UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C., 20460

OFFICE OF
CHEMICAL SAFETY AND
POLLUTION PREVENTION

MEMORANDUM

DATE: March 10, 2014

SUBJECT: Registration Review – Preliminary Problem Formulation for the Ecological Risk Assessment and Drinking Water Exposure Assessment to be Conducted for Imazapyr and Imazapyr Isopropylamine (PC Code 128829 (isopropylamine salt) and 128821 (imazapyr acid); DP Barcode 417327)

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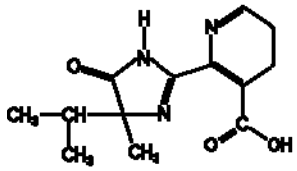
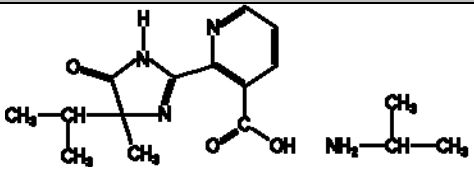
The Environmental Fate and Effects Division (EFED) has completed the preliminary problem formulation for the ecological risk to be conducted as part of the Registration Review of imazapyr and imazapyr isopropylamine. At this time, EFED does not expect to conduct a new drinking water assessment given that the Health Effects Division (HED) does not anticipate conducting a dietary assessment. This document is intended to provide an overview of what is currently known regarding the environmental fate and ecological effects associated with imazapyr and imazapyr isopropylamine and their degradation products, and outlines uncertainties regarding attributes of the parent compounds and their transformation products. It describes the preliminary ecological risk hypothesis and the processes that will be used during the completion of the ecological risk assessment in support of Registration Review.

1. INTRODUCTION

The active ingredient imazapyr is a systemic imidazolinone herbicide that is used for control of most annual and perennial broadleaf weeds and grasses, woody species, and riparian and emergent aquatic weeds species. It is formulated both as an acid (imazapyr) and as an isopropylamine salt (imazapyr IPA). The mode of action of imazapyr is to inhibit acetohydroxyacid synthase (ALS) which interferes with plant cell growth and DNA synthesis.

The chemical structure of imazapyr along with the chemical identifiers is provided in **Table 1**.

Table 1. Imazapyr Chemical Identifiers

Chemical Name	Imazapyr	Imazapyr IPA
Chemical Structure		
Chemical Abstracts Service (CAS) Registry Number	81510-03-0	81334-34-1

Imazapyr is currently registered for use in terrestrial (railroads and industrial right-of-ways, fencerows, wildlife habitats and forests) and aquatic (ponds, lakes, reservoirs, marshes, bayous, canals, streams, rivers, and water drainage systems) non-crop sites and for corn fields. Aqueous imazapyr formulations may be mixed with surfactants or oils for application, as well as mixed with other herbicides and fertilizers. Imazapyr is also available in a water dispersible granular formulation and an emulsifiable concentrate. Typical terrestrial application methods consist of ground and aerial spray, with granular broadcast applications for forestry uses, while surface waters including bogs, marshes, potholes, wetlands, and intermittently flooded areas are treated directly with aqueous formulations. For more information on use and usage, please see the BEAD Chemical Profile document.

2. PREVIOUS RISK ASSESSMENTS

An ecological risk assessment in support of the re-registration eligibility decision (RED) for imazapyr (both acid and salt formulations; PC Codes: 128821 and 128829), hereafter referred to as imazapyr, was finalized by EFED on September 30, 2005 (DP Barcode: D313607) (**Table 2**). The screening level risk assessment indicated risk to non-target terrestrial plants (monocots and dicots) and aquatic vascular plants from imazapyr use, based on the highest application rate from a variety of use patterns. Seedling emergence and vegetative vigor for both monocots and dicots would be impacted by exposure to both the imazapyr acid and the isopropylamine salt. The assessment indicated minimal risk of acute effects to fish and aquatic invertebrates and minimal risks to aquatic non-vascular plants at maximum application rates. In addition, there were no chronic risks to fish and invertebrates, although there was an uncertainty for estuarine/marine

fish and invertebrates, since no toxicity data were available to observe the prolonged effects of imazapyr to these taxa. Likewise, acute and chronic risks to mammals and birds consuming food types containing imazapyr residues are not expected from the labeled uses of the herbicide. EFED currently does not quantify risks to terrestrial non-target insects; however, available data on honey bees indicate that the risk to terrestrial non-target insects was likely to be low. The assessment indicated the potential for indirect risk to all taxa from direct effects on plants (*i.e.*, effects on habitat and/or primary productivity).

An assessment of risk to the listed California Red-Legged Frog (CRLF, *Rana aurora draytonii*) was completed on July 20, 2007. That assessment indicated no expected direct effects on either the aquatic or terrestrial phase CRLF. There were also no indirect effects expected for the CRLF through direct effects to either its terrestrial or aquatic food sources. The assessment determined that the CRLF may be adversely affected through direct effects on habitat and/or primary productivity (*i.e.*, ecosystem structure and function for both the aquatic plant community and riparian vegetation). Critical habitat may also be adversely modified based on direct effects to aquatic vascular plants and terrestrial plants. The risks exceeded the level of concern (LOC) for non-listed non-target terrestrial plants (monocots and dicots) for all imazapyr uses. The risks to non-listed non-target aquatic vascular plants exceeded the LOC for aquatic, rangeland and forestry uses (aerial application) as well as rights-of-way (assuming 50% pervious surfaces). No effects were expected for aquatic non-vascular plants.

A Special Local Needs 24(c) assessment was conducted in May 24, 2010 (DP Barcode D374578). The request was to allow broadcast application of imazapyr (Arsenal PowerLine EPA Reg. No. 241-431) on grass pasture for control of cogongrass (*Imperata cylindrica*) in areas that may be grazed or cut for hay. The assessment indicated no expected risks for effects to aquatic and terrestrial animals from the proposed broadcast spray application of 0.75 lb a.e./A of imazapyr on pastures. Non-target terrestrial plants may be adversely affected from the proposed use. Off-site movement of imazapyr onto non-target terrestrial plants is associated with both runoff onto adjoining fields and spray drift deposition.

Finally, an assessment was conducted in August 2, 2010 (DP Barcode D379032). BASF petitioned to add aquatic use sites to the Arsenal Powerline™ herbicide (EPA Reg. No. 241-431) label to allow direct application of imazapyr to potable surface water, public waters, private waters, livestock watering ponds, recreational water areas at a maximum rate of 1.5 lb a.e/A per year.

Table 2. Summary of Previous Risk Assessments Conducted by EFED on Imazapyr

Use	Reference (DP Barcode)	Max. Application Rate	Taxa for which risk was identified at the Agency's concern levels
Various	RED, 2005 (D313607)	1.5 lbs a.e./A	Terrestrial plants, aquatic vascular plants; fish, aquatic invertebrates, aquatic non-vascular plants
Various	CRLF, 2007	1.5 lbs a.e./A	CRLF assessment: Terrestrial plants and aquatic vascular plants

Table 2. Summary of Previous Risk Assessments Conducted by EFED on Imazapyr			
Use	**Reference (DP Barcode)**	**Max. Application Rate**	**Taxa for which risk was identified at the Agency's concern levels**
Grass pasture	SLN 24(c), 2010 (D374578)	0.75 lb a.e./A	Terrestrial plants and aquatic vascular plants
Direct aquatic	D379032	1.5 lbs a.e./A	Terrestrial plants, aquatic vascular plants; fish, aquatic invertebrates, aquatic non-vascular plants

Previous Drinking Water Assessments

The drinking water assessment (DWA) for imazapyr was conducted on terrestrial (spot treatment on pasture) and aquatic uses (D275562, 2003). The DWA was based on an application rate of 1.5 lb a.e./A, which represents the maximum application rate for aquatic use sites (**Table 3**).

Table 3. Estimated Drinking Water Concentrations (µg/L) for Imazapyr

Use Pattern	Models	Peak	Annual Average	30-year Annual Average
Aquatic/Terrestrial@ 1.5 lb a.e./A (D275562, 2003)	Tier I FIRST	137	81	NA
	SCI-GROW	35.9		NA

NA=not applicable for a Tier 1 drinking waters assessment

Clean Water Act Programs

Imazapyr is not identified as a cause of impairment for any water bodies listed as impaired under section 303(d) of the Clean Water Act (http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/index.cfm). No Total Maximum Daily Load (TMDL) criteria have been developed for imazapyr. Aquatic life benchmarks have published for imazapyr (http://www.epa.gov/oppefed1/ecorisk_ders/aquatic_life_benchmark.htm) (**Table 4**). The aquatic life benchmarks represent ecotoxicity endpoints derived from risk assessments to support pesticide registrations.

Table 4: OPP Aquatic Life Benchmarks for Imazapyr

Compound	Fish		Invertebrate		Non-Vascular Plants	Vascular Plants
	Acute	Chronic	Acute	Chronic		
	µg/L					
Imazapyr	>50000	43100	50000	97100	12000	24

3. ENVIRONMENTAL FATE AND TRANSPORT

The environmental fate database is complete for assessing the environmental fate and transport of imazapyr and imazapyr isopropylamine (Appendix A). Imazapyr is an anionic, organic acid (pK_a of about 3.8) that is non-volatile, degrades through photolysis in clear shallow waters, and is both persistent and mobile in soil. A summary of selected physical and chemical properties for imazapyr and imazapyr isopropylamine salt are presented in **Table 5**. Imazapyr is mainly present in anionic form at typical environmental pHs, and the behavior of the acid and salt forms are expected to be similar, therefore, the environmental fate of the imazapyr is evaluated in terms of acid equivalents. Most environmental fate data available for imazapyr are based on dissociation of the isopropylamine salt in water. Imazapyr was essentially stable to aerobic and anaerobic soil metabolism, and no major transformation products were identified during the course of laboratory studies (**Table 6**). Field study observations are consistent with imazapyr's intrinsic ability to persist in soils and move via runoff in surface water and leach to groundwater. Imazapyr did not bioconcentrate in submitted laboratory studies. The relatively high solubility in water and low n-octanol to water partitioning ratio of imazapyr is also consistent with little likelihood of bioconcentration.

Table 5. Physical and Chemical of Imazapyr and the Isopropylamine Salt of Imazapyr

Physical and Chemical Properties		
Chemical name	**Imazapyr**	**Imazapyr Isopropylamine Salt**
	2-[4,5-Dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-3-pyridinecarboxylic acid	2-Propanamine, 2-(4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-3-pyridinecarboxylate
Empirical Formula	$C_{13}H_{15}N_3O_3$	$C_{13}H_{15}N_3O_3 \cdot C_3H_9N$
Molecular Weight	293.16 g/mol	322.19 g/mol
Aqueous Solubility at 25 °C	11.1 g/L	MRID 00145872
pK_a	3.8	MRID 00145872
Vapor Pressure at 60 °C	$<10^{-7}$ mm Hg	MRID 00145872
Henry's Law Constant at 25 °C	$<7 \times 10^{-17}$ atm x m3/mol	Calculated
Log P_{ow} at pH 7 and 20 °C	0.22	MRID 00145872

Table 6. Environmental Fate Data for Imazapyr and Imazapyr IPA

Guideline #	Data Requirement (material)	MRID #	Values
835.2120	Hydrolysis (Imazapyr)	00132359	$t_{½}$=Stable
835.2240	Photodegradation in Water (Imazapyr)	00131617	$t_{½}$-=2.3-3 days
835.2210	Photodegradation on Soil (Imazapyr)	40003713	$t_{½}$=149 days
835.4100	Aerobic Soil Metabolism (Imazapyr) (Imazapyr)	41023201 45119701	$t_{½}$=5.9 years $t_{½}$=296 days
835.4200	Anaerobic Soil Metabolism (Imazapyr)	00131619	$t_{½}$=Stable
835.4400	Anaerobic Aquatic Metabolism (Imazapyr)	40003712	$t_{½}$=Stable
835.4300	Aerobic Aquatic Metabolism (Imazapyr) (Photoproducts: CL 9140, CL 119060)	41002301 41891501 45119702	$t_{½}$Stable-Parent $t_{½}$=5.7 days-CL9140 (Upper 90% CB of Mean) $t_{½}$=8 days-CL119060(Upper 90% CB of Mean)
835.1230 835.1240	Leaching-Adsorption/Desorption (Imazapyr + photoproducts)	45119705	Sand-K_f=0.091 (1/N=0.733) Kfoc=19.4 (Parent) Silt loam-K_f=0.091 (1/N=0.887) Kfoc=19.4 (Parent) Sand-K_f=0.69 (1/N=0.811) Kfoc=149 (CL9140) Silt loam-K_f=31.6 (1/N=0.955) Kfoc=4940 (CL9140) Sand-K_f=0.551 (1/N=0.939) Kfoc=117 (CL119060) Silt loam-K_f=5.77 (1/N=0.962) Kfoc=902 (CL119060)
835.6100	Terrestrial Field Dissipation (Imazapyr) (Arsenal 2AS) (Arsenal 2AS)	45119706 42192101 42192102	$t_{½}$ =143 days – OR field study (soil) $t_{½}$= 64 days – NC field study (soil) $t_{½}$= 94 days-IA field study (soil) $t_{½}$=126 days-NE field study (soil)
835.6300	Aquatic Field Dissipation (Imazapyr) (Arsenal 2AS)	45119707 41891501	$t_{½}$ = 3 days- FL field study (water and sediment) $t_{½}$= 4 days- LA field study (water and sediment)
835,6400	Forestry Dissipation (Arsenal)	40003714	$t_{½}$ =24 days- AL field study (soil) $t_{½}$ =26 days- AL field study (soil)
850.1730	Accumulation in Fish	—	No Data
Non-guideline	Accumulation- aquatic non-target (Imazapyr) (Imazapyr)	45119707 45119709	Fish/Crayfish- No detectable bioaccumulation Shrimp/Oysters- No detectable bioaccumulation BCF<1

Transformation Products

Although imazapyr is stable to hydrolysis and microbial metabolism, photodegradation in water is an important route of dissipation. Major photodegradation products of imazapyr (>10% of applied radiation) are CL11960 and CL9140. The degradation product CL252974 was a minor transformation product (<6.9% of applied radiation) in hydrolysis and aerobic soil metabolism studies. The transformation products CL11960 and CL9140 are prone to degrade through oxidative mineralization to CO_2. These transformation products are listed in **APPENDIX A** with the maximum amounts of each observed in the various environmental fate studies.

4. RECEPTORS

The toxicity endpoints for imazapyr acid for use in the risk assessment are shown in **Table 7.** Available aquatic ecotoxicity study endpoints on imazapyr salt and acid are summarized in **Table 8** and **Table 9.** The available terrestrial ecotoxicity study endpoints on the isopropylamine salt of imazapyr, and its acid form, are in **Table 10** and **Table 11**. A summary of the ecotoxicity data is shown in **APPENDIX C**. The endpoints from the toxicity tests with the isopropylamine salt of imazapyr are expressed in acid equivalents (a.e.).

Table 7. Toxicity Endpoints Used in Assessment of Risk in Acid Equivalents

Organisms	Toxicity Endpoint	MRID
Aquatic Organisms		
Acute Freshwater fish LC_{50} (mg ae/L)	>100	00131629 thru -631
Acute Freshwater invertebrate EC_{50} (mg ae/L)	>100	00131632
Acute Marine/estuarine fish LC_{50} (mg ae/L)	>184	41315801
Acute Marine/estuarine invertebrate (mollusk) EC_{50} (mg ae/L)	>132	45119710
Acute Marine/estuarine invertebrate (pink shrimp) LC_{50} (mg ae/L)	>189	41315803
Chronic Freshwater fish NOAEC (mg ae/L)	43.1	41315804
Chronic Freshwater invertebrate NOAEC (mg ae/L)	97.1	41315805
Aquatic nonvascular plants EC_{50}/NOAEC (mg ae/L)	11.5/7.16	43889102
Aquatic vascular plants EC_{50}/NOAEC (mg ae/L)	0.018/0.011	43889102
Terrestrial Organisms		
Acute Avian (oral dose-based) LD_{50} (mg ae/kg-bw)	>2150	00131633 00131634
Acute Avian (dietary) LC_{50} (mg ae/kg-diet)	>5000	00131635 00131636
Acute Mammal (oral dose-based) LC_{50} (mg ae/kg-bw)	>5000	00132030
Chronic Avian (dietary) NOAEC (mg ae/kg-diet)	1670	45119714
Chronic Mammal (dietary) NOAEC (mg ae/kg-diet)	10000	41039505
Chronic Mammal (dose-based) NOAEL (mg ae/kg-bw/day)	738	41039505
Acute Terrestrial Invertebrate (contact) LD_{50} (µg a.e./bee)	>100	00131637
Dicot Seedling Emergence (EC_{25})/($NOAEC/EC_{05}$) (lbs ae/A)	0.0024/0.00017	40811801
Dicot Vegetative Vigor (EC_{25})/($NOAEC/EC_{05}$) (lbs ae/A)	0.0009/0.000064	
Monocot Seedling Emergence (EC_{25})/($NOAEC/EC_{05}$) (lbs ae/A)	0.0046/0.00099	
Monocot Vegetative Vigor (EC_{25})/($NOAEC/EC_{05}$) (lbs ae/A)	0.012/0.0039	

Receptors

Tables 8 through **Table 11** provide a summary of the aquatic and terrestrial taxonomic groups, respectively, and most sensitive surrogate species tested to characterize the potential acute and chronic ecological effects of imazapyr.

Effects to Aquatic Animals

Table 8 provides a summary of endpoints from aquatic toxicity studies for imazapyr acid. The available toxicity data for the salt are no more toxic than the acid and are summarized in **Appendix C**.

Table 8. Summary of Endpoints from Aquatic Toxicity Studies for Imazapyr Acid

Taxonomic Group	Study Type	Species	% ae	Endpoint	Toxicity Category / Endpoint Affected	MRID No. Author/Year	Study Classification
Freshwater Fish	Acute	Bluegill sunfish *(Lepomis macrochirus)*	93	96-hour LC_{50}: >100 mg/L	Practically non-toxic	00131630 ABC Laboratories, 1983	Acceptable
		Rainbow trout *(Oncorhynchus mykiss)*	93	96-hour LC_{50}: >100 mg/L	Practically non-toxic	00131629 ABC Laboratories, 1983	Acceptable
		Channel catfish *(Ictalurus punctatus*)	93	96-hour LC_{50}: >100 mg/L	Practically non-toxic	00131631 ABC Laboratories, 1983	Acceptable
	Chronic: Early-life stage study	Rainbow Trout *(Oncorhyncus mykiss)*	99.5	NOAEC/LOAEC: 43.1/92.4 mg ae/L[1]	Larval survival	41315804 Ward, 1988	Supplemental
		Fathead Minnow (*Pimephales promelas*)	99.6	NOAEC/LOAEC: 118/>118 mg ae/L	No treatment-related effects	45119711 Drottar *et al.*, 1998	Acceptable
	Chronic: Full life cycle	Fathead Minnow *(Pimephales promelas)*	100	NOAEC/LOAEC: 120/>120 mg ae/L	No treatment-related effects	45119712 Drottar *et al.*, 1999	Supplemental
Freshwater invertebrates	Acute	Waterflea (*Daphnia magna*)	93	48-hour EC_{50}: >100 mg/L	Practically non-toxic	00131632 ABC Laboratories, 1983	Acceptable
	Chronic: Life cycle	Waterflea *(Daphnia magna)*	99.5	21-day NOAEC/LOAEC: 97.1/>97.1 mg/L	No effects on growth or reproduction	41315805 Manning, 1988	Acceptable

Table 8. Summary of Endpoints from Aquatic Toxicity Studies for Imazapyr Acid							
Taxonomic Group	**Study Type**	**Species**	**% ae**	**Endpoint**	**Toxicity Category / Endpoint Affected**	**MRID No. Author/Year**	**Study Classification**
Estuarine/ Marine Fish	Acute	Silverside minnow *(Menidia menidia)*	99.5	96-hour LC_{50}: >184 mg ae/L	Practically non-toxic	41315801 Manning , 1988	Acceptable
	Chronic*	Data not submitted	N/A	N/A	N/A	N/A	N/A
Estuarine/ Marine Invertebrates	Acute	Eastern oyster (*Crassostrea virginica*)	99.6	96-hour EC_{50} >132 mg ae/L	Practically non- toxic	45119710 Drottar *et al*., 1997	Acceptable
		Eastern oyster (*Crassostrea virginica*)	99.5	96-hour EC_{50}: >173 mg ae/L	Practically non- toxic	41315802 Ward, 1998	Supplemental
		Pink shrimp *(Penaeus duorarum)*	99.5	LC_{50} >189 mg ae/L	Practically non-toxic	41315803 Manning, 1988	Acceptable
	Chronic*	Data not submitted	N/A	N/A	N/A	N/A	N/A

* The EC_{50}/NOAEC values from the toxicity tests with the isopropylamine salt of imazapyr are expressed in acid equivalents (a.e.). The toxicity values with the acid are not expressed in terms of acid equivalents.

[1]Equation for calculating acid equivalents (a.e.): (molecular weight of acid / molecular weight of salt) x endpoint derived from study with isopropylamine salt as test compound.

Therefore, given the endpoint from a study conducted with the salt, to obtain the acid equivalent of the concentration, multiply the endpoint in terms of a.i. of salt by 0.9098 (i.e., 293.16 g/mol divided by 322.19 g/mol) to obtain the concentration in acid equivalents.

**Estuarine and Marine Fish and Invertebrates, Chronic*

Chronic studies on estuarine/marine fish and invertebrates were not submitted. Although acute studies are available for freshwater and marine/estuarine fish and invertebrates and chronic studies are available for freshwater fish and invertebrates, acute to chronic ratios could not be estimated because all of the acute LC_{50}/EC_{50} values are greater than values. As a result, an assumption will be made that the marine/estuarine fish and invertebrates will have a similar sensitivity to imazapyr as freshwater fish and invertebrates, especially since the acute LC_{50} values of these taxa were all greater than 100 mg a.e./L. There is uncertainty associated with this assumption because quantifiable taxonomic sensitivity factors between the two broad categories of fish and invertebrates do not exist. There is additional uncertainty associated with the estimated chronic NOAEC for estuarine/marine fish and for estuarine/marine invertebrates because the acute toxicity data do not allow for a definitive determination of the relative sensitivity of freshwater and estuarine/marine fish and invertebrates.

Effects to Aquatic Plants

Unlike the effect of the isopropylamine salt to aquatic animals with respect to the imazapyr acid (*i.e.* the salt is no more toxic than the acid), the toxicity of the isopropylamine salt is more toxic to aquatic vascular plants and non-vascular plants (based on duckweed and green algae) than imazapyr acid (**Table 9**).

Table 9. Non-target Aquatic Plant Toxicity for Imazapyr Acid and Isopropylamine Salt of Imazapyr

Species [Tier II]	% ae	EC_{50}/NOAEC	Endpoints Affected	MRID No. Author, Year	Study Classification
Isopropylamine Salt of Imazapyr*					
Duckweed (*Lemna gibba*)	23.3	0.018/0.011 (mg ae/L)	Frond production	43889102 Hughes *et al*., 1995	Acceptable
Green Algae (*Selenastrum capricornutum)*	23.3	11.5/7.16 (mg ae/L)	Slight change in cell shape	43889102 Hughes *et al*., 1995	Acceptable
Imazapyr Acid					
Duckweed (*Lemna gibba*)	99.5	0.024/0.01 (mg a.i./L)	Population growth Frond production	40811802 Hughes, 1987	Acceptable
Green Algae (*Selenastrum capricornutum*)	99.5	71/50.9 (mg a.i./L)	Cell density	40811802 Hughes, 1987	Acceptable
Blue-green Algae (*Anabaena flos-aquae*)	99.5	12.2/9.6 (mg a.i./L)	Cell density	40811802 Hughes, 1987	Acceptable
Diatom (*Navicula pelliculosa*)	99.5	>41/41 (mg a.i./L)	Cell density	40811802 Hughes, 1987	Acceptable
Diatom (*Skeletonema costatum*)	99.5	92/15.9 (mg a.i./L)	Cell density	40811802 Hughes, 1987	Acceptable

*The EC_{50}/NOAEC values from the toxicity tests with the isopropylamine salt of imazapyr are expressed in acid equivalents (a.e.)

Terrestrial Effects Characterization

Terrestrial Animals

Table 10 provides a summary of endpoints from terrestrial toxicity studies for imazapyr. The available toxicity data (subacute dietary avian and rat acute studies) for the salt are no more toxic than the acid and are summarized in **Appendix C**.

Table 10. Summary of Endpoints from Terrestrial Animal Toxicity Studies for Imazapyr Acid							
Taxonomic Group	**Study Type**	**Species**	**% ae**	**Endpoint**	**Toxicity Category / Endpoint Affected**	**MRID No. Author/Year**	**Study Classification**
Birds	Acute Oral	Northern bobwhite quail *(Colinus virginianus)*	93	LD_{50}: >2,150 mg ae/kg-bw	Practically non-toxic	00131633 Bio-Life Assoc., 1983	Acceptable
		Mallard duck *(Anas platyrhynchos)*	93	LD_{50}: >2,150 mg ae/kg-bw	Practically non-toxic	00131634 Bio-Life Assoc., 1983	Acceptable
	Sub-acute Dietary	Northern bobwhite quail *(Colinus virginianus)*	93	8-day LC_{50}: >5,000 mg ae/kg-diet	Practically non-toxic	00131635 Bio-Life Assoc., 1983	Acceptable
		Mallard duck *(Anas platyrhynchos)*	93	8-day LC_{50}: >5,000 mg ae/kg-diet	Practically non-toxic	00131636 Bio-Life Assoc., 1983	Acceptable
	Chronic: Reproduction	Northern bobwhite quail *(Colinus virginianus)*	100	NOAEC/LOAEC: 1,670/>1,670 mg ae/kg-diet	No treatment-related toxicity	45119714 Ahmed *et al.*, 1999	Acceptable
		Northern bobwhite quail *(Colinus virginianus)*	Tech	NOAEC/LOAEC: 2000/>2000 mg ae/kg-diet	No treatment-related toxicity	43831401 1987	Acceptable
		Mallard duck *(Anas platyrhynchos)*	Tech	NOAEC/LOAEC: 1890/>1890 mg ae/kg-diet (2000 nominal)	No treatment-related toxicity	43831402 1987	Acceptable
Mammals	Acute	Rat (Sprague-Dawley)	93	LD_{50} >5,000 mg ae/kg bw (males/females)	Mortality	00132030 American Cyanamid Co., 1983	Acceptable
	Chronic: Developmental[2]	Rat (Sprague Dawley)	93	NOAEL/LOAEL = 300/1000 mg/kg bw/day	Maternal tox[1]	00131611 Salamon & Mayhew, 1983	Acceptable
				NOAEL = 1000 mg/kg bw/day	Developmental		
		Rabbit (New Zealand White)	93	NOAEL = 400 mg/kg bw/day	No effects	00131613 Mayhew & Salamon, 1983	Acceptable

Table 10. Summary of Endpoints from Terrestrial Animal Toxicity Studies for Imazapyr Acid							
Taxonomic Group	**Study Type**	**Species**	**% ae**	**Endpoint**	**Toxicity Category / Endpoint Affected**	**MRID No. Author/Year**	**Study Classification**
	Chronic: Reproduction	Rat (Sprague Dawley)	99.5	NOAEL = 738 mg/kg bw/day - Males NOAEL = 933.3 mg/kg bw/day – Females 10000 ppm for both males and females.	No effects	41039505 Robinson, 1987	Acceptable
Terrestrial invertebrates	Acute contact	Honey Bee *(Apis mellifera)*	Tech	LD_{50}: >100 µg ae/bee	Practically non-toxic	00131637 Atkins, 1983	Acceptable

[1] Maternal toxicity - Gravid dams exhibited salivation during gestation days 8 - 15 (likely related to gavage route of administration).
[2] Developmental toxicity - No treatment-related effects in developmental parameters; no treatment-related malformations

Terrestrial Plants

Results of Tier II toxicity studies with monocots and dicots indicate that seedling emergence and vegetative vigor are severely impacted by exposure to imazapyr acid and to the isopropylamine salt of imazapyr (**Table 11**).

Table 11. Summary of Endpoints from Terrestrial Plant Toxicity Studies for Imazapyr Acid and Isopropylamine Salt								
Taxonomic Group	**Study Type**	**Species**	**Compound**	**EC_{25} lbs ae/A**	**NOAEC /[EC_{05}]** ** **lbs ae/A**	**Endpoint Affected**	**MRID No. Author/Year**	**Study Classification**
Monocot	Seedling Emergence	Oat	Acid	0.054	0.0156	Height	40811801 Banks, 1988	Supplemental
		Onion		0.034	[0.01]	Weight		
		Wheat		**0.0046**	**[0.00099]**	Weight		
Dicots		Sugar beet		**0.0024**	**[0.00017]**	Weight		
		Tomato		0.008	0.0003	Weight		
Monocots	Vegetative Vigor	Corn		>0.0156	0.0078	Weight		
		Oat		0.013	0.0039	Height		
		Wheat		**0.012**	**0.0039**	Weight		
Dicots		Sugar beet		0.00097	[0.00039]	Weight		
		Sunflower		0.0054	0.0039	Weight		
		Cucumber		**0.0009**	**[0.000064]**	Height		

Table 11. Summary of Endpoints from Terrestrial Plant Toxicity Studies for Imazapyr Acid and Isopropylamine Salt

Taxonomic Group	Study Type	Species	Compound	EC_{25} lbs ae/A	NOAEC /[EC_{05}]** lbs ae/A	Endpoint Affected	MRID No. Author/Year	Study Classification
		Tomato		>0.0156	0.00097	Weight		
Monocots		Onion		0.012	[0.005]	Dry weight	43889101 Feutz & Canez, 1995	Acceptable
Dicots		Soybean	Salt*	0.034	0.008	Shoot length		
		Sugar beet		0.002	0.001	Dry weight		

*The EC_{50}/NOAEC values from the toxicity tests with the isopropylamine salt of imazapyr are expressed in acid equivalents (a.e.).
**If the NOAEC value is above the EC_{25}, equal to the EC_{25}, or below the lowest concentration, an EC_{05} value is used instead.
Bold values are used in risk assessment.

Ecological Incidents

The ecological incident information system (EIIS) is an OPP database that houses ecological incidents that have been reported to the Agency. When available, EIIS includes date and location of an incident, type and magnitude of effects observed in various species, use(s) of pesticides known or suspected of contributing to the incident, and results of any chemical residue analysis or other analyses conducted during incident investigation. EIIS incidents are categorized according to the certainty that the incident resulted from pesticide exposure. The Avian Monitoring System (AIMS) is a database administered by the American Bird Conservancy that contains publicly available data on reported avian incidents involving pesticides. Many of the incidents listed in this database are also in the EIIS. However, there was only a single report in the AIMS database linked to the isopropylamine salt of imazapyr (PC Code 128829) which was considered an unlikely factor in the death of 70 birds from a fence row multiple herbicide use in South Carolina in 1992 (#I000022-001).

In addition to the incidents recorded in EIIS and AIMS, the Agency maintains a database (IDS) which stores counts of minor incidents that pesticide registrants record in quarterly aggregated incident reports. Ecological incidents recorded in these aggregated reports include those categorized as 'minor fish and wildlife' (W-B), 'minor plant' (P-B), and 'other non-target' (ONT) incidents. 'Other non-target' incidents include reports of adverse effects to insects and other terrestrial invertebrates. A review of this database in February 2014 indicates the following:

A total of 229 incidents for the imazapyr acid (PC Code 128821): all 229 P-B.
A total of 61 incidents for the isopropylamine salt (PC Code 128829): 6 W-B, 55 P-B.

Twelve incidents resulting from imazapyr and its isopropylamine salt use have been recorded in the Ecological Incident Information System (EIIS) as of April 25, 2005. Incidents reported include possible impacts to terrestrial and aquatic plants, fish and birds. The majority of reported incidents are damage to terrestrial plants, especially food crops as a result of exposure following

application of formulations containing imazapyr and other active pesticide ingredients (**Table 12a** and **12b**).

Table 12a. Incident Reports Involving Imazapyr Acid (04/20/1995 – 8/14/2013)

Location and Incident #	Organism Involved	Product	Contact with Product/Symptoms	Certainty	Legality
Driveway CO 1006019-001	Willow and Spruce	Imazapyr	Driveway surface application/Mortality	Probable	Intentional misuse
Chelan County WA 1014406-001	Cherry and pear trees	Imazapyr	Applied in irrigation canal/Several dead or dying cherry and pear tress.	Possible	Unknown
Dubuque County IA 1008079-001	Corn crop	Mixture of Hornet (unknown pesticide) and Lightning (imazapyr)	Post-emergent application/low yield and death in 120 acres.	Possible	Registered Use
Whitman County/ Washington State 1014407-017	Winter wheat	Imazapyr	Carryover residues from application to peas the previous Spring/damage. Complication assigning causes to the case concerning detection limits for imazapyr.	Probable	Unlikely
Texas 1005972-001	Live oaks	Imazapyr	Application to neighbor's property/injury to 3 live oaks.	Probable	Registered Use
Halifax County, NC 1003826-008	Goldfish	Arsenal (imazapyr)	Aerially applied to nearby 145 acre area followed by rain 12 days later/mortality. No residues found in area. Cause of mortality not determined.	Possible	Registered Use
Grant, WA 1020459-003	Potato	Imazapyr	Plant damage due to drift exposure.	Possible	Unknown
Montgomery, IN 1012366-031	Corn	Imazapyr	Plant damage from direct broadcast application to 203 acres of corn.	Probable	Misuse
Grant, WA 1013884-015	Birch and Willow	Imazapyr	Mortality from spray drift.	Highly Probable	Misuse
Limestone, AL 1025684-001	Tomato	Imazapyr	Plant damage to 1,200 tomato plants	Possible	Unknown

			from spray drift.		
Adams, WA 1020459-012	Wheat	Imazapyr	Plant damage to wheat from runoff.	Possible	Unknown
Grant, WA 1020459-001	Wheat	Imazapyr	Plant damage to wheat from drift and runoff.	Possible	Unknown
Bolivar, MO 1025432-001	Green bean and Tomato	Imazapyr	Mortality to green beans and tomatoes from spray drift.	Possible	Registered Use
Leake, MS 1025563-001	Soybean	Imazapyr	Plant damage to 0.75 acres.	Possible	Unknown
Maricopa, AZ 1024071-369	Trees	Imazapyr	Mortality due to direct treatment.	Possible	Unknown

Table 12b. Incident Reports Involving the Isopropylamine Salt of Imazapyr (05/26/1992 – 06/04/2004)

Location and Incident #	Organism Involved	Product	Contact with Product/Symptoms	Certainty	Legality
Aiken County, SC 1000022-001	Birds and Fish	Arsenal (imazapyr) Karmex (Diuron) Escort (Metsulfuron methyl)	Spray on fence row drifted onto adjacent bird nest boxes located from 2-85 feet of application site; runoff into a pond 60 foot away/bird kill of nesting and mature birds and fish and algae kill in pond.	Possible	Unknown
Cass County, Texas 1015265-001	Loblolly pine seedlings	Hexazinone, glyphosate, imazapyr	Hexazinone in soil samples, Onestep (glyphosate and imazapyr) used in site preparation for planting of seedlings/mortality	Possible	Registered Use
AR 1015280-001	Tomatoes, Cantaloupes Water-melons	Krenite Arsenal Escort Glyphos (glyphosate, imazapyr, metsulfuron methyl)	Krenite/Arsenal/Escort mixture applied to transmission right-of-way (150 yards to 1/4 mile distance). Glyphos applied to pond levee 30-40 feet from watermelon and cantaloupe fields./Severe curling of oldest leaves on tomato plants with interveinal chlorosis. Mature tomatoes rotted from stem side. Watermelon and	Possible	Registered Use

			cantaloupes aborted blooms and fruit. Pattern of glyphosate drift could be seen across field. No residues of any of applied pesticides found in plant tissues.		
Washington County Florida 1013550-007	Beans Oak Trees Grape vines	Garlon 4 Chopper	Spraying to a forest site 150-200 feet away/beans exhibited chlorosis and cupping; grapes were chlorotic, and some oak leaves turned brown.	Probable	Registered Use

5. EXPOSURE PATHWAYS OF CONCERN

The high persistence of imazapyr in terrestrial limits potential routes of dissipation to leaching, runoff, and spray drift. In aquatic environments, imazapyr dissipation is expected to be controlled by photodegradation. Field dissipation studies show that imazapyr is moderately persistent under typical use conditions. Although the routes of dissipation of imazapyr were not clearly defined in field dissipation studies, there was discernible movement or leaching of imazapyr into the soil profile.

The exposure pathways for imazapyr may result in a wide range of potential aquatic and terrestrial exposure scenarios. For this problem formulation, the drinking water and inhalation pathways were screened using the SIP (Screening Imbibition Program) and STIR (Screening Tool for Inhalation Risk) screening methods and were found to be exposure pathways of low concern. However, it is noted that the screening analysis do not include aggregation with all other exposure pathways (dietary, dermal, inhalation, or drinking water), which together, may contribute to a total exposure that has a potential for effects to non-target animals. The risk characterization section will discuss the impact of the consideration of other routes of exposure that have been identified as potentially important, and the degree of certainty associated with screening-level risk assessment conclusions. SIP and STIR are described in detail at http://www.epa.gov/oppefed1/models/terrestrial/index.htm and the SIP and STIR model outputs are available in **APPENDIX D** and **E**, respectively.

6. ANALYSIS PLAN

Drinking Water Assessment

EFED does not expect to conduct a new drinking water assessment given that the Health Effects Division (HED) does not anticipate conducting a dietary assessment. A drinking water assessment may be updated if a human health dietary risk assessments of imazapyr is conducted.

The current models available for conducting drinking water assessment for surface water include PRZM (Pesticide Root Zone Model, version 3.12.3, June 2006) and EXAMS (Exposure Analysis Modeling System, version 2.98.04.06, April 2005) models. PRZM will be used to simulate pesticide transport as a result of runoff and erosion from an agricultural field while EXAMS will be used to estimate environmental fate and transport of pesticides in the index reservoir. Measures of exposure will be based on maximum single and year (including multiple seasons per year) labeled application rates, minimum retreatment intervals, and conservative methods of application.

Currently, groundwater modeling is completed using PRZM-Groundwater (PRZM-GW version 1.0, December 11, 2012), using the GW-GUI (Graphical User Interface, version 1.0, December 11, 2012) and SCI-GROW (Screening Concentration in Groundwater, version 2.3, August 8, 2003). SCI-GROW is an empirical model based on a linear best fit through 13 single-application groundwater studies. PRZM-GW can be used to simulate vertical pesticide transport through the

soil profile into an aquifer following application to an agricultural field. The PRZM scenarios used in groundwater simulations are representative of vulnerable sites—shallow unconfined aquifers under an agricultural field with leaching prone soil—and output values represent pesticide concentrations that may be observed in drinking water resulting from the use of groundwater vulnerable to pesticide contamination as source water. The results are expected to represent the upper bound values on the concentrations of toxic residues that might be found in drinking water supplied by groundwater.

Ecological Risk Assessment

Measures of Exposure

In order to estimate risks of imazapyr exposure to aquatic and terrestrial organisms, all exposure modeling and resulting risk conclusions will be made based on maximum application rates, application methods, and any mitigation measures specifically indicated on the label. The models that will be used to predict the EECs of imazapyr are discussed on OPP's model website.[1] These models include: PRZM (Pesticide Root Zone Model) and EXAMS (Exposure Analysis Modeling System), PRZM-groundwater (GW), AgDrift, AgDisp, T-REX, TerrPlant, SIP (Screening Imbibition Program), and STIR (Screening Tool for Inhalation Risk). Because imazapyr is applied through aerial and ground spray and is an herbicide, a comprehensive spray drift buffer zone analysis will be conducted.

For imazapyr, the predicted estimated environmental concentrations of imazapyr acid will be used to calculate risk quotients. For the T-REX model, we will assume that the default half-life value of 35 days for foliar residue dissipation will capture the parent and degradates, unless data becomes available to suggest that the 35-day half-life is inadequate. If the estimated environmental concentrations (EECs) generated by T-REX with the default foliar dissipation half-life result in risk quotients (RQs) that are sufficient to exceed any levels of concern (LOCs), then the risk assessor will obtain more data or alter the default value to characterize risk with alternative values. (It should be noted that in T-REX, the foliar dissipation half-life does not affect EECs when only one application is simulated.)

Measure of Effects

Ecological effects data are used as measures of direct and indirect effects to biological receptors. Data are typically obtained from registrant-submitted studies or from literature studies identified by ECOTOX. The ECOTOX database provides more ecological effects data in an attempt to bridge existing data gaps. ECOTOX is a source for locating single chemical toxicity data and potential chemical mixture toxicity data for aquatic life, terrestrial plants, and wildlife. ECOTOX was created and is maintained by the U.S. EPA, Office of Research and Development, and the National Health and Environmental Effects Research Laboratory's Mid-Continent Ecology Division.

[1] http://www.epa.gov/opp00001/science/models_pg.htm

Integration of Exposure and Effects

Risk characterization is the integration of exposure and ecological effects to determine the potential ecological risk from the use of pesticides and the likelihood of direct and indirect effects to non-target organisms in aquatic and terrestrial habitats. For the assessment of risks, the risk quotient (RQ) method is used to compare exposure and measured toxicity values. EECs are divided by acute and chronic toxicity values. The resulting RQs are then compared to the Agency's Levels of Concern (LOCs) (USEPA 2004). These criteria will be used to indicate when imazapyr use, as directed on the label, has the potential to cause adverse direct or indirect effects to non-target organisms. In addition, any incident data from the EIIS, IDS, and AIMS will be considered as part of the risk characterization.

Endangered Species Assessments

Consistent with the Agency's responsibility under the Endangered Species Act (ESA), the Agency will evaluate exposure and potential risks to federally-listed threatened and/or endangered (listed) species from registered uses of pesticides in registration review.

Endocrine Disruptor Screening Program

As required by FIFRA and FFDCA, EPA reviews numerous studies to assess potential adverse outcomes from exposure to chemicals. Collectively, these studies include acute, subchronic and chronic toxicity, including assessments of carcinogenicity, neurotoxicity, developmental, reproductive, and general or systemic toxicity. These studies include endpoints which may be susceptible to endocrine influence, including effects on endocrine target organ histopathology, organ weights, estrus cyclicity, sexual maturation, fertility, pregnancy rates, reproductive loss, and sex ratios in offspring. For ecological hazard assessments, EPA evaluates acute tests and chronic studies that assess growth, developmental and reproductive effects in different taxonomic groups. As part of its most recent registration decision for imazapyr EPA reviewed these data and selected the most sensitive endpoints for relevant risk assessment scenarios from the existing hazard database. However, as required by FFDCA section 408(p), imazapyr is subject to the endocrine screening part of the Endocrine Disruptor Screening Program (EDSP).

EPA has developed the EDSP to determine whether certain substances (including pesticide active and other ingredients) may have an effect in humans or wildlife similar to an effect produced by a "naturally occurring estrogen, or other such endocrine effects as the Administrator may designate." The EDSP employs a two-tiered approach to making the statutorily required determinations. Tier 1 consists of a battery of 11 screening assays to identify the potential of a chemical substance to interact with the estrogen, androgen, or thyroid (E, A, or T) hormonal systems. Chemicals that go through Tier 1 screening and are found to have the potential to interact with E, A, or T hormonal systems will proceed to the next stage of the EDSP where EPA will determine which, if any, of the Tier 2 tests are necessary based on the available data. Tier 2 testing is designed to identify any adverse endocrine-related effects caused by the substance, and

establish a dose-response relationship between the dose and the E, A, or T effect.

Under FFDCA section 408(p), the Agency must screen all pesticide chemicals. Between October 2009 and February 2010, EPA issued test orders/data call-ins for the first group of 67 chemicals, which contains 58 pesticide active ingredients and 9 inert ingredients. A second list of chemicals identified for EDSP screening was published on June 14, 2013[2] and includes some pesticides scheduled for registration review and chemicals found in water. Neither of these lists should be construed as a list of known or likely endocrine disruptors.

For further information on the status of the EDSP, the policies and procedures, the lists of chemicals, future lists, the test guidelines and the Tier 1 screening battery, please visit our website.[3]

7. PRELIMINARY IDENTIFICATION OF DATA GAPS

Table 13 identifies the environmental fate studies submitted by the registrant, as well as study classifications and whether or not additional data are needed in order to support the registration review exposure assessments.

Table 13. Submitted Environmental Fate Data for Chemical Imazapyr and its Isopropylamine Salt

Guideline	Data Requirement (material)	MRID #	Study Classification	Are data needed to conduct risk assessment?
835.2120	Hydrolysis (Imazapyr[a])	00132359	Acceptable	No
835.2240	Photodegradation in Water (Imazapyr)	00131617	Acceptable	No
835.2210	Photodegradation on Soil (Imazapyr)	40003713	Acceptable	No
835.2370	Photodegradation in Air	—	—	—
835.4100	Aerobic Soil Metabolism (Imazapyr) (Imazapyr)	41023201 45119701	Acceptable Supplemental	No
835.4200	Anaerobic Soil Metabolism (Imazapyr)	00131619	Acceptable	No
835.4400	Anaerobic Aquatic Metabolism (Imazapyr)	40003712	Acceptable	No
	Aerobic Aquatic Metabolism (Imazapyr) (Photoproducts: CL 9140, CL 119060)	41002301 41891501 45119702	Acceptable Supplemental Acceptable	No

[2] See http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPPT-2009-0477-0074 for the final second list of chemicals.

[3] http://www.epa.gov/endo/

Table 13. Submitted Environmental Fate Data for Chemical Imazapyr and its Isopropylamine Salt				
Guideline	**Data Requirement (material)**	**MRID #**	**Study Classification**	**Are data needed to conduct risk assessment?**
835.4300	(Photoproducts: CL 9140, CL 119060)			
835.1230 835.1240	Leaching-Adsorption/Desorption (Imazapyr + photoproducts)	45119705	Acceptable	No[b]
835.1410	Laboratory Volatility	—	—	—
835.8100	Field Volatility	—	—	—
835.6100	Terrestrial Field Dissipation (Imazapyr) (Arsenal 2AS[a]) (Arsenal 2AS)	45119706 42192101 42192102	Supplemental Upgradeable Upgradeable	No
850.6100	ECM/ILV for Soil and Water	41891501	--	No
835.6300	Aquatic Field Dissipation (Imazapyr) (Arsenal 2AS)	45119707 41891501	Unacceptable Supplemental	No
835,6400	Forestry Dissipation (Arsenal)	40003714	Acceptable	No
850.1730	Accumulation in Fish			No
850.1730	Accumulation- aquatic non-target (Imazapyr) (Imazapyr)	45119707 45119709	Supplemental Supplemental	No
835.7100	Ground Water- small prospective	—	—	—

[a] Imazapyr refers to the parent compound (2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-3-pyridinecarboxylic acid); Arsenal 2AS is the isopropylamine salt (2-Propanamine, 2-(4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-3-pyridinecarboxylate). CL 9140 is pyridine 2,3-dicarboxylic acid. CL 119060 is Furo[3,4]pyridine-5(7*H*), one-7-hydroxy.
[b] Limited to two soils.

Ecological Effects

Table 14 and **Table 15** identify the ecological effects studies (aquatic and terrestrial, respectively) submitted by the registrant, as well as study classifications and whether or not additional data are needed in order to support the registration review risk assessments.

A passerine study is not available; however, given the low sensitivity of the quail and mallard duck to imazapyr, it is assumed that further testing on passerines will not be of great value to inform on the potential toxicity of imazapyr.

The terrestrial plant guidelines (850.4100 and 850.4150) are partially fulfilled (four species of monocots, including corn; five species of dicots, including soybean and sugar beet) (MRID 40811801; acid).

Table 14. Submitted Aquatic Toxicity Data for Chemical Imazapyr and its Isopropylamine Salt

OCSPP Guideline	Data Requirement	Submitted Studies (MRID) [Acid/Salt]	Study Classifications [Acid/Salt]	Are data needed to conduct risk assessment?	Comments
850.1010	Freshwater invertebrate acute toxicity	00131632 / 00147117	All acceptable	No	Although TEP data would address some uncertainty regarding potential toxicity of the formulations applied directly to water, the TGAI data show that imazapyr is practically non-toxic and no aquatic animal incidents have been reported.
850.1025 850.1035 850.1045 850.1055	Saltwater invertebrate acute toxicity	41315803 41315802 45119710 / No salt	Acceptable Supplemental Acceptable	No	Although TEP data would address some uncertainty regarding potential toxicity of the formulations applied directly to water, the TGAI data show that imazapyr is practically non-toxic and no aquatic animal incidents have been reported.
850.1075	Freshwater fish acute toxicity	00131630 00131629 00131631 / 45119713 00147116	All acceptable	No	Although TEP data would address some uncertainty regarding potential toxicity of the formulations applied directly to water, the TGAI data show that imazapyr is practically non-toxic and no aquatic animal incidents have been reported.
850.1075	Saltwater fish acute toxicity	41315801 / No salt	Acceptable	No	Although TEP data would address some uncertainty regarding potential toxicity of the formulations applied directly to water, the TGAI data show that imazapyr is practically non-toxic and no aquatic animal incidents have been reported.
850.1300	Freshwater invertebrate life cycle	41315805 / No salt	Acceptable	No	--
850.1350	Saltwater invertebrates life cycle	No data	N/A	No	--
850.1400	Freshwater fish early-life stage	41315804 45119711 / No salt	Supplemental Acceptable	No	--

Table 14. Submitted Aquatic Toxicity Data for Chemical Imazapyr and its Isopropylamine Salt					
OCSPP Guideline	**Data Requirement**	**Submitted Studies (MRID) [Acid/Salt]**	**Study Classifications [Acid/Salt]**	**Are data needed to conduct risk assessment?**	**Comments**
850.1400	Saltwater fish early-life stage	No data	N/A	No	While data are unavailable for this taxa, sensitivity of saltwater fish is assumed to be similar to that of the freshwater fish, which in this case is low.
850.1500	Freshwater fish full life cycle	45119712 No salt	Supplemental	No	--
850.4400	Aquatic plant growth: Tier II vascular plants	40811802 43889102	All acceptable	No	--
850.5400	Aquatic Plant Growth: Tier II algae	40811802 43889102	All acceptable	No	--

Table 15. Submitted Terrestrial Toxicity Data for Chemical Imazapyr and its Isopropylamine Salt					
OCSPP Guideline	**Data Requirement**	**Submitted Studies (MRID) [Acid/Salt]**	**Study Classifications [Acid/Salt]**	**Are data needed to conduct risk assessment?**	**Comments**
850.2100	Avian Oral Toxicity	00131633 00131634 No salt	All acceptable	No	While data are unavailable for passerine (40 CFR, Part 158-Subpart G). acute oral studies on quail and mallard duck indicates low sensitivity to imazapyr.
850.2200	Avian Dietary Toxicity	00131635 00131636 00147115	All acceptable	No	--
850.2400	Wild Mammal Toxicity	00132030 00147049 44735301	All acceptable	No	--
850.3020	Honeybee Acute Contact Toxicity	00131637 No salt	Acceptable	No	--
850.2300	Avian Reproduction Toxicity	45119714a 43831401 43831402 No salt	Acceptable Acceptable Acceptable	No	--
850.4100	Seedling Emergence Tier II	40811801 No salt	Supplemental	No	--
850.4150	Vegetative Vigor Tier II	40811801 40003711 43889101	Supplemental Supplemental Acceptable	No	--
850.1735	Whole sediment: acute freshwater invertebrates	No data	N/A	No	Half-life of the imazapyr in sediment is >10 days (aerobic aquatic metabolism study, MRID 41002301) but the log P_{ow} is 0.22. Furthermore, imazapyr is not expected to partition to sediment.
850.1740	Whole sediment: acute marine invertebrates	No data	N/A	No	Half-life of imazapyr in sediment is >10 days (aerobic aquatic metabolism study, MRID 41002301), but the log P_{ow} is 0.22. Furthermore, imazapyr is not expected to partition to sediment.
Non-GLN	Whole sediment: chronic invertebrates freshwater and marine	No data	N/A	No	Half-life of the imazapyr in sediment is >10 days (aerobic aquatic metabolism study, MRID 41002301), but the log P_{ow} is 0.22. Furthermore, imazapyr is not expected to partition to sediment.

APPENDIX A- Summary of Environmental Fate Data

Hydrolysis (835.2120, MRID 00132359, Study Status: Acceptable). Imazapyr is stable to hydrolysis at environmentally relevant pH values and temperatures. Imazapyr was stable in aqueous buffer solutions (pH 5 and 7) and distilled water (pH 5.2) for up to 30 days at 25±1°C. Imazapyr degraded slowly in an aqueous pH 9 buffer solution. The only identified degradate was 2-[(1-carbomyl-1,2-dimethylpropyl)carbomyl] nicotinic acid (CL 252974). Minor degradates were not identified.

Aqueous Photolysis (835.2240, MRID 00131617, Study Status: Acceptable). Imazapyr is susceptible to photolysis. Imazapyr degraded with a half-life of 2.5-5.3 days in distilled water or buffer solution at pH 5 or 9, at 25°C, irradiation with a xenon arc lamp (12 hours/day) for up to 10 days. Two major degradates were formed: 2,3-pyridinecarboxylic acid (CL 9140, 22.7%) and 7-hydroxy-furo[3,4-b]pyridin-5(7H)-one (CL 119060, 9.7%). Unidentified degradates comprised up to 7.1% of the applied radioactivity. Imazapyr was stable in the dark during the 10-day incubation period.

Soil Photolysis (835.2210, MRID 40003712, Study Status: Acceptable). Imazapyr degraded slowly on irradiated soil. ^{14}C-pyridine-ring-labeled imazapyr applied at a rate of 1.5 lb ae/acre, degraded with an extrapolated half-life of 149 days on sandy loam soil irradiated a 4-week period. No degradate was >10% of the applied radioactivity. In dark controls, imazapyr was 95-98% of the applied radioactivity after 4 weeks. Unidentified residues were 2.9-4.9% of the applied radioactivity.

Aerobic Soil Metabolism (835.4100, MRID 41023201, Study Status: Acceptable). Imazapyr is essentially stable to degradation in soil maintained under aerobic conditions. ^{14}C/^{13}C-labeled imazapyr was added to Princeton sandy loam soil (soil moisture 75% of field capacity) at a concentration of 1.5 ppm. Samples were maintained at 25°C in the dark for up to 365 days. Volatiles and/or CO_2 were collected in traps. At 365 days, 88% of the applied radioactivity remained as parent imazapyr (calculated half-life of 5.9 years). Unextractable residues averaged 4% of the applied radioactivity during the study and accounted for 5% at 365 days. Cumulative $^{14}CO_2$ accounted for up to 7% of the applied radioactivity after 365 days. Material balance averaged 101%.

Aerobic Soil Metabolism (835.4100, MRID 45119701, Study Status: Supplemental). The aerobic soil metabolism of [pyridine-6-^{14}C]-imazapyr was studied for 121 days in Sassafras sandy loam soil (pH 6.0, organic matter 2.0%; soil moisture content of 75% of 1/3 bar) from New Jersey. Samples were keep in the dark at 25±1°C. [^{14}C]Imazapyr was applied at the nominal rate of 0.22 mg ae./kg soil (equivalent to 0.44 lb ae/acre or 0.50 kg ae/ha with 15-cm soil incorporation). Because the 121-day study period was short compared to the persistence of [pyridine-6-^{14}C]imazapyr, there was insufficient time for the full pattern of formation and decline of products to develop. At study end, approximately 72% of the amount of parent recovered at the beginning of the study remained. A structurally similar transformation product,

2-[4-Isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl]-3-hydroxy pyridine, was present at approximately 7% of parent radioactivity recovered at the beginning of the study and increased slowly for the duration of the study. Volatilized $^{14}CO_2$ totaled approximately 6% of initial parent radioactivity at 121 days.

Two additional minor transformation products, 2-[(1-carbamoyl-1,2-dimethylpropyl)carbamoyl] nicotinic acid and 2-[4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl]-3-carboxymethyl pyridine, were each detected at ≤3% of the applied, but may have been artifacts produced during sample extraction and preparation. Organic volatiles were <0.1% of applied at any sampling interval. Material balance ranged from approximately 100% to 97%.

The extrapolated first-order kinetics regression half-life for parent imazapyr for the 121-day period is 296 days (r^2 = 0.89, 95% confidence interval of 247 to 370 days). If the two putative artifact compounds are assumed to be parent material and included in the regression, then the apparent half-life increases slightly to 313 days (r^2 = 0.90, 95% confidence interval of 264 to 387 days).

Anaerobic Soil Metabolism (835.4200, MRID 00131619, Study Status: Acceptable). Imazapyr was stable in sandy loam soil. Sandy loam soil (1.8% organic matter, pH 5.3-6.5, CEC 8.5 meq/100 g) was treated with a 50:50 mixture of ^{14}C and ^{13}C-carboxy-labeled imazapyr at 1 lb ae/acre. Radioactivity in the water extract was three-fold that in the soil.

Anaerobic Aquatic Degradation (835.4400, MRID 40003712, Study Status: Acceptable). Imazapyr is resistant to anaerobic aquatic degradation. ^{14}C-pyridine-labeled imazapyr, applied at 1.5 lb/A, was incubated in an anaerobic sand sediment:water system in the dark at 19-22°C for up to 4 months. Imazapyr comprised 96-98% of the recovered radioactivity at all sampling intervals.

Aerobic Aquatic Metabolism (835.4300, MRID 41002301, Study Status: Acceptable). Imazapyr did not degrade in water or sediment under aquatic conditions. ^{14}C-Imazapyr was added to a series of water and soil sediments (92% sand) collected from an irrigation pond at a rate equivalent to 1.5 lb/A. Sample containers were maintained under positive pressure in the dark at 25°C. $^{14}CO_2$ accounted for <2% of the applied radioactivity 4 weeks (there were no organic volatiles). Over the course of the study, >96% of the applied radioactivity remained in the aqueous phase while <2% was bound to soil. Analysis by thin-layer chromatography determined that parent imazapyr accounted for >97% of the applied radioactivity after 4 weeks.

Aerobic Aquatic Metabolism of Two Degradates of Imazapyr (835.4300, MRID 45119702, Study Status: Acceptable). The aerobic degradation of the imazapyr degradation products, [pyridine-6-^{14}C]-labeled furo[3,4-b]pyridine-5-(7*H*)-one-7-hydroxy (CL 119060) and pyridine 2,3-dicarboxylic acid (CL 9140), was studied in each of two pond water:sediment systems. A pond water:sediment system (water pH 8.2; sand sediment pH 7.7, organic matter 0.8%) from Florida, and a pond water:sediment system (water pH 7.9; silt loam sediment pH 6.6, organic matter 1.1%) from Missouri were studied for 14 days in darkness at 25±1°C.

[^{14}C]furo[3,4-*b*]pyridin-5(*7H*)-one,7-hydroxy- and [^{14}C]pyridine 2,3-dicarboxylic acid was applied separately at the nominal rate of 0.083 mg ae/L. The sediment:water ratio used was 175 g wet sediment:200 mL water. For both test compounds and systems, aerobic conditions were maintained in the water layers of the sediment:water systems, but the sediment layers remained anaerobic throughout the study. Levels of parent [^{14}C]furo[3,4-*b*]pyridin-5(*7H*)-one,7-hydroxy- and [^{14}C]pyridine 2,3-dicarboxylic acid and transformation products were identified only in the water layers. To compensate for the failure to identify and quantify residues extracted from the sediments and low material balances during later sampling intervals, it was assumed that all extracted sediment residues were unreacted starting materials. These extracted sediment residues were then added to parent materials identified and quantified in the water phases to estimate total system (water + sediment phases) half-lives.

In the water layer, the major nonvolatile transformation product of [pyridine-6-^{14}C]furo[3,4-*b*]pyridin-5(*7H*)-one,7-hydroxy-pyridine 2,3-dicarboxylic acid. This compound was detected at maximums of 20% of applied at 1 day and 28% at 3 days, in the sand and silt loam sediment systems, respectively. Nicotinic acid was identified as a nonvolatile transformation product, and detected at maximums of 6% at 2 days and 10% at 1 day, in the sand and silt loam sediment systems, respectively. Unidentified polar products increased to maximums of 33-41% of applied at 7 days in both systems. For both test systems, nonextractable [^{14}C]residues were ≤6% at any sampling interval. $^{14}CO_2$ was a major volatile transformation product, totaling 45% for sand sediment:water systems. The first-order kinetics regression half-life for [pyridine-6-^{14}C]furo[3,4-*b*]pyridin-5(*7H*)-one,7-hydroxy- in the Florida pond system (water + sediment) was 3.9 days (r^2 = 0.95, 95% confidence interval of 3.4 to 4.5 days). The Missouri pond system first-order regression half-life (water + sediment) for [pyridine-6-^{14}C]furo[3,4-*b*]pyridin-5(*7H*)-one,7-hydroxy- was 5.8 days (r^2 = 0.80, 95% confidence interval of 4.5 to 8.2 days). The average half-life for the Florida and Missouri systems for [pyridine-6-^{14}C]furo[3,4-*b*]pyridin-5(*7H*)-one,7-hydroxy- was 5±1 days with an upper 90% confidence bound on the mean of 8 days.

No major nonvolatile transformation products of [pyridine-6-^{14}C]pyridine 2,3-dicarboxylic acid were detected in the water layers. Minor nonvolatile transformation products were unidentified polar products. For both sediments, nonextractable [^{14}C]residues were ≤3.9% at any sampling interval. $^{14}CO_2$ was a major volatile transformation product, totaling 53% for sand sediment:water systems and 23% for silt loam sediment:water systems at study termination. Organic volatiles were <0.1% of applied at any sampling interval. The first-order kinetics regression half-life for of [pyridine-6-^{14}C]pyridine 2,3-dicarboxylic acid for the Florida pond system (water + sediment) was 3 days (r^2 = 0.56, 95% confidence interval of 1.9 to 5.9 days). The Missouri pond system first-order regression half-life (water + sediment) for pyridine 2,3-dicarboxylic acid was 4 days (r^2 = 0.88, 95% confidence interval of 3.5 to 5.5 days). The average half-life for the Florida and Missouri systems for pyridine 2,3-dicarboxylic acid is 4±1.0 days with an upper 90% confidence bound on the mean of 5.7 days.

Aerobic Aquatic Metabolism of Imazapyr Photodegradation Products (835.4300, MRID 41891501, Study Status: Supplemental). This study addressed the aerobic aquatic metabolism of the two major aqueous photodegradation products of imazapyr, 2,3-pyridinedicarboxylic acid (CL 9140) and 7-hydroxy-furo[3,4-b]pyridin-5(7H)-one (CL 119060) over a 4-week period. The photoproducts were generated by irradiating 10 mg of imazapyr in 50 mL of deionized water which yielded the major products CL 9140 and CL 119060 (22% and 24%, respectively). The photoproducts were added to pond water and sediment from a wetland in New Jersey. Evolved CO_2 was trapped and measured. The study presented evidence that CL 119060 is rapidly converted to CL 9140) which, in turn, is metabolized to CO_2.

Adsorption/Desorption (835.1230/835.1240, MRID 45119705, Study Status: Acceptable). The batch-equilibrium adsorption/desorption characteristics of ^{14}C-6-pyridine-ring-labeled- imazapyr and the metabolites (photoproducts) pyridine 2,3-dicarboxylic acid and furo[3,4-*b*]pyridin-5(*7H*)-one,7-hydroxy- (both ^{14}C-6-labeled in the pyridine ring) were each studied separately in a sand sediment from Florida [pH - 7.7, organic carbon - 0.47%] and a silt loam sediment from Missouri [pH - 6.6, organic carbon - 0.64%]. The equilibrating solution used was 0.01 M $CaCl_2$, at a soil/solution ratios of 1:2 (w:v). The desorption phase of the study was carried out at 20±1°C for 27.5 hours (imazapyr), 24 hours (pyridine 2,3-dicarboxylic acid) or 44 hours (furo[3,4-*b*]pyridin-5(*7H*)-one,7-hydroxy-). The desorption phase was conducted once. Supernatant solutions were analyzed using LSC and HPLC. Sediments were extracted with 0.1 M sodium hydroxide following desorption, analyzed by LSC. Radioactivity in the soil residue after extraction was determined by combustion.

Imazapyr: Freundlich adsorption parameters and average simple adsorption/desorption coefficients are given in Table A-1 below. The Freundlich adsorption coefficients (K_f) were 0.091 (1/N=0.733; K_{foc}= 19.4) and 0.523 (1/N=0.887; K_{foc}=81.4) for the sand and silt loam sediments, respectively. Corresponding simple adsorption coefficients adjusted for organic carbon (K_{oc}) were 30.6 and 99.8 mL/g organic carbon.

Pyridine 2,3-dicarboxylic acid: Freundlich adsorption parameters and average simple adsorption/desorption coefficients are given in the results synopsis and in Table A-2 below. The Freundlich adsorption coefficients (K_f) were 0.699 (1/N=0.811; K_{foc}= 149.4) and 31.6 (1/N=0.955; K_{foc}=4940) for the sand and silt loam sediments, respectively. Corresponding K_{oc} values were 217 and 6053 mL/g organic carbon.

Furo[3,4-*b*]pyridin-5(*7H*)-one,7-hydroxy-: Freundlich adsorption parameters and average simple adsorption/desorption coefficients are given in the results synopsis and in Table A-3 below. The Freundlich adsorption coefficients (K_f) were 0.551 (1/N=0.939; K_{foc}= 117) and 5.77 (1/N=0.962; K_{foc}=902) for the sand and silt loam sediments, respectively. Corresponding K_{oc} values were 134 and 1020 mL/g organic carbon.

Table B-1: Adsorption and desorption parameters for imazapyr in the sediments.

Soil	Freundlich Adsorption				Simple Ads/Des Coefficient Averages			
	Kf ads	1/N	R^2	Kf ads oc	Kads	Kads oc	Kdes	Kdes oc
Sand sediment (FL)	0.091	0.733	0.976	19.4	0.144	30.6	0.338	71.9
Silt loam sediment (MO)	0.523	0.887	0.999	81.7	0.639	99.8	1.02	159

Kf ads – Freundlich adsorption coefficient; 1/N – Slope of Freundlich adsorption isotherm.
Subscript oc indicates sorption per unit organic carbon ([K x 100]/% organic carbon).
R^2 - Regression coefficient of Freundlich equation.

Table B-2: Adsorption and desorption parameters for Pyridine 2,3-dicarboxylic acid in the sediments.

Soil	Freundlich Adsorption				Simple Ads/Des Coefficient Averages			
	Kf ads	1/N	R^2	Kf ads oc	Kads	Kads oc	Kdes	Kdes oc
Sand sediment (FL)	0.699	0.811	0.998	149	1.02	217	1.60	340
Silt loam sediment (MO)	31.6	0.955	0.999	4940	38.7	6053	140	21,900

Kf ads – Freundlich adsorption coefficient; 1/N – Slope of Freundlich adsorption isotherm.
Subscript oc indicates sorption per unit organic carbon ([K x 100]/% organic carbon).
R^2 - Regression coefficient of Freundlich equation.

Table B-3: Adsorption and desorption parameters for Furo[3,4-*b*]pyridin-5(*7H*)-one,7-hydroxy- in the sediments.

Soil	Freundlich Adsorption				Simple Ads/Des Coefficient Averages			
	Kf ads	1/N	R^2	Kf ads oc	Kads	Kads oc	Kdes	Kdes oc
Sand sediment (FL)	0.551	0.939	0.998	117	0.628	134	1.89	402
Silt loam sediment (MO)	5.77	0.962	1.000	902	6.53	1020	16.9	2640

Kf ads - Freundlich adsorption coefficient; 1/N -Slope of Freundlich adsorption isotherm.
Subscript oc indicates sorption per unit organic carbon ([K x 100]/% organic carbon).
R^2 - Regression coefficient of Freundlich equation.

Terrestrial Field Dissipation (835.6100, MRID 42192101, Study Status: (Supplemental). Arsenal 2AS, the isopropylamine salt of imazapyr (22.6% ae in aqueous solution) dissipated with a calculated half-life of 143 days. However, the dissipation pathway(s) was not addressed. The test material was applied by boom sprayer to a bareground plot of silt loam soil (2.6% organic matter, pH 5.1, CEC 16.9 meq/100 g) located in Hillsboro, Oregon. Application rate was 1.53 lb ae/acre. Sprinkler irrigation was applied at 0.5 to 3.0 inches, 1-3 times/month. The temperature ranged from 6 to 100°F, total precipitation was 67 inches, and irrigation total was 29 inches. Imazapyr was found primarily in the 0-6-inch soil layer at a maximum concentration of 400 ppb. In the 6-12-inch layer, residues were ≤6 ppb at 1-30 days,

14-17 ppb at 240 days, and 6-13 ppb at 452 days. In the deeper soil layers residues were <8 ppb immediately posttreatment, and not detected at later sampling times. A half-life of 143 days was calculated. Residues in a control plot were ≤4 ppb. Routes of dissipation were not provided.

T**errestrial Field Dissipation (835.6100, MRID 42192102, Study Status: Supplemental).** Arsenal 2AS, the isopropylamine salt of imazapyr (22.6% ae in aqueous solution) dissipated with a calculated half-life of 64 days. However, the mode(s) of dissipation was not addressed. The test material was applied by backpack sprayer to a bareground plot of sandy loam soil (2.3% organic matter, pH 5.7, CEC 6.75 meq/100 g) located in Janesville, North Carolina. Application rate was 1.53 lb ae/acre. Sprinkler irrigation was applied at 0.58 to 2.0 inches, 3-5 times/month. The temperature ranged from 18 to 98°F, total precipitation was 67 inches and irrigation totaled 22 inches. Imazapyr residues were found primarily in the 0-6-inch soil layer, averaging 300-440 ppb immediately posttreatment and declining to 7-12 ppb at 240-360 days. In the 6-12-inch layer, residues were at a maximum of 10-21 ppb at 14 days. In the 12-18 inch and 18-24 inch depths, residues reached a maximum of 8-14 ppb and 7-11 ppb, respectively, at 30 days. In the deeper soil layers, residues were ≤6 ppb at all sampling times. Residues in a control plot were ≤3 ppb. Routes of dissipation were not provided.

Terrestrial Field Dissipation (835.6100, MRID 45119706, Study Status: Supplemental). This study shows that imazapyr is prone to leach and is relatively long-lived. Cropped corn fields in Iowa and Nebraska were used as the study sites. Apparent, simple first-order regression half-lives at all sampled depths (0-36 inches) were 94 days in Iowa (95% confidence limits 84-107 days, $r^2 = 0.88$) and 126 days in Nebraska (95% confidence limits 113-143 days, $r^2 = 0.88$). The degree to which the apparent loss/dispersal of imazapyr was due to transformation, plant uptake, volatilization, leaching, runoff, etc. was not determined. There was no analysis for transformation products (degradates or metabolites), no measurement of plant uptake, or attempt to correlate daily rainfall/irrigation with pesticide disappearance or potential for movement in soil during the course of study. Therefore, disappearance half-lives represent only lower limits for what may be much longer effective half-lives, and cannot be assumed to be attributable to degradation or detoxification of parent (or any possible by-products).

For the present study, casual inspection of the soil concentration data shows quick infiltration of imazapyr into moist surface soil, and close correlation between rainfall/irrigation events with eventual leaching of imazapyr into the lower soil depths (down to 30 or 36 inches). Rainfall/irrigation was said to be typical or average for the experimental sites in Iowa and Nebraska. These penetrations into soil are evidence of high mobility. Furthermore, the leaching occurred in soils with characteristics that are not usually associated with high potential for leaching. The soils had relatively high cation exchange capacities, organic matter, and moisture retention capacity. Subsoil clay content was approximately 25-30%.

Aquatic Field Dissipation (835.6300, MRID 41891501, Study Status: Supplemental). Arsenal 2AS rapidly dissipated from shallow ponds in Florida and Louisiana during summer months. Arsenal 2AS applied at the proposed maximum label rate of 1.5 lb ae/acre dissipated

with half-lives of 3 and 4 days in pond water and sediment, respectively. In a similar study carried out in Louisiana, Arsenal 2AS dissipated with half-lives of 2 and 4 days in pond water and sediment, respectively. The analytical detection limits were too high to provide an understanding of the formation and decline kinetics of the degradation kinetics. Because these studies were conducted in shallow ponds during the summer months, the rapid dissipation observed in these studies may not be representative of dissipation rates at other aquatic environments.

Forestry Dissipation (835.6400, MRID 40003714, Study Status: Supplemental). Imazapyr applied by aerial spray to a forest dissipated primarily by runoff, and to a lesser degree, by foliar absorption. Arsenal was applied by helicopter at 2.24 kg/ha (2 lb ae/acre) with Igepal DM-710 as a surfactant, over two forested watersheds in Fayette and Randolph counties, Alabama, in May and June, 1985. Each site was divided into two water sheds, one treated and one control. Precipitation was measured at each site, and stream water levels were monitored. Samples were taken of water, suspended sediment, vegetation (composited), litter, and soil (up to 20 inches depth), the latter by area of ridge, mid-slope and lower slope.

Description, Fayette county site. This was a 121-ha site of mixed hardwoods. Pines in the plot had been harvested earlier. The application took place over 4 days due to weather conditions of intermittent fog and drizzle. The plot was drained by a single stream. The soil was sand loam (1.92% organic matter, CEC 3.7 meq/100 g).

Description, Randolph county site. This was a 40-ha area of loblolly pine seedlings and mixed hardwoods. The plot was drained by a single stream. The underlying soil was loam (4.4% organic matter, CEC 4.17 meq.100 g).

Results, Fayette county. Imazapyr dissipated from vegetation with a half-life of 12 days (highest mean residue, about 100 ppb at 3 days post-treatment), from litter with a half-life of 44 days, from 0-4-inch depth of bare ground soil with a half-life of 24 days, and from 0-4-inch depth litter-covered soil with a calculated half-life of 19 days. Residues were found primarily in the 0-12-inch soil depth. Residues in stream grab samples were highest during application (up to 680 ppb) and following storm events. Stream residues declined to trace amounts at later sampling intervals. Only one stream sediment sample contained a detectable residue, 52 ppb.

Results, Randolph county. Imazapyr dissipated from vegetation with a half-life of 40 days (highest mean residue, 122 ppb immediately post-treatment), from litter with a half-life of 37 days, from 0-4-inch depth of bare ground soil with a half-life of 26 days, and from 0-4-inch depth litter-covered soil with a calculated half-life of 34 days. Residues were found primarily in the 0-12-inch soil depth. Visual observation indicated at least 99% kill of all targeted vegetation.

Bioconcentration in Aquatic Non-target Organisms (850.1730, MRID 45119707. Study Status: Supplemental). Parent imazapyr did not bioconcentrate appreciably in the fish and crayfish species tested (three fish and one crayfish species at each site, total of four different species). There were no tests for degradates in any of the test species. It should be noted that the

reported limit of quantitation for parent in tissue was a relatively high 50 ppb. In several instances, for unknown or unverified reasons, there was some limited mortality of some test species and/or their partial disappearance, such that for some sampling intervals there were insufficient amounts of tissue for analysis. However, this does not significantly alter the general conclusion of no appreciable bioconcentration of parent above a concentration of 50 ppb.

Bioconcentration in Aquatic Non-target Organisms (850.1730, MRID 45119709, Study Status: Supplemental). Under test conditions (28-day exposure periods at mean measured concentrations of 250 ppb for oysters and 260 ppb for shrimp followed by 14-day depuration periods), overall results for the two test species, oyster and shrimp, are essentially the same. There was no bioconcentration of pyridyl-6-^{14}C-imazapyr [bioconcentration factor (BCF) <1)]. The study was deficient for both oyster and shrimp because of relatively high levels of quantitation (LOQ; 72 ppb for oyster, 128 ppb for shrimp) compared to exposure concentrations. Consequently, because of the relatively low and variable concentrations of residues compared to the LOQ, uptake and depuration rates of imazapyr could not be calculated meaningfully, and no metabolite identification work was conducted. The information was considered supplemental, but no additional studies are needed.

APPENDIX B-Transformation Products in Environmental Fate Studies

Study MRID	Study Type	System	Imazapyr half-life	Maximum transformation products (% of applied radiation)					
				CL 288247 [1]	CL 252974	CL 119060	CL 9140	CL 252974 5	CO_2
00132359	Hydrolysis (161-1)	pH 5 at 25°C	Stable	ND[2]	ND	ND	ND	ND	ND
		pH 7 at 25°C	Stable	ND	ND	ND	ND	ND	ND
		pH 9 at 25°C	Stable	ND	6.9	ND	ND	ND	ND
00131617	Photolysis in water (161-2)	pH 5 and 9 at 25°C (12 hour exposure cycle)	2.5 - 5.3 days	ND	ND	9.7	22.7	ND	NA[3]
40003713	Photolysis in soil (161-3)	Loamy sand soil	Stable (~149 days)	ND	ND	ND	ND	ND	NA
41023201	Aerobic Soil Metabolism (162-1)	Loamy sand soil	Stable	ND	ND	ND	ND	ND	7
45119701	Aerobic Soil Metabolism (162-1) (Supplemental)	Loamy sand soil	(~5.9 years) >296 days	ND	3	ND	ND	ND	6
00131619	Anaerobic Soil Metabolism (162-2)	Loamy sand soil	Stable (>60 days)	ND	ND	ND	ND	ND	ND
40003712	Anaerobic Aquatic Metabolism (162-3)	Total system	>120 days	ND	ND	ND	ND	ND	ND
41002301	Aerobic Aquatic Metabolism (162-4)	Total system	>120 days	ND	ND	ND	ND	ND	1.1
45119702	Aerobic Aquatic Metabolism (162-4) - Degradate metabolism	Total system							
		(CL 119060 metabolism)	4.9 days	NA	NA	NA	20.4	ND	44.9
		(CL 9140 metabolism)	3.6 days	NA	NA	NA	NA	ND	53
42192101	Terrestrial field dissipation (164-1)	Bare ground / Silt loam soil Hillsboro, Oregon	143 days	NA	NA	NA	NA	NA	NA
42192102	Terrestrial field dissipation (164-1)	Bare ground / Sandy loam soil Janesville, North Carolina	64 days	NA	NA	NA	NA	NA	NA
40003714	Forestry Dissipation (164-3)	Aerial application, residues measured	12-40 days (vegetation) 37-44 days (litter)	NA	NA	NA	NA	NA	NA

APPENDIX C- Ecological Effects Data

Studies are with imazapyr acid, unless otherwise noted

71-1 Avian Acute Oral (850.2100)

Bobwhite Quail. MRID 00131633 (Acceptable). In a 14-day oral gavage study, imazapyr acid was determined to be practically non-toxic to bobwhite quail with an LD_{50} of >2,150 mg ae/kg. The study is scientifically sound and follows the guideline protocols.

Mallard Duck. MRID 00131634 (Acceptable). In a 14-day oral gavage study, imazapyr acid was determined to be practically non-toxic to mallard ducks with an LD_{50} of >2,150 mg ae/kg. The study is scientifically sound and follows the guideline protocols.

71-2 Avian Subacute Dietary (850.2200)

Imazapyr acid
Bobwhite Quail. MRID 00131635 (Acceptable). In an 8-day dietary study, imazapyr acid was determined to be practically non-toxic to upland game birds (bobwhite quail) with an LC_{50} >5000 ppm. The study is scientifically sound and generally followed guideline protocols; however, there was some unexplainable low weight gains and mortality at the 625 ppm test concentration.

Mallard. MRID 00131636 (Acceptable). In an 8-day dietary study, imazapyr acid was determined to be practically non-toxic to mallard ducklings with an LC_{50} >5000 ppm.. The study is scientifically sound and generally followed guideline protocols.

Imazapyr isopropylamine salt
Bobwhite Quail. MRID 00147115 (Acceptable). In an 8-day dietary study, the isopropylamine salt of imazapyr was determined to be practically non-toxic to upland game birds (bobwhite quail) with an LC_{50} >5000 ppm. The study is scientifically sound and generally followed guideline protocols. This study was conducted with the formulated product to ensure that isopropylamine did not affect the toxicity of the active ingredient.

71-4 Avian Reproduction (850.2300)

Bobwhite Quail. MRID 45119714a (Acceptable). In a one-generation reproductive toxicity study, imazapyr acid produced no evidence of treatment-related adverse effects on adult or reproductive parameters with an NOAEC of 1670 ppm. The study is scientifically sound and generally followed guideline protocols.

Mallard. MRID 45119714b (Invalid). In a one-generation reproductive toxicity study, imazapyr acid resulted in a significant reduction in the ratio of viable embryos/eggs at the 1,670 ppm

treatment level. However, the study was determined to be invalid due to bacterial contamination and high embryonic mortality in the controls. EFED recommended that another study be conducted to determine the reproductive toxicity of imazapyr to waterfowl.

Bobwhite Quail. MRID 43831401 (Originally Supplemental; Reclassified Core). In a one-generation reproductive toxicity study, imazapyr acid resulted in reduced hatchlings/live embryo at 2000 ppm (LOEC; NOEC = 1000 ppm); however, the study was originally determined to be supplemental due to guideline deficiencies (primarily, EECs would be higher than highest dose tested and control egg shell cracking was 13%). EFED reevaluated the studies and determined that the dosing did reflect the maximum EEC and that the handling and measurement deficiencies did not reflect a dose-response relationship; consequently, the study was reclassified as core and the NOEC was changed to 2000 ppm.

Mallard. MRID 43831402 (Originally Supplemental; Reclassified Core). In a one-generation reproductive toxicity study, imazapyr acid produced no evidence of treatment-related adverse effects on adult or reproductive parameters with an NOAEC of 1890 ppm (measured concentration; 2000 ppm nominal concentration). However, the study was originally determined to be supplemental due to guideline deficiencies (primarily, EECs would be higher than highest dose tested, inaccurate measurement of egg shell thickness, and insufficient pre-egg laying period.) EFED reevaluated the studies and determined that the dosing did reflect the maximum EEC and that the measurement deficiencies did not reflect a dose-response relationship; consequently, the study was reclassified as core and the NOAEC was established at 2000 ppm.

72-1 Freshwater Fish Acute (850.1075)

Imazapyr acid

Rainbow Trout. MRID 00131629 (Acceptable). In a 96-hour acute test, imazapyr acid was determined to be practically non-toxic to rainbow trout with an LC_{50} of >100 mg/L. The NOEC was determined to be 100 mg/L. The study is scientifically sound and meets guideline protocols.

Bluegill Sunfish. MRID 00131630 (Acceptable). In a 96-hour acute test, imazapyr acid was determined to be practically non-toxic to bluegill sunfish with an LC_{50} of >100 mg/L. The NOEC was determined to be 100 mg/L. The study is scientifically sound and meets guideline protocols.

Channel Catfish. MRID 00131631(Acceptable). In a 96-hour acute test, imazapyr acid was determined to be practically non-toxic to channel catfish with an LC_{50} of >100 mg/L. The NOEC was determined to be 100 mg/L. The study is scientifically sound and meets guideline protocols.

Imazapyr isopropylamine salt

Rainbow Trout. MRID 45119713 (Acceptable). In a 96-hour flow-through test, imazapyr isopropylamine salt was determined to be practically non-toxic to rainbow trout with an LC_{50} of >110 mg ae/L (mean measured concentration; nominal concentration 120 mg ae/L). The NOEC was determined to be 110 mg ae/L. The study is scientifically sound and meets guideline protocols.

Bluegill Sunfish. MRID 00147116 (Acceptable). In a 96-hour test, imazapyr isopropylamine salt was determined to be practically non-toxic to bluegill sunfish with an LC_{50} of >818 mg ae/L (1000 mg ai/L). The study is scientifically sound and meets guideline protocols.

72-2 Freshwater Invertebrate Acute (850.1010)

Imazapyr acid

Daphnia. MRID 00131632 (Core). In a 48-hour acute test, imazapyr acid was determined to be practically non-toxic to daphnids with an EC_{50} of >100 mg/L. The study is scientifically sound and meets guideline protocols.

Imazapyr isopropylamine salt

Daphnia. MRID 00147117 (Core). In a 48-hour static test, imazapyr isopropylamine salt was determined to be practically non-toxic to daphnids with an EC_{50} of 614 mg ae/L (750 mg ai/L). The study is scientifically sound and meets guideline protocols.

72-3a Estuarine/Marine Fish Acute (850.1075)

Silverside Minnow. MRID 41315801 (Acceptable). In a 96-hour flow-through test, imazapyr acid was determined to be practically non-toxic to silverside minnow with an LC_{50} of >184 mg ai/L (mean measured concentration; nominal concentration 200 mg ai/L). The NOEC was determined to be 184 mg ai/L. The study is scientifically sound and meets guideline protocols.

72-3b Estuarine/Marine Invertebrate Acute (850.1025, 850.1045)

Eastern Oyster. MRID 45119710 (Acceptable). In a 96-hour flow-through test, imazapyr acid was determined to be practically non-toxic to the eastern oyster with an EC_{50} of >132 mg ai/L (mean measured concentration; nominal concentration 120 mg ai/L). No mortalities were observed in either the treated or control groups. The control shell deposition during the study was 2.46 mm. The NOAEC was determined to be 132 mg ai/L, the highest concentration tested. No significant adverse effects were observed on shell deposition for any treated group. The study is scientifically sound and meets guideline protocols.

Eastern Oyster. MRID 41315802 (Supplemental). In a 96-hour flow-through test, imazapyr acid was determined to be practically non-toxic to the eastern oyster with an EC_{50} of >173 mg ai/L (mean measured concentration; nominal concentration 200 mg ai/L; the highest concentration tested). No mortalities were observed in either the treated or control groups. There was a statistically significant decrease in mean shell deposition at 173 mg/L when compared to the

control group ($p \leq 0.05$). The NOAEC was determined to be 109 mg ai/L. Originally, this study was classified as invalid because the control oyster growth (1.35 mm new shell deposition) did not meet the guideline requirement of 2 mm (amendment to SEP, dated 9/1990). In addition, the flow rate of the test solution was 1.05 L/oyster/hour. The protocols recommended by the SEP (APHA, 1981 and EPA, 1976) state that each oyster should receive a minimum of 5 L/oyster/hour. This study was later upgraded to supplemental. The memorandum stated that shell growth in the control group may be used as an indicator of stress for the oysters. Less than 2 mm shell growth in the control group indicates that the oysters may be undergoing stress. The low flow-through rate with no supplemental food added in this study may have contributed to stress on the oysters. For this study, it appears that the seawater was trucked in from the ocean to Gainesville, Florida. During such time, the food organisms (such as algae) may have been inhibited during the transport and storage. The oysters in the study may not have fed well because of the combination of the lower amount of available food organisms in the shipped sea water, the low flow rate and the lack of supplemental food added; thereby, contributing to inadequate shell deposition. However, since there was some dose-response, the study was upgraded to supplemental.

Pink Shrimp. MRID 41315803 (Acceptable). In a 96-hour flow-through test, imazapyr acid was determined to be practically non-toxic to pink shrimp with an LC_{50} of >189 mg ai/L (mean measured concentration; nominal concentration 200 mg ai/L). There was one mortality at the second highest concentration level (111 mg/L), which does not appear to be related to treatment. No other signs of toxicity were observed. Therefore, the NOAEC was determined to be 189 mg ai/L, the highest concentration tested. The study is scientifically sound and meets guideline protocols.

72-4a Freshwater Fish Early Life Stage (850.1400)

Fathead Minnow. MRID 45119711 (Acceptable). In an early life-stage flow-through test, imazapyr acid produced no treatment-related effects on embryonic survival, time to hatch, alevin survival, terminal length, or wet and dry weight. The NOEC was determined to be 118 mg ai/L (mean measured concentration; nominal concentration 120 mg ai/L). The study is scientifically sound and meets guideline protocols.

Rainbow Trout. MRID 41315804 (Supplemental). In an early life-stage flow-through test, imazapyr acid resulted in significantly reduced percent hatch and an observed reduction on survival at 92.4 mg/L (mean measured concentration; nominal concentration 100 mg/L). No abnormalities in embryonic or juvenile development were observed. The MATC was >43.1 and <92.4 mg/L; thus the geometric mean MATC was 63.1 mg/L. The study did not meet all guideline requirements (feeding limited the growth of replicates with higher fish densities).

72-4b Freshwater Invertebrate Life Cycle (850.1300)

Daphnia. MRID 41315805 (Acceptable). In a life cycle flow-through test, imazapyr acid produced no treatment-related effects on survival, growth and reproduction of first generation

daphnids. No physical or behavioral abnormalities were observed. The MATC and NOEL were determined to be ≥97.1 mg/L. The study is scientifically sound and meets guideline protocols.

72-5 Freshwater Fish Life Cycle (850.1500)

Fathead Minnow. MRID 45119712 (Supplemental). In a full life cycle flow-through test, imazapyr acid produced no treatment-related effects on growth, embryo survival, time to hatch, or larval and juvenile survival of the F_0 and F_1 generations. No treatment-related effects were observed on percent spawning frequency, mean number of eggs produced per female or mean percent fertilization success. The NOEC was reported at the nominal concentration of 120 mg ai/L (mean measured concentration 118 mg ai/L). The study is scientifically valid but did not meet all guideline requirements (F_1 generation was maintained for 4 weeks instead of 8 weeks).

81-1 Acute Mammalian Oral

Imazapyr acid
Rat. MRID 132030 (Acceptable). In an acute oral study, imazapyr acid was determined to have a low toxicity (Toxicity Category III) to rats with an LD_{50} >5000 mg/kg. The study is scientifically sound and meets guideline protocols.

Imazapyr isopropylamine salt
Rat. MRID 00147049 (Acceptable). In an acute oral study, imazapyr isopropylamine salt was determined to exhibit no toxicity (Toxicity Category IV) to rats with an LD_{50} of >5000 mg/kg (>4090 mg ae/kg). The study is scientifically sound and meets guideline protocols.

Rat. MRID 44735301 (Acceptable). In an acute oral study, imazapyr isopropylamine salt was determined to exhibit no toxicity (Toxicity Category IV) to rats with an LD_{50} of >5000 mg/kg (>4090 mg ae/kg). The study is scientifically sound and meets guideline protocols.

83-3 Mammalian Developmental

Rat. MRID 00131611 (Acceptable). In a 2-generation developmental study, imazapyr acid produced maternal toxicity in Sprague Dawley rats at 1000 mg ai/kg/day (LOAEL), based on salivation in the gravid dams between gestation days 8-15. The findings were determined to be treatment-related. The NOAEL was 300 mg /kg bw/day. No treatment-related effects were reported for developmental parameters. The study is scientifically sound and meets guideline protocols.

Rabbit. MRID 00131613 (Acceptable). In a 2-generation teratology study, imazapyr acid produced no treatment-related effects for maternal or developmental parameters; consequently, the NOAEL for both endpoints was ≥400 mg/kg bw/day in New Zealand white rabbits. The study is scientifically sound and meets guideline protocols.

83-4 Mammalian Reproduction

Rat. MRID 41039505 (Acceptable). In a 2-generation reproduction study, imazapyr acid produced no treatment-related effects for maternal or developmental parameters; consequently, the parental systemic, reproductive, and offspring NOAEL was ≥738 mg/kg bw/day in males and 933.3 mg/kg bw/day in females. The study is scientifically sound and meets guideline protocols.

122-2 Aquatic Plant Nonvascular (850.5400)

Imazapyr acid
Green algae. MRID 40811802 (Acceptable). In a Tier II toxicity test with *Selenastrum capricornutum*, the 7 day EC_{50} for cell density was 71 mg ai/L (NOEC = 50.9 mg ai/L). The study is scientifically sound and meets the guideline protocols.

Blue-green algae. MRID 40811802 (Acceptable). In a Tier II toxicity test with *Anabaena flos-aquae*, the7-day EC_{50} for cell density was 12.2 mg ai/L (NOEC = 9.6 mg ai/L). The study is scientifically sound and meets the guideline protocols.

Marine diatom. MRID 40811802 (Acceptable). In a Tier II toxicity test with *Skeletonema costatum*, the 7-day EC_{50} for cell density was 92 mg ai/L (NOEC = 15.9 mg ai/L). The study is scientifically sound and meets the guideline protocols.

Diatom. MRID 40811802 (Acceptable). In a Tier II toxicity test with *Navicula pelliculosa*, the 7-day EC_{50} for cell density was >41 mg ai/L (NOEC = 41 mg ai/L). The study is scientifically sound and meets the guideline protocols.

Imazapyr isopropylamine salt
Green algae. MRID 43889102 (Acceptable). In a Tier II toxicity test with green algae, the 7-day EC_{50}, based on slight changes in cell shape was 11.5 mg ae/L (NOEC = 7.16 mg ae/L). The study is scientifically sound and meets the guideline protocols.

123-1(a) Seedling Emergence - Tier II (850.4225)

Imazapyr Acid
Monocots (4 species) and Dicots (4 species). MRID 40811801 (Supplemental). In a Tier II seedling emergence study, the most sensitive monocot tested was wheat (EC_{25} 0.0046 lb ae/acre, EC_{05} 0.00099 lb ae/acre; shoot weight). The most sensitive dicot tested was sugarbeet (EC_{25} 0.0024 lb ae/acre, EC_{05} 0.00017 lb ae/acre; shoot weight). Due to deficiencies in the study, the guideline requirements are only partially fulfilled; acceptable data endpoints were used in the risk assessment.

Nontarget Terrestrial Plant Seedling Emergence Toxicity (Tier II)

Species	% ai	EC25 (lbs ai/A)	NOEC / [EC05]	Endpoint Affected	MRID No.	Study Classification
	22.6%				408118-01	
Monocot- Corn		0.025	0.0156	height		invalid[2]
Monocot- Oat		0.054	0.0156	"		supplemental[3]
Monocot- Onion		0.034	[0.01][A]	weight[4]		supplemental[3]
Monocot- Wheat		0.0046	[0.00099][A]	"		supplemental[3]
Dicot- Sunflower		0.0027	[0.000021][A]	height		invalid[2]
Dicot- Soybean		0.012	0.0078	"		invalid[2]
Dicot- Pea		0.093	0.0624	weight[4]		invalid[2]
Dicot-Cucumber		0.0043	[0.000005][A]	"		invalid[2]
Dicot- Sugarbeet		0.0024	[0.00017][A]	"		supplemental[3]
Dicot- Tomato		0.008	0.0003	"		supplemental[3]

[1]Determination of the most sensitive species is based on EC_{25} values; results are based on the non-linear regression analysis.

[2] Large seedlings were subjected to overcrowding, 10 seeds were planted in a 4-in dixie cup.

[3] Small seedlings could be subjected to overcrowding, 10 seeds were planted in a 4-in dixie cup.

[4] Fresh weight was recorded instead of dry weight.

[A] The NOEC value is above the EC25, equal to the EC25, or below the lowest concentration, an EC05 value is used instead. .

123-1(b) Vegetative Vigor - Tier II (850.4250)

Imazapyr acid

Monocots (4 species) and Dicots (4 species). MRID 40811801 (Supplemental). In a Tier II vegetative vigor study, the most sensitive monocot tested was wheat (EC_{25} 0.012 lb ae/acre, NOEC 0.0039 lb ae/acre; shoot weight). The most sensitive dicot tested was cucumber (EC_{25} 0.0009 lb ae/acre, EC_{05} 0.000064 lb ae/acre; shoot height). Due to deficiencies in the study, the guideline requirements are partially fulfilled; acceptable data endpoints were used in the risk assessment.

Species	% a.i.	EC_{25} (lbs ae/A)	NOEC [EC05] (lbs ae/A)	Endpoint affected	MRID No.	Study classification
	22.6%				408118-01	
Monocot-Corn		>0.0156[A]	0.0078	weight[2]		supplemental[3]
Monocot-Oats		0.013	0.0039	height		supplemental[3]
Monocot-Onion		--	--	n/a[C]		invalid
Monocot-Wheat		0.012	0.0039	weight[2]		supplemental[3]
Dicot-Soybean		--	--	n/a[C]		invalid
Dicot-Pea		--	--	n/a[C]		invalid
Dicot-Sugarbeet		0.00097	[0.00039][B]	weight[2]		supplemental[3]
Dicot-Sunflower		0.0054	0.0039	weight[2]		supplemental[3]
Dicot-Cucumber		0.0009	[0.000064][B]	height		supplemental[3]
Dicot-Tomato		>0.0156[A]	0.00097	weight[2]		supplemental[3]

[1]Determination of the most sensitive species is based on EC_{25} values.

[2] Fresh weight was recorded instead of dry weight.

[3] the toxicity values could be underestimated since the study was tested with older plants (28D) at a less sensitive stage of growth (timing of application).

[A] The EC25 value is above the highest concentration tested.

[B] The NOEC value is above the EC25, equal to the EC25, or below the lowest concentration, an EC05 value is used instead.

[C] No data

Imazapyr isopropylamine salt

Monocots (3 species) and Dicots (2 species). MRID 43889101 (Core). In a Tier II vegetative vigor study, chlorosis, stunting, and plant death were observed. The most sensitive monocot tested was onion (EC_{25} 0.010 lb ae/acre, NOEC 0.004 lb ae/acre; shoot weight). The most sensitive dicot tested was sugar beet (EC_{25} 0.0016 lb ae/acre, NOEC 0.0008 lb ae/acre; shoot weight). The study is scientifically sound and meets guideline protocols.

Monocots (4 species) and Dicots (4 species). MRID 40003711 (Supplemental). This study was a modified Tier II vegetative vigor study that did not meet guideline requirements. Only

descriptive summary data was presented; consequently effect levels were not determined. Observed effects included chlorosis, stunting, leaf tip burning, necrosis, and plant death.

123-2 Aquatic Plant Vascular (850.4400)

Imazapyr acid

Duckweed. MRID 40811802 (Acceptable). In a 14-day toxicity test with duckweed, the EC_{50} for frond production was 0.024 mg ai/L and the NOEC was 0.01 mg ai/L. Imazapyr is considered highly toxic and expected to exert a detrimental effect on vascular aquatic plants. The study is scientifically sound and meets guideline protocols.

Imazapyr isopropylamine salt

Duckweed. MRID 43889102 (Acceptable). In a 14-day toxicity test with duckweed, the EC_{50} for frond production was 0.018 mg ai/L and the NOEC was 0.011 mg ai/L. The study is scientifically sound and meets guideline protocols.

APPENDIX D

The Screening Imbibition Program (SIP v.1.0, Released June 15, 2010) was used to calculate an upper bound estimate of exposure using imazapyr's solubility (acid: 11,100 mg/L), the most sensitive acute and chronic avian toxicity endpoints (bobwhite quail LD_{50}>2,150 mg ae/kg-bw, MRID 00131633; and bobwhite quail NOAEC of 1670 mg ae/kg-diet, MRID 45119714 as well as mallard duck NOAEC of 1890 mg ae/kg-diet, MRID 43831402) and the most sensitive acute and chronic mammalian toxicity endpoints (rat LD_{50}>5,000 mg ae/kg-bw, MRID 00132030; and, a rat NOAEL of 300 mg/kg-bw/day, MRID 00131611). Drinking water exposure alone was determined to be a potential pathway of concern for avian and mammalian species on an acute and chronic basis. However, given that most studies indicated no effects (with the exception of the rat developmental study, MRID 00131611) it is possible that the result is largely due in part by the high solubility limit of imazapyr.

This pathway will be explored further with the development of SIP v.2.0 in the Ecological Risk Assessment for imazapyr. See table below for a sample of the output generated by SIP v.1.0. Detailed information about the SIP v.1.0, as well as the tool, can be found on the EPA's website at http://www.epa.gov/pesticides/science/models_pg.htm#terrestrial.

Table 1. Inputs

Parameter	Value
Chemical name	Imazapyr (acid)
Solubility (in water at 25°C; mg/L)	11100
Mammalian LD_{50} (mg/kg-bw)	5000
Mammalian test species	laboratory rat
Body weight (g) of "other" mammalian species	
Mammalian NOAEL (mg/kg-bw)	300
Mammalian test species	laboratory rat
Body weight (g) of "other" mammalian species	
Avian LD_{50} (mg/kg-bw)	2150
Avian test species	northern bobwhite quail
Body weight (g) of "other" avian species	
Mineau scaling factor	1.15
Mallard NOAEC (mg/kg-diet)	1890
Bobwhite quail NOAEC (mg/kg-diet)	1670
NOAEC (mg/kg-diet) for other bird species	
Body weight (g) of other avian species	
NOAEC (mg/kg-diet) for 2nd other bird species	
Body weight (g) of 2nd other avian species	

Table 2. Mammalian Results

Parameter	Acute	Chronic
Upper bound exposure (mg/kg-bw)	1909.2000	1909.2000
Adjusted toxicity value (mg/kg-bw)	3845.8028	230.7482
Ratio of exposure to toxicity	0.4964	8.2740
Conclusion*	**Exposure through drinking water alone is a potential concern for mammals**	**Exposure through drinking water alone is a potential concern for mammals**

Table 3. Avian Results

Parameter	Acute	Chronic
Upper bound exposure (mg/kg-bw)	8991.0000	8991.0000
Adjusted toxicity value (mg/kg-bw)	1548.9235	93.7677
Ratio of exposure to acute toxicity	5.8047	95.8859
Conclusion*	**Exposure through drinking water alone is a potential concern for birds**	**Exposure through drinking water alone is a potential concern for birds**

*Conclusion is for drinking water exposure alone. This does not combine all routes of exposure. Therefore, when aggregated with other routes (*i.e*., diet, inhalation, dermal), pesticide exposure through drinking water may contribute to a total exposure that has potential for effects to non-target animals.

APPENDIX E

The Screening Tool for Inhalation Risk (STIR v.1.0, November 19, 2010) was used to calculate an upper bound estimate of exposure using imazapyr acid's vapor pressure ($<10^{-7}$ mm Hg) and molecular weight (293.16 g/mol) for vapor phase exposure as well as the maximum application rate (1.5 lb a.i./A) and method of application for spray drift (i.e., ground and aerial spray). STIR incorporates results from several toxicity studies including acute oral and inhalation rat toxicity endpoints obtained from the "six-pack" of core studies, which are a series of six guideline studies that are submitted to the Registration Division of the Office of Pesticide Programs for technical and formulated products of a pesticide. The technical grade acute inhalation study (Guideline 870.1300) data was obtained from an HED risk assessment (US EPA 2010): LC_{50}> 1.3 mg/L (MRID 00252004); the typical duration for these studies is 4 hours, which was assumed for this study as well. The most sensitive acute oral avian toxicity endpoint (bobwhite quail LD_{50}>2,150 mg ae/kg-bw, MRID 00131633) and most sensitive acute mammalian endpoint (rat LD_{50}>5,000 mg ae/kg-bw, MRID 00132030) were obtained from ecological toxicity studies submitted to EFED. Based on the results of the STIR model, inhalation exposure alone was not determined to be a potential pathway of concern for avian and mammalian species on an acute basis.

Inhalation exposure via spray drift and/or vapor-phase of the pesticide alone does not appear to be of concern. The analysis of the inhalation route in STIR does not consider that aggregation with other exposure pathways such as dietary, dermal, or drinking water may contribute to a total exposure that has a potential for effects to non-target animals. However, the Agency does consider the relative importance of other routes of exposure in situations where data indicate that pesticide exposures through other routes may be potentially significant contributors to wildlife risk (USEPA, 2004). Detailed information about STIR v.1.0, as well as the tool, can be found on the EPA's website at: http://www.epa.gov/pesticides/science/models_pg.htm#terrestrial.

References;

USEPA. 2004. Overview of the Ecological Risk Assessment Process in the Office of Pesticide Programs. U.S. Environmental Protection Agency, Office of Prevention, Pesticides and Toxic Substances, Office of Pesticide Programs, Washington DC. January 23, 2004.

USEPA. 2010. Imazapyr: Revised Occupational and Residential Exposure/Risk Assessment Under 24(c) for the Proposed Use of Broadcast Application on Cogongrass in Areas that may be Grazed or Cut for Hay. U.S Environmental Protection Agency, Office of Chemical Safety and Pollution Prevention, Office of Pesticide Programs, Washington DC. July 27, 2010.

Sample input/output:

Input	
Application and Chemical Information	
Enter Chemical Name	Imazapyr
Enter Chemical Use	various
Is the Application a Spray? (enter y or n)	y
If Spray What Type (enter ground or air)	air
Enter Chemical Molecular Weight (g/mole)	261.28
Enter Chemical Vapor Pressure (mmHg)	1.00E-07
Enter Application Rate (lb a.i./acre)	1.5
Toxicity Properties	
Bird	
Enter Lowest Bird Oral LD_{50} (mg/kg bw)	2150
Enter Mineau Scaling Factor	1.15
Enter Tested Bird Weight (kg)	0.178
Mammal	
Enter Lowest Rat Oral LD_{50} (mg/kg bw)	5000
Enter Lowest Rat Inhalation LC_{50} (mg/L)	1.3
Duration of Rat Inhalation Study (hrs)	4
Enter Rat Weight (kg)	0.35

Output		
Results Avian (0.020 kg)		
Maximum Vapor Concentration in Air at Saturation (mg/m^3)	1.58E-03	
Maximum 1-hour Vapor Inhalation Dose (mg/kg)	1.98E-04	
Adjusted Inhalation LD_{50}	3.12E+00	
Ratio of Vapor Dose to Adjusted Inhalation LD_{50}	6.36E-05	**Exposure not Likely Significant**
Maximum Post-treatment Spray Inhalation Dose (mg/kg)	1.44E-01	
Ratio of Droplet Inhalation Dose to Adjusted Inhalation LD_{50}	4.62E-02	**Exposure not Likely Significant**
Results Mammalian (0.015 kg)		
Maximum Vapor Concentration in Air at Saturation (mg/m^3)	1.58E-03	
Maximum 1-hour Vapor Inhalation Dose (mg/kg)	2.49E-04	
Adjusted Inhalation LD_{50}	7.74E+01	
Ratio of Vapor Dose to Adjusted Inhalation LD_{50}	3.22E-06	**Exposure not Likely Significant**
Maximum Post-treatment Spray Inhalation Dose (mg/kg)	1.81E-01	
Ratio of Droplet Inhalation Dose to Adjusted Inhalation LD_{50}	2.34E-03	**Exposure not Likely Significant**