. Radiolabeled $^{14}CO_2$ accounted for 2.4% of the applied radioactivity at 1 day post-treatment, increased to 33.8% by 7 days, and was 63.2% at 14 days.

- **Anaerobic Aquatic Metabolism (MRID 43908301)**

Radiolabeled [^{14}C]dimethylamine, at a nominal application rate of 10 ppm, had a registrant-calculated half-life of 1612 days (EFED calculated half-life is 1732 days with r^2 of 0.59) . In the total sediment/water system, the parent compound was initially 99.4% of the applied radioactivity and varied from 87.9 to 91.3% at 60-180 days. In the water phase, the parent compound was initially present at 67.0% of the applied radioactivity, was 60.1-61.9% from 3 to 60 days post-treatment and 54.0-54.7% at 119-180 days. The minor degradate monomethylamine was present at 2.0-3.5% of the applied from 0 to 180 days post-treatment. In the sediment extracts, the parent compound was present at 29.2-37.3% of the applied radioactivity from 0 to 180 days post-treatment with no apparent pattern of increase or decrease. The minor degradate monomethylamine was present at 1.2-2.3% of the applied radioactivity throughout the incubation.

Nonextractable [^{14}C]residues were a maximum of 8.8% of the applied radioactivity at 119 days post-treatment; [^{14}C]residues removed by acid hydrolysis were 7.0% of the applied radioactivity and [^{14}C] residues associated with humic acid, fulvic acid and humin fractions were 0.38%, 0.51% and 0.87% of the applied, respectively. Evolved ^{14}CO2 accounted for $\leq$2.0% of the applied radioactivity.

- **Batch Equilibrium** (**Accession No. 00023098**)

Radiolabeled dimethylamine had Freundlich adsorption coefficients of 32 (n=1) in a Melfort loam, 11.47 (n=1.0) in a Weyburn Oxburn loam, 12 (n=1.0) in a Regina heavy clay, 9.2 (n=0.99) in a Indian Head loam, and 4.5 in a Asquith sandy loam (O.M.=1.77%).

2,4-D IPA

Physical and Chemical Properties

Common name:	2,4-D IPA
Chemical name:	isopropylamine 2,4-dichlorophenoxyacetate
Molecular formula:	$C_{11}H_{15}Cl_2NO_3$
CAS Number:	5742-17-6
Molecular weight:	280.04
Vapor pressure (20^{o}C):	Decomposed to acid (-3.9 to 24^{o}C)
Henry's Law:	Not reported. Dissociates rapidly to acid
Solubility (25^{o}C):	37.3 g/100 mL @ 20^{o}C
Log K_{ow}:	Not reported. Dissociates rapidly to acid

- **Dissociation Study (MRID 41353702)**

Dissociation times were 120 minutes for 2,4-D and 1minute for 2,4-D IPA and 2,4-D TIPA. Complete dissociation was determined through a comparison of theoretical and estimated electrical conductance measurements at infinite dilution. Conductance at infinite dilution was estimated using the Onsager equation; this equation is linear for fully dissociated compounds or strong electrolytes. The estimated and theoretical conductance were 379 μmhos and 360 :mhos for 2,4-D, 60 μmhos and 64.9 μmhos for 2,4-D IPA and 39 μmhos and 45.7 μmhos for 2,4-D TIPA.

- **Field Dissipation Studies (No field dissipation studies were submitted for 2,4-D IPA)**

- **Aquatic Field Dissipation Studies (No aquatic field dissipation studies were submitted for 2,4-D IPA)**

Isopropylamine

- **Aerobic Soil (MRID 43821501)**

Isotopic diluted radiolabeled [2-^{14}C]isopropylamine hydrochloride, at a nominal application rate of 0.93 ppm, degraded with a registrant-calculated half-life of 11.8 hours (r^2 = 0.90) in Commerce silt loam soil (fine-silty,mixed, superactive, nonacid, thermic Aeric Fluvaquents collected from Washington County, MS) and 18.2 hours (r^2 = 0.95) in Hanford sandy loam soil

(coarse-loamy, mixed, superactive, nonacid, thermic Typic Xerorthents collected from Fresno County, CA) initially adjusted to 75% of 0.33 bar moisture content and incubated in darkness at 25 ^{o}C for up to 120 hours; however, the apparent half-life occurred between 24 and 32 hours in the sandy loam soil.

In the Commerce silt loam soil, the parent compound was initially present at 84.9% (0.79 ppm) of the applied radioactivity, decreased to 41.9% (0.39 ppm) by 24 hours and 6.5% (0.06 ppm) by 32 hours, and was 1.8-2.5% (0.02 ppm) from 48 to 120 hours post-treatment. Nonextractable [^{14}C]residues were initially 29% of the applied radioactivity at 24 hours, were a maximum of 53% at 56 hours post-treatment, and were 41% at 120 days. The radioactivity associated with the fulvic acid, humic acid, and humin fractions was 9.5%, 3.4%, and 41% of the applied, respectively, at 120 hours post-treatment. Evolved $^{14}CO_2$ accounted for 9% of the applied radioactivity at 24 hours and increased to 36% by 120 hours post-treatment.

In the Hanford sandy loam soil, the parent compound was initially present at 96.1% (0.89 ppm) of the applied radioactivity, decreased to 59.4% (0.55 ppm) by 24 hours and 28.3% (0.26 ppm) by 32 hours, and was 0.4% (<0.01 ppm) at 120 hours post-treatment. Nonextractable [^{14}C]residues were a maximum of 49% of the applied radioactivity at 48 hours post-treatment and were 34% at 120 days. The radioactivity associated with the fulvic acid, humic acid, and humin fractions was 10.9%, 4.8%, and 34% of the applied, respectively, at 120 hours post-treatment. Evolved $^{14}CO_2$ accounted for 5% of the applied radioactivity at 24 hours and increased to 35% by 120 hours post-treatment.

- **Aerobic Aquatic Metabolism (MRID 43799107)**

Isotopically diluted radiolabeled [2-^{14}C]isopropylamine hydrochloride, at a nominal application rate of 0.74 μg/mL, degraded with a registrant-calculate half-life of 21.6 hours (r^2 = 0.89) in aerobic flooded silt loam sediment that was incubated in darkness at 25 ^{o}C for up to 146 hours; however, the parent was present at 86.1% of the applied radioactivity at 26 hours post-treatment. In the total sediment/water system, the parent compound was initially present at 90.4% of the applied radioactivity, decreased to 86.1% by 26 hours and 55.1% by 72 hours, was 3.9% at 104 hours (the next sampling interval), and was 0.6% at 146 hours post-treatment. In the water phase, the parent compound was initially present at 47.7% of the applied radioactivity, increased to a maximum of 55% by 14 hours post-treatment, decreased to 30.2% by 72 hours and 1.4% by 104 hours, and was 0.1% at 146 hours. In the sediment phase, the parent compound was initially present at 42.7% of the applied radioactivity, decreased to 33.7% by 14 hours, increased to 42.1% by 26 hours, decreased to 24.9% by 72 hours and 2.5% by 104 hours, and was 0.5% by 146 hours post-treatment. Radioactivity present in the sediment NaOH extract was initially 2% of the applied radioactivity at 72 hours and increased to a maximum of 20% by 72 hours post-treatment; however, [^{14}C]residues were not characterized.

Nonextractable [^{14}C] residues were 22% of the applied radioactivity at 72 hours, increased to a maximum of 44% by 104 hours, and were 36% at 146 hours post-treatment. Radioactivity associated with the fulvic acid, humic acid and humin fractions was 9%, 8% and 35% of the applied, respectively, at 146 hours post-treatment. Evolved $^{14}CO_2$ initially accounted for 3% of the applied radioactivity at 72 hours post-treatment and increased to 24% by 146 hours.

- **Anaerobic Aquatic Metabolism (MRID 43799104)**

Isotopically diluted radiolabeled isopropylamine, at a nominal application rate of 0.74 μg/mL, had registrant calculated half-life of 320 days (EFED calculated a half-life of 408 days with r^2 = 0.91) in anaerobic aquatic environment. In the total sediment/water system, the parent compound was initially present at 92.0% of the applied radioactivity, decreased to 82.1% by 33 days post-treatment, and was 67.1% at 181 days. In the water phase, the parent compound was initially present at 26.2% of the applied radioactivity, decreased to 20.1% by 33 days post-treatment, and was 15.8% at 181 days. In the sediment phase, the parent compound was initially present at 65.8% of the applied radioactivity, decreased to 59.7% by 60 days post-treatment, and was 51.3% at 181 days. Radioactivity present in the sediment NaOH extract was initially 10-12% of the applied radioactivity from 60 to 111 days and was a maximum of 24% at 181 days post-treatment; [^{14}C]residues were not characterized.

Nonextractable [^{14}C]residues were a maximum of 23% of the applied radioactivity at 33 days and were 5% (one replicate) at 60 days post-treatment. Radioactivity associated with the fulvic acid, humic acid, and humin fractions was 9%, 1%, and 5% of the applied, respectively, at 60 days post-treatment. Evolved $^{14}CO_2$ accounted for 2-4% of the applied radioactivity from 33 to 181 days post-treatment. The distribution ratio of [^{14}C]residues between the sediment and water fractions was not reported, but the majority of [^{14}C]residues was observed in the sediment phase throughout the incubation (0 to 181 days); [^{14}C]residues in the water phase were initially 26% of the applied radioactivity and decreased to 16% by 181 days post-treatment and [^{14}C]residues in the sediment phase were 66-85% of the applied throughout the incubation period (reviewer-calculated).

2,4-D TIPA

Physical and Chemical Properties

Common name:	2,4-D TIPA
Chemical name:	triisopropanolamine 2,4-dichlorophenoxyacetate
Molecular formula:	$C_{17}H_{27}Cl_2NO_6$
CAS Number:	32341-80-3
Molecular weight:	412.31
Vapor pressure (20 ^oC):	$<1 \times 10^{-7}$ mmHg @ 14 – 28 ^oC
Henry's Law:	Not reported. Dissociates rapidly to acid
Solubility (25 ^oC):	
Log K_{ow}:	Not reported. Dissociates rapidly to acid

Dissociation Study (MRID 41353702)

Dissociation times were 120 minutes for 2,4-D and 1minute for 2,4-D IPA and 2,4-D TIPA. Complete dissociation was determined through a comparison of theoretical and estimated electrical conductance measurements at infinite dilution. Conductance at infinite dilution was estimated using the Onsager equation; this equation is linear for fully dissociated compounds or strong electrolytes. The estimated and theoretical conductance were 379 μmhos and 360 μmhos for 2,4-D, 60 μmhos and 64.9 μmhos for 2,4-D IPA and 39 μmhos and 45.7 μmhos for 2,4-D TIPA.

- **Field Dissipation Studies- (No field dissipation studies were submitted for 2,4-D TIPA)**

- **Aquatic Field Dissipation Studies-(No aquatic field dissipation studies were submitted for 2,4-D TIPA)**

Triisopropanolamine

- **Aerobic Soil (MRID 43799102)**

Isotopic diluted radiolabeled [1-^{14}C]triisopropanolamine, at a nominal application rate of 3.3 ppm, degraded with a registrant-calculated half-life of 1.6 days (0-13 day data; $r^2 = 0.74$) in Catlin silty clay loam soil and 1.7 days (0-13 day data; $r^2 = 0.86$) in Commerce silt loam soil adjusted to 75% of the soil moisture content at 0.33 bar and incubated in darkness at 25 ± 1 ^oC for up to 20 days. EFED, using nonlinear regression on all of the data (untransformed),

calculated similar half-lives of 0.9 (r^2 = 0.978) and 1.6 (r^2 = 0.987) days, respectively, for the Catlin and Commerce soils. The major degradate, diisopropanolamine (DIPA) degraded with EFED calculated half-lives of 2.3 (r^2 = 0.962) and 1.6 (r^2 = 0.970) days, respectively, in the Catlin and Commerce soils.

Based on HPLC analysis of the Catlin silty clay loam soil extracts, the parent compound was initially present at 97.1% (3.2 ppm) of the applied radioactivity, decreased to 72.2% (2.4 ppm) by 2 hours and 39.3% (1.3 ppm) by 1 day, and was 1.5% (one of two replicates; 0.05 ppm) at 20 days post-treatment. The major degradate, diisopropanolamine (DIPA) was initially present at 15.9% (0.52 ppm) of the applied radioactivity at 1 day post-treatment, increased to a maximum of 24.2% (0.80 ppm) by 3 days, decreased to 2.7% (0.09 ppm) by 13 days, and was 0.32% (one of two replicates; 0.01 ppm) at 20 days. Nonextractable [^{14}C]residues were initially (day 0) 10.5% of the applied radioactivity, increased to a maximum of 30.6% by 13 days post-treatment, and were 25.2% at 20 days. Radioactivity associated with the humic acid, fulvic acid, and humin fractions was 2.0%, 9.8%, and 20.4% of the applied, respectively, at 6 days post-treatment. Evolved $^{14}CO_2$ accounted for 7.5% of the applied radioactivity at 1 day post-treatment and increased to 70.2% by 20 days.

Based on HPLC analysis of the aqueous:methanol extracts, the parent compound was initially present at 97.7% (3.2 ppm) of the applied radioactivity, decreased to 57.9% (1.9 ppm) by 1 day and 30.2% (1.0 ppm) by 3 days, was 2.7% (0.09 ppm) of the applied at 6 days post-treatment, and was last detected at 0.74% (0.02 ppm) of the applied at 13 days post-treatment. The major degradate, diisopropanolamine (DIPA) was initially present at 15.3% (0.50 ppm) of the applied radioactivity at 1 day post-treatment, increased to a maximum of 20.1% (0.66 ppm) of the applied by 3 days post-treatment, and was last detected at 0.81% (0.03 ppm) of the applied at 13 days post-treatment. Nonextractable [^{14}C]residues were initially (day 0) 5.9% of the applied radioactivity, increased to a maximum of 25.2% of the applied by 6 days post-treatment, and were 20.6% of the applied at 20 days post-treatment. Radioactivity associated with the humic acid, fulvic acid, and humin fractions was 1.2%, 6.2%, and 23.7% of the applied, respectively, at 6 days post-treatment. Evolved $^{14}CO_2$ accounted for 3.4% of the applied radioactivity at 1 day post-treatment and increased to 66.9% of the applied by 20 days post-treatment.

- **Aerobic Aquatic Metabolism (MRID 43799108)**

Radiolabeled [1-^{14}C]triisopropanolamine, at a nominal application rate of ppm, degraded with a registrant calculated half-life of 14.3 days. The half-life of the minor degradate, (2-oxopropyl)diisopropanolamine was 13.1 days as calculated by EFED. In the total sediment/water system, the parent compound was initially present at 66.1% of the applied radioactivity, increased to 71.6% by 2 days, decreased to 24.5% by 11 days, increased to 42.0% by 21 days, and decreased to 14.1% by 30 days post-treatment. In the aqueous phase, the parent compound was initially present at 36.5% of the applied radioactivity, increased to a maximum of

50.1% by 2 days, decreased to 13.2% by 11 days, increased to 24.8% by 21 days, and decreased to 6.0% by 30 days post-treatment. Unidentified radioactivity (designated as M4) was detected at a maximum of 16.2% of the applied radioactivity at 11 days post-treatment and was 3.8% at 30 days; M4 was composed of two degradates occurring at an approximate ratio of 70:30. The minor degradate (2-oxopropyl)diisopropanolamine was present at a maximum of 6.5% of the applied radioactivity at 25 days post-treatment and was 2.3% at 30 days. In the sediment extracts, the parent compound was initially present at 29.6% of the applied radioactivity, decreased to 11.4% by 11 days, was 16.8-18.0% from 14 to 21 days, and was 8.1% at 30 days post-treatment. The minor degradate (2-oxopropyl)diisopropanolamine was present at a maximum of 4.6% of the applied radioactivity at 17 days post-treatment and was 4.4% at 30 days.

Nonextractable [^{14}C]residues were a maximum of 30.8% of the applied radioactivity at day 0 and were 19.2-25.1% of the applied from 2 to 30 days post-treatment. Radioactivity associated with the fulvic acid, humic acid, and humin fractions was 12%, 12%, and 6% of the applied, respectively, at day 0. Evolved $^{14}CO_2$ accounted for 0.3% of the applied radioactivity at 2 days post-treatment and increased with variability to 39.3% by 30 days.

- **Anaerobic Aquatic Metabolism (MRID 43799105)**

Radiolabeled [1-^{14}C]triisopropanolamine, at a nominal application rate of ppm is stable under anaerobic aquatic conditions. In the total sediment/water system, the parent compound was initially present at 58.5% of the applied radioactivity, decreased to 49.7% by 112 days post-treatment, and was 52.4% at 192 days. In the water phase, the parent compound was initially present at 21.4% of the applied radioactivity and was 13.6-16.8% from 19 to 192 days post-treatment. In the alkaline sediment extracts, the parent compound was present at 25.1-29.7% of the applied radioactivity from 0 to 192 days post-treatment.

Radioactivity in the acidic sediment extract accounted for 8.3-9.6% of the applied from 0 to 192 days post-treatment; ^{14}C residues were not characterized. Nonextractable ^{14}C residues were initially (day 0) 34.8% of the applied radioactivity and increased to a maximum of 49.5% by 192 days post-treatment. Radioactivity associated with the humic acid, fulvic acid, and humin fractions was initially (day 0) 1.6%, 23.6%, and 9.6% of the applied, respectively, and was 1.3%, 28.2%, and 20.0% of the applied, respectively, at 192 days post-treatment. Evolved $^{14}CO_2$ accounted for a maximum of 0.6% of the applied radioactivity by 192 days post-treatment.

2,4-D DEA

Physical and Chemical Properties

Common name:	2,4-D DEA
Chemical name:	Diethanolamine 2,4-dichlorophenoxyacetate
Molecular formula:	$C_{12}H_{17}Cl_2NO_5$
CAS Number:	5742-19-8
Molecular weight:	326.18
Vapor pressure (20 ^oC):	1.33 x 10^{-5} pa @ 25 ^oC
Henry's Law:	5.38 x 10^{-9} pa m^3/mol
Solubility (25 ^oC):	806 mg/g
Log K_{ow}:	-1.65@ 25 ^oC

- **Dissociation Study (MRID 41972501)**

Dissociation times were 3 minutes for 2,4-D sodium salt, 3 minutes for 2,4-D DEA and 200 minutes for 2,4-D acid. Complete dissociation was determined through a comparison of theoretical and estimated electrical conductance measurements at infinite dilution. Conductance at infinite dilution was estimated using the Onsager equation; this equation is linear for fully dissociated compounds or strong electrolytes. The estimated and theoretical conductance were 83 cm^2 μmhos mol^{-1} and 82 cm^2 μmhos $mol^{-1}$for 2,4-D, 65 cm^2 μmhos^{-1} and 63 cm^2 μmhos mol^{-1} for 2,4-D DEA, and 303 cm^2 μmhos mol^{-1} and 401 cm^2 μmhos mol^{-1} for 2,4-D acid. The discrepancy between theoretical and estimated equivalent conductances for 2,4-D acid may be explained by incomplete dissociation of the carboxylic acid (pKa).

- **Field Dissipation Studies- (No field dissipation studies were submitted for 2,4-D DEA)**

- **Aquatic Field Dissipation Studies-(No aquatic field dissipation studies were submitted for 2,4-D DEA)**

Diethanolamine

- **Aerobic Soil Metabolism(MRID 43685901)**

Radiolabeled [^{14}C]diethanolamine, at a nominal application rate of 10 ppm, degraded with a registrant-calculated half-life of 1.4 days (r^2 = 0.98; 0-7 day data) in Hanford sandy loam soil (Coarse_loamy, mixed, superactive, nonacid, thermic Typic Xerorthents) adjusted to 75% of

0.33 bar moisture content and incubated in darkness at 25 ± 1 ^{o}C for up to 90 days; degradation was observed to be biphasic with slower degradation occurring from 7 to 90 days post-treatment. EFED calculated a similar half-life (1.7 days) using nonlinear regression with all the data.

The parent compound was initially present at 81.6% (8.2 ppm) of the applied radioactivity, decreased to 70.6% (7.1 ppm) by 1 day and 38.0% (3.8 ppm) by 2 days, and was 0.54-1.1% (0.054-0.11 ppm) from 14 to 90 days post-treatment. The minor degradate glycine (M4) was a maximum of 5.0% (0.50 ppm) of the applied radioactivity at 3 days post-treatment. The minor degradate ethanolamine (M5) was a maximum of 2.6% (0.26 ppm) of the applied radioactivity at 2 days post-treatment. An unidentified degradate (M2) was a maximum of 9.9% (0.99 ppm) of the applied radioactivity at day 0. Seven additional unidentified minor degradates were a combined maximum of 11.7% (1.2 ppm) of the applied radioactivity at 2-3 days post-treatment and were 1.4% (0.14 ppm) at 90 days. Nonextractable [^{14}C]residues were initially 6.6% of the applied radioactivity, increased to a maximum of 33.1% by 7 days post-treatment, and were 24.2% at 90 days. Radioactivity associated with the humic acid, fulvic acid, and humin fractions were 3.7%, 4.4%, and 5.0% of the applied, respectively, at 7 days post-treatment. Evolved $^{14}CO_2$ accounted for 1.1% of the applied radioactivity at 1 day post-treatment, was 14.1% at 2 days, and accounted for 59.9% at 90 days.

- **Aerobic Aquatic Metabolism (MRID 43685902 & 44439401)**

Radiolabeled [^{14}C]diethanolamine, at a nominal application rate of 10 ppm (10 μg/g), degraded with a registrant-calculated half-life of 10.3 days (r^2 = 0.96; 0-21 day data) in aerobic flooded silt loam sediment that was incubated in darkness at 25 ± 1 ^{o}C for up to 30 days. EFED calculated a half-life of 5.8 days (r^2 = 0.86; 0-30 day data). In the total sediment/water system, the parent compound was initially present at 67.3% of the applied radioactivity, decreased to 63.4% by 7 days and 27.2% by 14 days, and was 1.4% at 30 days post-treatment. In the water phase, the parent compound was initially present at 20.5% of the applied radioactivity, was a maximum of 28.7% at 3 days post-treatment, decreased to 23.0% by 7 days and 6.7% by 14 days, and was 0.24% at 30 days. The minor degradate ethanolamine (M5) was a maximum of 0.13% of the applied radioactivity at 14 days post-treatment and was 0.07% at 30 days. In the sediment extracts, the parent compound was initially present at 46.8% of the applied radioactivity, decreased to 34.2% by 3 days post-treatment, increased to 40.4% by 7 days, decreased to 20.4% by 14 days, and was 1.2% at 30 days. The minor degradate ethanolamine (M5) was a maximum of 2.1% of the applied radioactivity at 7 days post-treatment and was 0.24% at 30 days. The NaOH filter rinsate initially (day 0) accounted for 19.9% of the applied radioactivity and accounted for 6.9-13.9% from 3 to 30 days.

Nonextractable [^{14}C]residues were initially (day 0) 6.0% of the applied radioactivity, increased to a maximum of 26.7% by 21 days, and were 24.0% at 30 days post-treatment. Most (12.7% of the applied) of the radioactivity associated with the nonextractable [^{14}C]residues (day 14) was extracted by acid reflux; however, residues were not characterized. Radioactivity associated

with the humin, humic acid, and fulvic acid fractions was 5.5%, 3.4%, and 2.2% of the applied, respectively, at 14 days post-treatment. Evolved $^{14}CO_2$ accounted for 0.59% of the applied radioactivity at 3 days post-treatment, increased to 18.7% by 14 days, and was 55.0% at 30 days; [^{14}C]organic volatiles were negligible. The distribution ratio of [^{14}C]residues between the water and sediment fractions was not reported, but the majority of [^{14}C]residues was observed in the sediment phase. In the water phase, [^{14}C]residues were a maximum of 29.1% of the applied radioactivity at 3 days and decreased to 1.7% by 30 days. In the sediment phase, [^{14}C]residues were 67.7-82.1% of the applied radioactivity from 0 to 7 days and were 40.0-53.2% of the applied from 21 to 30 days.

- **Anaerobic Aquatic Metabolism (MRID 43882901)**

Radiolabeled [^{14}C]diethanolamine degraded with a registrant-calculated half-life of 1050 days (EFED calculated half-life is 990 days with r^2 of 0.42). In the total sediment/water system, the parent compound was initially present at 81.2% of the applied radioactivity, was 73.3-76.6% from 3 to 59 days post-treatment, and was 82.7% at 120 days. In the water phase, the parent compound was initially present at 57.5% of the applied radioactivity, decreased to 48.7% by 59 days post-treatment, and was 54.1% at 120 days. In the sediment phase, the parent compound was initially present at 23.6% of the applied radioactivity and increased with variability to a maximum of 28.6% by 120 days post-treatment.

The minor degradate ethanolamine (M5) was detected three times at ≤0.80% of the applied radioactivity (7, 30 and 59 days). The NaOH filter rinsate accounted for 7.4-16.8% of the applied radioactivity throughout the incubation period; however, ^{14}C residues were not characterized. Nonextractable ^{14}Cresidues were initially (day 0) 12.3% of the applied radioactivity, increased to a maximum of 19.8% by 59 days post-treatment, and were 11.3% at 120 days. Most of the radioactivity (14.1% of the applied) associated with the nonextractable ^{14}C residues in selected samples (59 days) was extracted by acid reflux; residues were not characterized. Radioactivity associated with the humic acid, fulvic acid, and humin fractions was 1.4%, 2.8%, and 1.4% of the applied, respectively, at 59 days post-treatment. Evolved $^{14}CO_2$ accounted for ≤0.03% of the applied radioactivity at each sampling interval.

Esters

The EFED strategy for assessing the environmental fate of 2,4-D esters is based on bridging of laboratory fate data from 2,4-D ester to 2,4-D acid. EFED required hydrolysis data and terrestrial field dissipation data to confirm rapid de-esterification in aquatic and terrestrial environments.

The de-esterification of 2,4-D esters is more difficult to generalize because it is dependent on heterogenous hydrolysis (microbial-mediated hydrolysis and surface-catalyzed) and homogenous hydrolysis (alkaline catalyzed) (Schwarzenbach, et al.1993). The deesterification of 2,4-D ester leads to formation of 2,4-D acid and an associated alcohol moiety. Unlike the physical dissociation mechanism of 2,4-D amine salts, the de-esterification of 2,4-D esters is dependent on abiotic processes and microbial-mediated processes. Any environmental variable influencing microbial populations or microbial activity could theoretically influence the persistence of the 2,4-D ester. Soil properties including clay mineralogy, organic carbon content, temperature, and moisture content are known to influence hydrolysis rates (Wolfe, et al, 1989 and Wolfe, 1990).

Paris, et al (1981) found the average de-esterification half-life of 2,4-D BEE in natural waters from 31 sites with varying temperature and pH conditions (5.4 to 8.2) was 2.6 hours. They found that 2,4-D BEE degradation could be explained using second-order kinetics accounting for microbial population numbers and aqueous concentration of 2,4-D BEE. Further research indicated second-order de-esterfication rates can be predicted through a linear regression [log k_b=(0.799±0.098)* log K_{ow}-(11.643±0.204), r^2=0.94] using the octanol:water coefficient (log K_{ow}) as the independent variable.

Additionally, various mineral surfaces (Fe, Al, Ti oxides) have been shown to influence hydrolysis of carboxylate esters (Torrent and Stone, 1994). Abiotic hydrolysis of 2,4-D esters, however, is expected to be more predictable in alkaline environments. Several field studies show phenoxy herbicide esters are more persistent under extremely dry soil [< soil wilting point (~15 bars)] conditions (Smith and Hayden, 1980; Smith, 1972; Smith,1976). In moist soils [~50 to 80% field capacity (~0.3 bars)] and soil slurries, phenoxy herbicide esters degraded rapidly (>85% degradation) during a 48 hour incubation period. These hydrolysis studies indicate the alkyl chain configuration affected hydrolysis rates in soils and soil slurries. The iso-octyl ester of 2,4-D (2,4-D EHE) had slower hydrolysis rates when compared to n-butyl and isopropyl esters of 2,4-D. In field studies, Harrison, et al (1993) found no 2,4-D and 2,4-DP esters were detected in runoff water (though detection limits were relatively high @ 20 ug ae/l for 2,4-D EHE) from turf sites with 2,4-DP and 2,4-D ester applications.

Registrant sponsored research indicates the 2,4-D esters (ethylhexyl, isopropyl, butylethyl) degrade rapidly ($t_{1/2}$< 24 hours) in soil slurries, aerobic aquatic environments, and anaerobic, acidic aquatic environments. In terrestrial field dissipation studies for 2,4-D EHE, the half-lives for 2,4-D EHE ranged from 1 to 14 days with median half-life of 2.9 days. 2,4-D BEE, applied

as granules, degraded rapidly in the water column in aquatic field dissipation studies under alkaline conditions. However, the 2,4-D BEE residues were detected in sediment samples from Day 0 (immediately post-treatment) to 186 days post-treatment. It is unclear whether 2,4-D BEE persistence in sediment is due to the slow release of the granule formulation or to slow deesterification of sediment bound 2,4-D BEE. Available open-literature and registrant sponsored laboratory data would suggest slow granule dissolution prolonged the persistence of 2,4-D BEE. In forest dissipation studies, the 2,4-D EHE ester degraded slowly on foliage and in leaf litter.

2,4-D EHE

Physical and Chemical Properties

Common name:	2,4-D EHE
Chemical name:	2-ethyhexyl 2,4-dichlorophenoxyacetate
Molecular formula:	$C_{16}H_{22}Cl_2O_3$
CAS Number:	1928-43-4
Molecular weight:	333.26
Vapor pressure (20 ^oC):	3.6×10^{-6} mm Hg
Henry's Law:	1.82×10^{-5} atm-m^3/mole
Solubility (25 ^oC):	86.7 ppb @ 20 ^oC
Log K_{ow}:	5.78

- **Abiotic Hydrolysis** (**MRID 42735401**)

Radiolabeled 2,4-D EHE, at 30 μg/L, had a first-order half-life of 99.7 days (R^2=0.931) in pH 5 buffer solution, 48.3 days (R^2=0.929) in pH 7 buffer solution, and 52.2 hours (R^2=0.975) in pH 9 buffer solution The major degradate was identified as 2,4-D. Unknown radiolabeled degradates were also detected (<2.5% of applied).

- **Microbial-mediated and Surface-catalyzed Hydrolysis** (MRID 42770502; 42770501; Grover, 1973. Weed Research 13:51-58; Smith, 1972. Weed Science 12:364-372; Smith , 1976. Weed Research 16:19-22; Wilson and Cheng. 1978 J. Environ. Qual. 7:281-286; Schwarzenbach et al. 1993; Paris et al, 1981; (Wolfe, et al, 1989 and Wolfe, 1990).

Radiolabeled 2,4-D EHE, at 30 μg/L, had a first-order half-life of 6.2 hours (R^2=0.997) in nonsterile, Tittabawasse River water (pH=8.0), 1.25 hours in a Catlin silty loam slurry, and 1.45 hours in Hanford sandy loam slurry. The major degradate product was 2,4-D.

Open literature data indicate that carboxylic acid esters are prone to both surface-catalyzed hydrolysis and microbial mediated hydrolysis (Schwarzenbach, et al.1993). Sediment and soils may promote hydrolysis through reactions with surface hydroxyl groups from transition metal oxide and hydroxide mineral coatings on sediments or soils. Another theory is that the diffuse double layer at the interface of sediment or soil surfaces has higher hydroxide concentrations causing alkaline-catalyzed hydrolysis.

Microbial-mediated hydrolysis of carboxylic acid esters is an enzymatic controlled process (Schwarzenbach, et al.1993). Paris, et al (1981) tested the rate of microbial degradation of 2,4-D BEE in natural waters from 31 sites with varying temperature and pH conditions (5.4 to 8.2). The authors found that in waters typical of natural conditions and at concentrations normally encountered in rivers and lakes, the rate constants from all sites were within a factor of eight and estimated a mean half life of 2.6 hours. Degradation kinetics could be described using second order kinetics. Paris, et al (1983) found hydrolysis rates of 2,4-D n-alkyl esters in natural waters could be predicted using a linear regression equation using log Kow as the independent variable [log kb=(0.799 ± 0.098)* log Kow-(11.643 ± 0.204)]. Although the available data indicate rapid degradation of 2,4-D esters in natural waters, microbial mediated hydrolysis rates in soils may be dependent on clay mineralogy, organic carbon content, temperature, and moisture content (Wolfe, et al, 1989 and Wolfe, 1990).

Phenoxyacetate esters of 2,4-D (iso-propyl, iso-butyl, iso-octyl) rapidly hydrolyzed ($t_{1/2}$= 30 minutes) in alkaline salt solutions (Smith, 1972**)**. Phenoxyacetate esters of 2,4-D, 2,4,5-T, 2,4-DP and 2,4-DB (iso-propyl, iso-octyl, iso-butyl) rapidly hydrolyzed in moist Canadian soils and soil slurries (Smith, 1976). The rate of hydrolysis of the phenoxyacetate esters was reduced in soils with a low moisture content (Smith, 1976, Smith, 1972, Groom, 1973).

- **Photodegradation in Water (MRID 42749702)**

Radiolabeled 2,4-D EHE, at 30 μg/L, had a first-order half-life of 128.2 days in pH 5 buffer solution irradiated with natural light. The degradation half-life of 2,4-D EHE was 252.5 days in dark controls. Photodegradate were identified as 2,4-D (0.3 to 6.0% of applied), 2,4-dichlorophenol (2,4-DCP) (0.5 to 7.6% of applied), 2-ethylhexyl 4-chlorophenoxyacetate (0.1 to 1.5% of applied). Unknown degradates (0.3 to 6.6% of applied) were also detected. The main degradate in dark control samples was 2,4-D. The reported data indicate 2,4-D EHE should not rapidly photodegrade in acidic aquatic environments.

- **Laboratory Volatility (MRID 42059601**)

Radiolabeled 2,4-D EHE, applied as Esteron 99 Concentrate at a rate of 15.8 lbs ae/A, was not volatile (< 0.22% of applied) from sandy loam soil. At 1 to 1.5 days post-treatment, the observed volatilization rate and air concentration of 2,4-D EHE was 8.06 x 10^{-4} μg/cm^2/hr and

34.84 μg/m^3 and 3.45 x 10^{-3} μg/cm^2/hr during air flow rates of 100 ml/min and 300 ml/min, respectively. During the volatility study, 2,4-D EHE was rapidly degraded ($t_{1/2}$= 8 days) to form 2,4-D. The reported data indicate 2,4-D, EHE, formulated in ESTERON 99 Concentrate, and its major degradate 2,4-D are not volatile from soil.

- **Terrestrial Field Dissipation** (**MRIDs 43914701; 43762401; 43762402; 43514601; 43533401;43864001;43592801;43762403;43762404;43640601;43831702;43872703;43849102;43831701; 43705202)**

General: The registrant submitted 15 terrestrial field dissipation using 2,4-D EHE. Field studies were conducted on bareground, pasture, corn, turf, and wheat. In addition, two forest field dissipation studies were conducted using 2,4-D EHE.

The registrant conducted a total of 15 terrestrial field dissipation studies in CA, CO, NC, ND, NE, OH and TX on bareground plots as well as plots cropped to corn, pasture, turf and wheat. 2,4-D EHE had first-order half lives ranging between 0.9 days to 14.3 days with a median half-life of 2.9 days. The first-order half-life of 2,4-D acid ranging from 1.2 days to 42.5 days with a median half-life of 6.2 days. These half-lives reflect dissipation from the surface soil layer (0 to 6 inches) and do not include residues which have leached below the surface layer. The data indicate a rapid to moderately rapid dissipation rate for 2,4-D. Similar degradation rates were found in aerobic soil metabolism laboratory studies (MRIDs 00116625 and 43167501) Dissipation rates for 2,4-D degradation products (2,4-DCP and 2,4-DCA) were not estimated because of their sporadic occurrence patterns in surface soils. 2,4-D EHE was not persistent (median half-life =2.9 days) under field conditions.

2,4-D residues were detected below a depth of 18 inches in eleven of the terrestrial field dissipation studies reviewed and was detected below 30 inches in five studies **(MRID 43914701, 43762402, 43831703, 43849101, and 43872702**). Leaching appears to be a route of dissipation when precipitation or irrigation exceed evapotranspiration.

The registrant submitted storage stability studies for 2,4-D, 2,4-DCP, and 2,4-DCA. These studies were conducted on soils taken from field dissipation studies in Colorado, North Carolina, and Texas. An analysis of storage stability studies indicate that 2,4-D and 2,4-DCA are stable (average half-lives 2605 to 2876 days), respectively, during frozen storage for up to 454 days. However, the frozen storage stability half-lives for 2,4-D 2-EHE (114, 194, and 1066 days) and 2,4-DCP (85, 257, 2310 and 3465 days) indicate that 2,4-D 2-EHE and 2,4-DCP may not be stable under all storage conditions. Thus, there is uncertainty about the quality of the 2,4-D 2-EHE and 2,4-DCP field dissipation data because of the variable nature of the storage stability studies.

The following summary table presents the basic results of the individual field dissipation studies

submitted for 2,4-D DMAS and 2,4-D. For a more detailed review of the individual studies the reader is directed to review individual Data Evaluation Records (DER).

MRID #	ST	County	EUP	Form	Use	Single App Rate (lbs ae/A)	No of Apps	Annual App Rate (lbs ae/A)	Surface Soil Half-life (First Application)-Days		Surface Soil Half-life (Second Application)-Days		Surface Soil Half-life (Third Application)-Days		Surface Soil Half-life (Fourth Application)-Days		Maximum Depth of Detection (inches)				Precip + Irrig (in)	Pan Evap (in)
									2,4-D EHE	2,4-D	2,4-D EHE	2,4-D	2,4-D EHE	2,4-D	2,4-D EHE	2,4-D	2,4-D EHE	2,4-D	2,4-DCP	2,4-DCA		
43914701	CA	Tulare	EHE	Conc	Bare	2.2	2	4.4	2.3	3.8	2.6	6.2					30	48	6	18	26.8	
43762401	CA	Tulare	EHE	Conc	Bare/Past	2.2	2	4.4	3.5	7.5	5.1	39.2					12	24	6	6		
43762402	CA	Tulare	EHE	Conc	Turf	2.2	2	4.4	2.1	6.2	2.2	9.7					6	42	18	NA		
43514601	CO	Eaton	EHE	Conc	Bare	1.25	2	2.5	1.7	6.6	1.7	2.2					6	12	6	NA	12.7	26.2
43533401	CO	Eaton	EHE	Conc	winter wheat	1.25	2	2.5	3.4	6.5	2	2.8					6	6	6	6	12.7	27
43864001	NE	York	EHE	Conc	Bare	variable rates	4	5.5	2.6	42.5	5.8	4.4	2.9	4.7	7.5	4.5	12	18	6	6	31.3	
43592801	NC	Rowland	EHE	Conc	Bare	1.25	2	2.5	14.2	5.5	2.8	3.2					6	6	6	6	33.1	42.5
43762403	NC	Rowland	EHE	Conc	Bare	2.2	2	4.4	0.9	2.7	1.2	1.8					12	12	6	6	20.4	31.99
43762404	NC	Rowland	EHE	Conc	Turf	2.2	2	4.4	NA	4.5	NA	2.2					6	18	6	6	31	34.04
43640601	NC	Rowland	EHE	Conc	Wheat	1.25	2	2.5	11.4	9.4	1.8	9.6					6	6	6	6	33.1	41
43831702	ND	Northwood	EHE	Conc	Bare	1.4	2	2.8	4.4	6.1	3.6	5.6					12	12	6	6	16.02	
43872703	OH	New Holland	EHE	Gran	Bare	2.2	2	4.4	6	10.7	6.3	10.3					12	12	6	6	18.72	
43849102	OH	New Holland	EHE	Conc	Bare	variable rates	4	5.68	10.9	31.5	6.6	5.4	2.8	1.2	2.9	9	12	12	6	NA	30.8	
43831701	OH	New Holland	EHE	Gran	Turf	2.2	2	4.4	14.3	24.6	1.1	13					12	12	6	6	18.67	

MRID		County	EUP	Form	Use	Single App Rate (lbs ae/A)	No of Apps	Annual App Rate (lbs ae/A)	Surface Soil Half-life (First Application)-Days		Surface Soil Half-life (Second Application)-Days		Surface Soil Half-life (Third Application)-Days		Surface Soil Half-life (Fourth Application)-Days		Maximum Depth of Detection (inches)				Precip + Irrig (in)	Pan Evap (in)
									2,4-D EHE	2,4-D	2,4-D EHE	2,4-D	2,4-D EHE	2,4-D	2,4-D EHE	2,4-D	2,4-D EHE	2,4-D	2,4-DCP	2,4-DCA		
43705202	TX	Eagle Lake	**EHE**	Conc	Past	2	2	4	1.4	4.2	1.1	13.1					6	12	6	NA	36.9	39.9

- **Forest Field Dissipation (MRID 43908303 & 43927101)**

2,4-D EHE, broadcast applied as a spray at a nominal rate of 4.0 lb a.e./A to a forested plot of sandy clay loam soil in Georgia, dissipated with registrant-calculated half-lives for 2,4-D acid of 1.7 days (r^2 = 0.92; 0-7 day data) in protected soil, 7.2 days (r^2 = 0.75; 0-62 day data) in foliage, and 51.0 days (r^2 = 0.55) in leaf litter. The 2,4-D EHE was detected in the exposed soil at only two sampling intervals and was not detected after 3 days post-treatment. The major degradate 2,4-D acid dissipated with registrant-calculated half-lives of 4.0 days (r^2 = 0.61; 0-30 day data) in exposed soil, 3.6 days (r^2 = 0.51; 0-15 day data) in protected soil, 23.5 days (r^2 = 0.73; 0-180 day data) in foliage, and 52.2 days (r^2 = 0.57) in leaf litter. EFED estimated half-lives on foliage for 2,4-D of 32.5 days (r^2 = 0.80) and for 2,4-D EHE of 32.7 days (r^2 = 0.51). EFED estimated half-lives in leaf litter for 2,4-D of 51.7 days (r^2 = 0.55) and for 2,4-D EHE of 50.5 days (r^2 = 0.53).

In the exposed soil, the parent was initially present in the 0- to 6-inch depth at 0.14 ppm, was not detected at 1 day post-treatment, and was last detected at 0.029 ppm at 3 days; the parent was not detected below the 0- to 6-inch depth. The major degradate 2,4-D acid was initially (day 0) present in the 0- to 6-inch depth at a maximum of 0.15 ppm, was not detected at 1 day post-treatment, was 0.074 ppm at 3 days, and was last detected at 0.010 ppm (one of three replicates) at 15 and 30 days; 2,4-D acid was not detected below the 0- to 6-inch depth. The degradates 2,4-DCP and 2,4-DCA were not detected at any sampling interval or depth.

In the protected soil, the parent was initially present in the 0- to 6-inch depth at 0.058 ppm, decreased to 0.036 ppm by 1 day post-treatment, and was last detected at 0.010 ppm (one of three replicates) at 7 days. The parent was detected once in the 6- to 12 inch depth, at 0.016 ppm (one of three replicates) at 1 day post-treatment; the parent was not detected at any other sampling interval below the 0- to 6-inch depth. The major degradate 2,4-D acid was initially (day 0) present in the 0- to 6-inch depth at 0.11 ppm, was a maximum of 0.19 ppm at 1 day post-treatment, and was last detected at 0.012 ppm (two of three replicates) at 15 days; 2,4-D acid was detected once in the 6- to 12 inch depth, at 0.014 ppm (two of three replicates) at 1 day post-treatment. The degradates 2,4-DCP and 2,4-DCA were not detected at any sampling interval or depth.

In the foliage, the parent was initially present at 36.9 ppm, decreased to 15.5 ppm by 1 day and 11.1 ppm by 3 days, was 0.36-2.5 ppm at 7-30 days post-treatment, and was last detected at 0.13 ppm (one of three replicates) at 62 days. The major degradate 2,4-D acid was initially (day 0) present at a maximum of 43.0 ppm, decreased to 25.0 ppm by 3 days and 4.3 ppm by 7 days, was 0.33-0.90 ppm at 62-118 days, and was last detected at 0.33 ppm at 180 days post-treatment. The major degradate 2,4-DCP was initially (day 0) present at 0.34 ppm, increased to a maximum of 0.39 ppm by 1 day post-treatment, was 0.12-0.34 ppm at 3-91 days, and was last detected at 0.24 ppm (one of three replicates) at 118 days. The major degradate 2,4-DCA was only detected twice, at 0.16 ppm at 7 days post-treatment and at 0.10 ppm (two of three replicates) at 180 days.

In the leaf litter, the parent was initially present at 50.6 ppm, was 11.1-13.9 ppm at 1-7 days and 0.25-1.0 ppm at 15-180 days, and was 0.12 ppm at 359 days post-treatment. The major degradate 2,4-D acid was initially (day 0) present at a maximum of 30.6 ppm, decreased to 15.9 ppm by 7 days and 1.5-1.9 ppm by 15-30 days, and was 0.18 ppm at 359 days post-treatment. The major degradate 2,4-DCP was initially (day 0) present at a maximum of 2.9 ppm, was 0.95-2.2 ppm at 1-7 days and 0.046-0.21 ppm at 15-180 days post-treatment, and was 0.036 ppm at 359 days. The major degradate 2,4-DCA was initially (day 0) present at 0.24 ppm, was a maximum of 0.37 ppm at 7 days, was 0.042-0.11 ppm at 15-180 days, and was 0.015 ppm (two of three replicates) at 359 days.

2,4-D EHE and its degradates were not detected in the adjoining pond water or pond sediment at any sampling interval.

2-Ethylhexanol

- **Aerobic Soil Metabolism (MRID 43415901)**

Radiolabeled 2-ethylhexanol, at 10.8 μg/g, degraded with half-life of 5.34 hours in a Hanford sandy loam. Radiolabeled residues were distributed in methanol/acetonitrile soil extracts (91 % applied immediately post-treatment), post extractable residues (49% of applied at 48 hours post-treatment), and KOH gas trap (70% applied at 14 days post-treatment). Residues in methanol/acetonitrile soil extracts were identified as 2-ethylhexanol (90% of applied immediately post-treatment) and 2-ethylhexanoic acid (84% of applied at 48 hours post-treatment). Five unidentified peaks (R_t ranged from 2.3 to 27.15 minutes) in methanol /acetonitrile soil extracts were also detected.

- **Anaerobic Aquatic Metabolism (MRID 43691001)**

Radiolabeled [1-^{14}C]2-ethylhexanol, at a nominal concentration of 10 ppm, degraded with a registrant-calculated half-life of 14.0 days (0 to 60 day data; $r^2 = 1.0$) in anaerobic flooded silty clay loam sediment that was incubated in darkness at 25 ± 1 ^{o}C for 270 days. The degradation was biphasic, with the slower phase beginning by 120 days post-treatment; the registrant-calculated half-life was based only on water and soil sample parent data (volatile parent data were not included) through 60 days post-treatment. Based on HPLC analysis, parent compound was initially present in the total sediment/water system at 99.6% of the applied radioactivity, decreased to 53.5% by 14 days post-treatment and 23.7% by 30 days, and was last detected at 1.6% of the applied at 120-179 days.

In the water phase, parent compound was initially present at 75.3% of the applied radioactivity, decreased to 40.0% by 14 days post-treatment, and was last detected at 1.1% of the applied at 179 days. The major degradate 2-EH Acid was initially present in the water phase at 9.3% of the

applied radioactivity at 7 days post-treatment, increased to a maximum of 60.5% of the applied by 120 days, and was 58.5-59.5% at 179-270 days. In the sediment extracts, the parent compound was present at 23.7-24.9% of the applied radioactivity from 0 to 7 days post-treatment, decreased to 13.5% by 14 days and 2.0% by 30 days, and was not detected from 60-270 days with the exception of 0.53% of the applied at 179 days. The major degradate 2-EH acid was initially present at 2.4% of the applied radioactivity at 7 days post-treatment, increased to a maximum of 19.4% of the applied by 30 days, and was 9.2-14.6% from 60 to 270 days.

Nonextractable [^{14}C]residues (bound) were a maximum of 6.7% of the applied radioactivity at 3 days post-treatment Total [^{14}C]volatiles accounted for 6.3-8.1% of the applied radioactivity from 3 to 14 days post-treatment and increased to 24.5-25.4% by 179 to 270 days. Based on analysis following precipitation with $BaCl_2$, evolved $^{14}CO_2$ accounted for 1.1-2.0% of the applied radioactivity from 3 to 29 days post-treatment and 6.3-9.1% from 60 to 270 days. [^{14}C]Volatiles were present at 4.9-7.1% of the applied radioactivity from 3 to 14 days post-treatment and 11.8-16.4% from 29 to 270 days; in the only sample for which residues were characterized (224 days), only parent compound was detected in the volatile traps following precipitation to remove $^{14}CO_2$.

2,4-D BEE

Physical and Chemical Properties

Common name:	2,4_D BEE
Chemical name:	2,4-D butoxyethyl ester
Molecular formula:	$C_{14}H_{18}Cl_2O_4$
CAS Number:	1929-73-3
Molecular weight:	321.20
Vapor pressure (20 ^oC):	2.4 x 10^{-6} mm Hg @ 25 ^oC
Henry's Law:	not calculated due to insolubility
Solubility (25 ^oC):	12.7 ±1 μg/L
Log K_{ow}:	4.35

- **Abiotic Hydrolysis** (**MRID 41353701**)

Radiolabeled 2,4-D BEE had first-order half-life of 196 days in pH 5 buffer solution, 47.5 hours in pH 7 buffer solution, and 55 minutes in pH 9 buffer solution. The major degradation product was 2,4-D acid.

- Microbial-Mediated and Surface-Catalyzed Hydrolysis (**Grover, 1973. Weed Research 13:51-58; Smith, 1972. Weed Science 12:364-372; Smith , 1976. Weed Research 16:19-22; Wilson and Cheng. 1978 J. Environ. Qual. 7:281-286.; Schwarzenbach et al. 1993; Paris et al, 1981; Paris et al., 1983; (Wolfe, et al, 1989 and Wolfe, 1990**).

Open literature data indicate that carboxylic acid esters are prone to both surface-catalyzed hydrolysis and microbial mediated hydrolysis (Schwarzenbach, et al.1993). Sediment and soils may promote hydrolysis through reactions with surface hydroxyl groups from transition metal oxide and hydroxide mineral coatings on sediments or soils. Another theory is that the diffuse double layer at the interface of sediment or soil surfaces has higher hydroxide concentrations causing alkaline-catalyzed hydrolysis.

Microbial-mediated hydrolysis of carboxylic acid esters is an enzymatic controlled process (Schwarzenbach, et al.1993). Paris, et al (1981) tested the rate of microbial degradation of 2,4-D BEE in natural waters from 31 sites with varying temperature and pH conditions (5.4 to 8.2). The authors found that in waters typical of natural conditions and at concentrations normally encountered in rivers and lakes, the rate constants from all sites were within a factor of eight and estimated a mean half life of 2.6 hours. Degradation kinetics could be described using second order kinetics. Paris, et al (1983) found hydrolysis rates of 2,4-D n-alkyl esters in natural waters could be predicted using a linear regression equation using log Kow as the independent variable

[log kb=(0.799 ± 0.098)* log Kow-(11.643 ±0.204)]. Although the available data indicate rapid degradation of 2,4-D esters in natural waters, microbial mediated hydrolysis rates in soils may be dependent on clay mineralogy, organic carbon content, temperature, and moisture content (Wolfe, et al, 1989 and Wolfe, 1990).

Phenoxyacetate esters of 2,4-D (iso-propyl, iso-butyl, iso-octyl) rapidly hydrolyzed ($t_{1/2}$= 30 minutes) in alkaline salt solutions (Smith, 1972**)**. Phenoxyacetate esters of 2,4-D, 2,4,5-T, 2,4-DP and 2,4-DB (iso-propyl, iso-octyl, iso-butyl) rapidly hydrolyzed in moist Canadian soils and soil slurries (Smith, 1976**)**. The rate of hydrolysis of the phenoxyacetate esters was reduced in soils with a low moisture content (Smith, 1976, Smith, 1972, Groom, 1973).

- **Photodegradation in Water (MRID 41483101)**

Radiolabeled 2,4-D BEE had a half-life of 74 days in both irradiated and dark control samples. The major degradate identified was 2,4-D acid at less than 17% of applied 2,4-D BEE. The data indicate that 2,4-D BEE does not photodegrade in slightly acid aqueous environments.

- **Photodegradation in Air (MRID 41483103**)

The non-volatile nature of 2,4-D BEE prevented an estimation of the photodegradation rate in air (where less than 1.4% of the applied 2,4-D BEE volatilized). No photodegradates were identified.

- **Anaerobic Aquatic Metabolism (MRID 42574701**)

Radiolabeled 2,4-D BEE, at 7 :g/g, degraded with a first-order half-life of 14.4 hours in a strongly acidic, rice paddy water and sediment test system. The major degradation product was 2,4-D. The degradate 2,4-D was stable during a 12 month incubation period. Unidentified residues were also detected (<4% of applied) in sediment and water samples.

- **Aquatic Field Dissipation (MRID 44525001, Accession No. 00115741)**

General: Aquatic dissipation of 2,4-D BEE was studied in ponds in NC, MN , and WA (**MRID 44525001**). Several issues limit interpretation of the aquatic field dissipation data including unreported flow rates for test ponds (if any); residues in outflow samples were not analyzed; pond water pH conditions are only representative of alkaline environments (pH~8.0), and 2,4-D BEE granules may persist in sediments.

North Carolina

Parent 2,4-D 2-butoxyethyl ester (AQUAKLEEN®, 27.6% a.i.), broadcast applied once at a

nominal rate of 200 lb a.i./A onto a man-made pond of Norfolk loam sediment in North Carolina, dissipated with registrant-calculated half-lives of 40 days (15 to 189 day data; $r^2 = 0.95$) in water and 27 days ($r^2 = 0.78$) in sediment. EFED estimated the half-life in water from the North Carolina pond using linear regression of log transformed data (mean concentrations across both depths) of 39.9 days ($r^2 = 0.99$) and 28.5 days ($r^2 = 0.86$) in the sediment. EFED also estimated half-lives in sediment from the North Carolina pond of 9.6 days ($r^2 = 0.87$) for 2,4-D BEE and 80.5 days ($r^2 = 0.84$) for the degradate 2,4-DCP.

2,4-D BEE was initially (day 0) present in the 0- to 5-cm sediment depth at 6.6 ppm, increased to a maximum of 7.7 ppm by 1 day post-treatment, decreased to 1.4 ppm by 7 days, and was last present at 0.87 ppm at 30 days. The parent compound was detected twice in the 5- to 10-cm depth, at 0.04 ppm at 0 and 3 days post-treatment (one replicate each). Parent was not present in the 10- to 15-cm depth and was detected twice in the 15- to 20-cm depth, at 0.03-0.05 ppm (one replicate each) from 0 to 1 day post-treatment.

2,4-D was initially (day 0) present in the 0- to 5-cm depth at 7.1 ppm, was a maximum of 8.3 ppm at 3 days post-treatment, decreased to 4.5 ppm by 15 days and 0.14 ppm by 59 days, and was 0.07 ppm at 189 days. In the 5- to 10-cm depth, 2,4-D was initially (day 0) present at 0.13 ppm, decreased to 0.05 ppm (two replicates) by 1 day post-treatment, increased to a maximum of 0.35 ppm by 30 days, and was 0.03 ppm (one replicate) at 189 days. In the 10- to 15-cm depth, 2,4-D was initially (day 0) present at a maximum of 0.31 ppm (two replicates) and was last present at 0.10 ppm (one replicate) at 90 days. In the 15- to 20-cm depth, 2,4-D was initially (day 0) present at a maximum of 0.36 ppm (one replicate), was 0.03-0.04 ppm (one or two replicates) from 3 to 30 days post-treatment, and was last present at 0.23 ppm at 90 days. The major degradate 2,4-DCP was present in the 0- to 5-cm depth at a maximum of 0.41 ppm at 15 days post-treatment and was 0.05 ppm at 189 days. In the 5- to 10-cm depth, 2,4-DCP was a maximum of 0.10 ppm (one replicate) at 0 day post-treatment and was 0.03 ppm (one replicate) at 189 days; 2,4-DCP was present in the 10- to 15-cm depth twice at 0.05 ppm (59 days) and 0.09 ppm (90 days; one replicate), and was present in the 15- to 20-cm depth once at 0.22 ppm (90 days; one replicate). The major degradate 4-CP was present in the 0- to 5-cm depth at a maximum of 0.18 ppm at 59 days post-treatment and was 0.06 ppm (three replicates) at 189 days. In the 5- to 10-cm depth, 4-CP was a maximum of 0.52 ppm (one replicate) at 30 days post-treatment and was 0.05 ppm (three replicates) at 189 days. 4-CP was present in the 10- to 15-cm depth at a maximum of 0.20 ppm (one replicate) at 59 days post-treatment and was last present at 0.05 ppm (one replicate) at 153 days; 4-CP was present in the 15- to 20-cm depth once at 0.07 ppm (90 days; one replicate). The major degradate 4-CPA was initially (day 0) present in the 0- to 5-cm depth at a maximum of 0.05 ppm (three replicates) and was last present at 0.03 ppm (one replicate) at 15 days. In the 5- to 10-cm depth, 4-CPA was present twice at 0.05 ppm (59 days; one replicate) and 0.04 ppm (122 days; one replicate); 4-CPA was present in the 10- to 15-cm depth twice at 0.16 ppm (59 days; one replicate) and 0.13 ppm (90 days; one replicate), and was present in the 15- to 20-cm depth once at 0.10 ppm (90 days; one replicate).

At the North Carolina site, the parent compound was present (day 0) in the surface and subsurface water once at 3.9 ppb (one replicate) and 42.2 ppb (one replicate), respectively. 2,4-D was present in the surface water at a maximum of 2750 ppb at 15 days post-treatment and decreased to 134 ppb by 189 days; 2,4-D was present in the subsurface water at a maximum of 2725 ppb at 15 days post-treatment and decreased to 135 ppb by 189 days. The major degradate 2,4-DCP was present in the surface water at 2.5-4.0 ppb from 3 to 30 days post-treatment and in the subsurface water at 3.8-9.3 ppb from 1 to 30 days post-treatment. The major degradate 4-CPA was present in the surface water at a maximum of 127 ppb at 122 days post-treatment and was 58.6 ppb at 189 days; 4-CPA was present in the subsurface water at a maximum of 122 ppb at 122 days post-treatment and was 59.5 ppb at 189 days. The major degradate 4-CP was present only in the subsurface water once at 3.1 ppb (three replicates) at 1 day post-treatment.

Minnesota

2,4-D EHE (AQUAKLEEN®, 27.6% a.i.), broadcast applied once at a nominal rate of 200 lb a.i./A onto a man-made pond of clay loam sediment in Minnesota, dissipated with registrant-calculated half-lives of 11 days ($r^2 = 0.75$) in water and 26 days ($r^2 = 0.68$) in sediment. The parent compound rapidly hydrolyzes to the acid equivalent 2,4-D following release from the granule; therefore, half-lives were based on 2,4-D data. Parent compound was initially (day 0) present in the 0- to 5-cm sediment depth at 29.5 ppm, was 5.7-12.0 ppm from 1 to 28 days post-treatment, was 24.1 ppm (two replicates) at 60 days, and was 1.6 ppm (two replicates) at 186 days. In the 5- to 10-cm depth, parent compound was initially (day 0) present at 0.15 ppm (three replicates), was a maximum of 0.45 ppm (two replicates) at 1 day, and was 0.06 ppm (one replicate) at 186 days. Parent was present in the 10- to 15-cm depth twice at 0.40 ppm (0 day) and 0.29 ppm (1 day; one replicate), and in the 15- to 20-cm depth once at 0.03 ppm (14 days; one replicate). 2,4-D was initially (day 0) present in the 0- to 5-cm depth at 26.3 ppm, increased to a maximum of 30.7 ppm by 1 day post-treatment, decreased to 18.9 ppm by 3 days, and was 0.65 ppm at 186 days. In the 5- to 10-cm depth, 2,4-D was present at a maximum of 0.81 ppm at 1 day post-treatment, decreased to 0.48 ppm by 3 days post-treatment, and was 0.09-0.41 ppm (one to four replicates) from 7 to 189 days with the exception of 111 days (detected <limit of quantitation). In the 10- to 15-cm depth, 2,4-D was initially (day 0) present at 0.84 ppm (three replicates), decreased to 0.11 ppm by 1 day, and was last present at 0.04 ppm at 111 days. In the 15- to 20-cm depth, 2,4-D was initially (day 0) present at 0.08 ppm (two replicates), was detected below the limit of quantitation (all replicates) at 1 day post-treatment, was 0.04-0.13 ppm from 3 to 28 days, and was last present at 0.04 ppm (one replicate) at 111 days. The major degradate 2,4-DCP was present in the 0- to 5-cm depth at 0.41 ppm from 0 to 1 day post-treatment, was a maximum of 1.2 ppm (three replicates) at 60 days post-treatment, and was 0.14 ppm at 186 days. In the 5- to 10-cm depth, 2,4-DCP was present sporadically at 0.04-0.16 ppm at 1, 3, 7, 60, and 122 to 186 days (one or two replicates). 2,4-DCP was present in the 10- to 15-cm and 15- to 20-cm depths once at 0.11 ppm (150 days; one replicate) and 0.04 ppm (150 days; one replicate), respectively. The major degradate 4-CP was initially (day 0) present in the 0- to 5-cm depth at 0.15 ppm (three replicates) and was 0.11-0.49 ppm (one to four replicates) from 1 to 28 days; 4-

CP was not detected below the 0- to 5-cm depth. The major degradate 4-CPA was present in the 0- to 5-cm depth at 0.21-0.23 ppm (one or two replicates) from 0 to 3 days post-treatment, was detected below the limit of quantitation from 7 to 14 days, was a maximum of 5.9 ppm at 60 days, and was 0.45 ppm (two replicates) at 186 days. In the 5- to 10-cm depth, 4-CPA was initially present at 0.06 ppm at 60 days and was 0.05-0.12 ppm (one to four replicates) from 111 to 186 days; 4-CPA was not present below the 5- to 10-cm depth.

The parent compound was present in the surface water at 6.0 ppb (day 0; two replicates) and 40.4 ppb (1 day; two replicates) only, and in the subsurface water at 2.2 ppb (day 0; one replicate) only. 2,4-D was present in the surface water at a maximum of 237 ppb at 1 day post-treatment, decreased variably to 109 ppb by 14 days, was detected below the limit of quantitation at 28 days, and was last present at 5.6 ppb at 60 days. 2,4-D was initially (day 0) present in the subsurface water at 42.2 ppb, increased to a maximum of 164 ppb by 14 days post-treatment, and was last present at 5.7 ppb at 60 days. The major degradate 4-CPA was present only in the subsurface water twice at 3.0-4.2 ppb from 14 to 28 days post-treatment.

Washington

2,4-D 2-butoxyethyl ester (AQUAKLEEN®, 27.6% a.i.), broadcast applied once at a nominal rate of 200 lb a.i./A onto a man-made pond of Quincy loamy sand sediment in Washington, dissipated with registrant-calculated half-lives of 2 days ($r^2 = 0.70$) in water and 5 days ($r^2 = 0.24$) in sediment. The parent compound rapidly hydrolyzes to the acid equivalent 2,4-D following release from the granule; therefore, half-lives were based on 2,4-D data. Parent compound was initially (day 0) present in the 0- to 5-cm sediment depth at 8.8 ppm (three replicates), was 0.03-0.07 ppm (one to three replicates) from 1 to 7 days post-treatment, and was last present at 1.5 ppm (two replicates) at 14 days; parent was not present below the 0- to 5-cm depth. 2,4-D was initially (day 0) present in the 0- to 5-cm depth at 5.9 ppm, was 0.30-1.1 ppm from 1 to 7 days post-treatment, and was last present at 1.6 ppm (three replicates) at 14 days. In the 5- to 10-cm depth, 2,4-D was initially (day 0) present at 0.53 ppm and was last present at 0.08 ppm at 3 days. In the 10- to 15-cm depth, 2,4-D was initially (day 0) present at 0.23 ppm (three replicates) and was last present at 0.04 ppm (three replicates) at 7 days. In the 15- to 20-cm depth, 2,4-D was initially (day 0) present at 0.16 ppm (three replicates) and was last present at 0.03 ppm (three replicates) at 7 days. The major degradate 2,4-DCP was present in the 0- to 5-cm and 5- to 10-cm depths once at 0.07 ppm (0 day; two replicates) and 0.06 ppm (1 day; one replicate), respectively; 2,4-DCP was not present below the 5- to 10-cm depth. The major degradate 4-CPA was present in the 0- to 5-cm depth once at 0.04 ppm (one replicate) at 0 day post-treatment; 4-CPA was not present below the 0- to 5-cm depth.

At the Washington site, the parent compound was present (day 0) in the surface and subsurface water once at 8.3 ppb (0 day; two replicates) and 4.5 ppb (three replicates), respectively. 2,4-D was initially (day 0) present in the surface water at 117 ppb, decreased to 37.8 ppb by 1 day post-treatment, and was last present at 4.0 ppb at 7 days. 2,4-D was initially (day 0) present in the

subsurface water at 102 ppb, decreased to 18.6 ppb by 1 day post-treatment, and was last present at 2.8 ppb (two replicates) at 14 days.

2,4-D acid, formulated as Weedar 64, applied at 20 and 40 lb/A, dissipated with half-lives of < 3 days in reservoirs at Banks Lake, Washington and Fort Cobb, Oklahoma **(Accession No. 00115741)**. The degradate dimethyl-nitrosamine was detected at pretreatment concentrations of 0.2 to 0.4 μg/l and post-treatment concentrations of 0.2 to 1.6 μg/l. The degradate 2,4-DCP was sporadically detected in hydrosoil samples from 7 days to 56 days post-treatment at 0.0078 to 0.0686 μg/g. The 2,4-DCP concentration in a pretreatment control sample was 0.0114 μg/g. 2,4-D acid residue accumulation was observed < 0.0421 μg/g in carp and largemouth bass. No 2,4-D residues were detected in white suckers.

2-Butoxyethanol

- **Aerobic Soil Metabolism (MRID 43799101)**

Radiolabeled 2-butoxyethanol, at a nominal application rate of 6 μg/g, degraded with a registrant-calculated half-life of 13.3 hours (r^2 = 0.93) in Hanford sandy loam soil and 35.5 hours (r^2 = 0.90) in Commerce silt loam soil adjusted to 75% of 0.33 bar moisture content and incubated in darkness at 25 ± 1 ^{o}C for up to 4 and 10 days, respectively. The parent was found to have converted primarily to the acid equivalent, 2-butoxyacetic acid, immediately following application, and the half-life calculation is based on the concentration of 2-butoxyacetic acid present in the test samples.

The parent compound was initially present in the Hanford sandy loam soil at 92.0% (5.5 ppm) of the applied radioactivity, decreased to 57.3% (3.4 ppm) by 1 hour, and was last detected at 19.3% (1.2 ppm) at 2 hours post-treatment. The major degradate 2-butoxyacetic acid was a maximum of 84.6% (5.1 ppm) of the applied radioactivity at 4 hours and decreased to 1.7% (0.10 ppm) by 96 hours post-treatment. Nonextractable [^{14}C]residues were initially (day 0) 1.9% of the applied radioactivity, increased to a maximum of 18.0% by 84 hours, and were 14.3% at 96 hours post-treatment. Evolved $^{14}CO_2$ initially accounted for 5.3% of the applied radioactivity at 12 hours, increased to 29.2% by 48 hours, and was 48.7% at 96 hours post-treatment.

The parent compound was initially present in the Commerce silt loam soil at 93.6% (5.6 ppm) of the applied radioactivity, decreased to 67.8% (4.1 ppm) by 1 hour and 45.8% (2.7 ppm) by 2 hours, and was last detected at 13.3% (0.80 ppm) at 4 hours post-treatment. The major degradate 2-butoxyacetic acid was a maximum of 91.9% (5.5 ppm) of the applied at 24 hours and decreased to 7.2% (0.43 ppm) by 6 days post-treatment. Nonextractable [^{14}C]residues were initially (day 0) 1.5% of the applied radioactivity, increased to a maximum of 18.6% by 6 days, and were 16.5% at 10 days post-treatment. Evolved $^{14}CO_2$ initially accounted for 4.1% of the applied radioactivity at 24 hours, increased to 25.0% by 96 hours, and was 59.6% at 10 days post-treatment.

- **Aerobic Aquatic Metabolism (MRID 43799106)**

Isotopically diluted [^{14}C]2-butoxyethanol, at a nominal application rate of 4 ppm, degraded with a registrant-calculated half-lives of 0.6 days ($r^2 = 0.96$) and 3.4 days ($r^2 = 0.88$) in aerobic flooded silty loam sediment that was incubated in darkness at 25 ± 1 ^{o}C for up to 10 days; however, the observed half-life occurred between 1 and 3 days post-treatment. The parent was found to have converted primarily to the acid equivalent, 2-butoxyacetic acid, by 3 days post-treatment. Residue characterization data were reported for the total sediment/water system only; reported data are reviewer-calculated means of two replicates. The parent compound was initially present at 92.9% of the applied radioactivity, decreased to 56.4% by 1 day post-treatment, and was last present at 3.5% at 3 days. The major degradate 2-butoxyacetic acid was initially (day 0) present at 2.2% of the applied radioactivity, increased to a maximum of 60.9% by 3 days, decreased to 52.7% by 7 days, and was 1.3% at 10 days post-treatment. EFED calculated a half-life of 1.3 days for 2-butoxyacetic acid, although an accurate half-life was not possible since the degradate was being degraded and formed at the same time.

Nonextractable [^{14}C]residues increased to a maximum of 9.6% of the applied radioactivity by 10 days post-treatment. Evolved $^{14}CO_2$ accounted for ≤3.8% of the applied radioactivity from 0 to 3 days, increased to 25.9% by 7 days, and was 66.9% at 10 days post-treatment.

- **Anaerobic Aquatic Metabolism (MRID 43799103)**

Isotopically diluted [4-^{14}C]2-butoxyethanol, at a nominal application rate of 4 Φg/mL, degraded with a registrant-calculated half-life of 1.4 days (0-14 day data; $r^2 = 0.99$) in anaerobic flooded silt loam sediment that was incubated in darkness at 25 ± 1 ^{o}C for up to 193 days (EFED estimated the half-life of 1.3 days with $r^2 = 0.99$). The parent was found to have converted primarily to the acid equivalent, 2-butoxyacetic acid, by 7 days post-treatment; EFED calculated an approximate half-life for 2-butoxyacetic acid as 74 days.

The parent compound was initially present at 90.3% of the applied radioactivity, decreased to 72.0% by 1 day and 39.2% by 2 days, and was last detected at 0.1% of the applied at 20 days post-treatment. The major degradate, 2-butoxyacetic acid, was initially (day 0) present at 1.2% of the applied radioactivity, increased to a maximum of 71.0% of the applied by 7 days post-treatment, decreased to 51.8% by 9 days and 45.5% by 29 days, and was 10.5% of the applied at 193 days post-treatment. Unidentified radioactivity was ≤ 2.0% of the applied radioactivity throughout the incubation period. Nonextractable [^{14}C]residues were initially (day 0) 0.3% of the applied radioactivity, increased to a maximum of 7.0% of the applied by 29 days post-treatment, and were 4.5% of the applied at 193 days post-treatment. Evolved $^{14}CO_2$ initially accounted for 0.1% of the applied radioactivity at 0.5 days post-treatment, increased with variability to 20.2% of the applied by 29 days, and was 57.3% of the applied at 193 days post-

treatment. The distribution ratio of [^{14}C]residues between the sediment and water phases was not reported, but the majority of [^{14}C]residues were observed in the water phase from 0 to 29 days post-treatment and in the volatile fraction at 193 days post-treatment (the next sampling interval); $^{14}CO_2$ generally increased over time and the distribution of [^{14}C]residues between sediment, water, and volatile fractions was 1:1.3:7 (sediment:water:volatile; reviewer-calculated) at 193 days. Material balances (based on LSC analyses of individual replicates) generally decreased throughout the incubation period. Material balances were 89.5-96.4% of the applied radioactivity from 0 to 7 days post-treatment and were 70.7-89.7% of the applied from 9 to 193 days post-treatment.

2,4-D IPE

Physical and Chemical Properties

Common name:	2,4_D IPE
Chemical name:	2,4-D isopropyl ester
Molecular formula:	$C_{11}H_{12}Cl_2O_3$
CAS Number:	94-11-1
Molecular weight:	263.12
Vapor pressure (20 ^oC):	5.3 x 10^{-6} mbar
Henry's Law:	6.3 x 10^{-5} atm-m^3/mole
Solubility (25 ^oC):	0.023 g/100mL
Log K_{ow}:	3.81

- **Abiotic Hydrolysis (MRID 41349601, 43441201)**

The dissipation of 2,4-D IPE appears to be dependent on de-esterification through alkaline-catalyzed abiotic hydrolysis and microbial-mediated or soil surface catalyzed de-esterification processes. The abiotic hydrolysis half-life of 2,4-D IPE was >30 days at pH 5, 89.2 days at pH 7, and 22.4 hours at pH 9.

- **Microbial-Mediated and Surface-Catalyzed Hydrolysis** (Grover, 1973. Weed Research 13:51-58; Smith, 1972. Weed Science 12:364-372; Smith , 1976. Weed Research 16:19-22; Wilson and Cheng. 1978 J. Environ. Qual. 7:281-286.)

Isopropyl 2,4-dichlorophenoxyacetate was rapidly de-esterified ($t_{1/2}$ < 13 hours) in an aerobic sandy loam soil and aerobic sediment-water test system. Alkaline catalyzed abiotic hydrolysis and de-esterification in soil of phenoxyacetate esters has been reported in open scientific literature. De-esterification of phenoxyacetate esters was not observed in soils with a low moisture content. Phenoxyacetate esters were also stable from de-esterification in formulated end-use products. The de-esterification of 2,4-D IPE will form 2,4-D and isopropanol (IPE).

Open literature data indicate that carboxylic acid esters are prone to both surface-catalyzed hydrolysis and microbial mediated hydrolysis (Schwarzenbach, et al.1993). Sediment and soils may promote hydrolysis through reactions with surface hydroxyl groups from transition metal oxide and hydroxide mineral coatings on sediments or soils. Another theory is that the diffuse double layer at the interface of sediment or soil surfaces has higher hydroxide concentrations causing alkaline-catalyzed hydrolysis.

Microbial-mediated hydrolysis of carboxylic acid esters is an enzymatic controlled process

(Schwarzenbach, et al.1993). Paris, et al (1981) tested the rate of microbial degradation of 2,4-D BEE in natural waters from 31 sites with varying temperature and pH conditions (5.4 to 8.2). The authors found that in waters typical of natural conditions and at concentrations normally encountered in rivers and lakes, the rate constants from all sites were within a factor of eight and estimated a mean half life of 2.6 hours. Degradation kinetics could be described using second order kinetics. Paris, et al (1983) found hydrolysis rates of 2,4-D n-alkyl esters in natural waters could be predicted using a linear regression equation using log Kow as the independent variable [log kb=(0.799 ± 0.098)* log Kow-(11.643 ± 0.204)]. Although the available data indicate rapid degradation of 2,4-D esters in natural waters, microbial mediated hydrolysis rates in soils may be dependent on clay mineralogy, organic carbon content, temperature, and moisture content (Wolfe, et al, 1989 and Wolfe, 1990).

Phenoxyacetate esters of 2,4-D (iso-propyl, iso-butyl, iso-octyl) rapidly hydrolyzed ($t_{1/2}$= 30 minutes) in alkaline salt solutions (Smith, 1972**)**. Phenoxyacetate esters of 2,4-D, 2,4,5-T, 2,4-DP and 2,4-DB (iso-propyl, iso-octyl, iso-butyl) rapidly hydrolyzed in moist Canadian soils and soil slurries (Smith, 1976**)**. The rate of hydrolysis of the phenoxyacetate esters was reduced in soils with a low moisture content (Smith, 1976, Smith, 1972, Groom, 1973).

- **Aerobic Soil and Aerobic Aquatic Metabolism (MRID 43149601)**

Radiolabeled 2,4-D IPE degraded with first-order degradation half-lives 0.9 hours and 13 hours in a sandy loam soil and sediment-water environment, respectively. The major degradate was identified as 2,4-D (60 to 96% of applied ^{14}C-2,4-D IPE).

Isopropanol

- **Anaerobic Aquatic Metabolism** (MRID 43606301)

Radiolabeled IPA, at 10 ppm, had an anaerobic aquatic half-life of 14.55 days in a silty clay loam sediment. The major degradate was identified as acetone (34.62% of total radioactivity at 30 days post-treatment). Volatile radiolabeled residues were identified as isopropanol and acetone (cumulative concentration of 49.55% of applied at 120 days post-treatment) and ^{14}C-CO_2 (15.86% of applied at 120 days post-treatment).