Pest Management Regulatory Agency
Agence de réglementation de la lutte antiparasitaire

Decision Document E95-03

Triasulfuron

The active ingredient triasulfuron and a formulated product, AMBER® 75WG, for control of several broadleaf weeds in Canadian spring wheat production, were granted full registration in August 1992.

This document provides a summary of data reviewed and the rationale for the registration decision concerning triasulfuron and AMBER® 75WG.

This Decision Document has been prepared in keeping with the Pest Management Regulatory Agency's ongoing efforts to regulate pest control products in an open and transparent manner.

(*publié aussi en français*)

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1.0 Summary

The purpose of this document is to summarize data submitted and reviewed in support of the proposal for the use of triasulfuron herbicide and to announce the formal regulatory decision on this active ingredient and its end-use product AMBER® 75WG. This regulatory decision was made following the review of available data supporting triasulfuron. Triasulfuron was demonstrated to effectively control specific broadleaf weeds when used as a fall or spring application in long-term spring wheat production systems in the brown and dark brown soil zone of Alberta and Saskatchewan.

In laboratory animals, triasulfuron was virtually nontoxic after acute or chronic exposure. It did not adversely affect reproductive capacity, nor was it teratogenic, oncogenic or mutagenic. With regard to occupational hazard and safety, the application of triasulfuron applied as the AMBER® 75WG formulation according to label directions results in an adequate margin of safety (MOS). A maximum residue limit (MRL) of 0.02 parts per million (ppm) has been proposed in triasulfuron-treated wheat. Such residues are not expected to pose a hazard to consumers.

Under prairie field conditions, triasulfuron was observed to be slightly persistent and did not leach appreciably. The major route of transformation of triasulfuron was determined to be by biotransformation by microorganisms. Field data have demonstrated that triasulfuron is persistent in the water of aquatic systems.

Mammals and birds are not expected to be exposed to acute or chronic hazard from the ingestion of residues of triasulfuron on food sources and risk to mammalian and avian reproduction is low. Triasulfuron is expected to be toxic to many terrestrial and aquatic rooted plants. The risk to duckweed and green algae is very high, and there is the potential for loss of wildlife habitat. The impact of triasulfuron on aquatic and terrestrial wildlife habitats will be reduced by the strict contraindication of aerial application, the requirement for the establishment of a 15-metre buffer zone around aquatic and wildlife habitats, and the restriction to use in the brown and dark brown soil regions of southern Alberta and Saskatchewan where there is a lower density of prairie potholes.

After considering the economic benefits and the identified risks associated with triasulfuron use in Canadian prairie spring wheat production, this active ingredient and its end-use product AMBER® 75WG have been granted full registration.

2.0 Pesticide Name and Properties

2.1 Pesticide Name

Common Name:	triasulfuron
Code Number:	CGA-131036
Chemical Name:	1-[2-(2-chloroethoxy)phenylsulphonyl]-3-(4-methoxy-6-methyl-1,3,5-triazin-2-yl)urea
CAS Registry No:	82097-50-5

2.2 Physical and Chemical Properties

2.2.1 Technical Triasulfuron

Empirical Formula:	$C_{14}H_{16}ClN_5O_5S$
Molecular Weight:	401.83
Physical Form:	crystalline solid
Colour:	white to grey
Odour:	odourless
pH:	5.13 at 24° C
Melting Point:	186° C
Vapour Pressure:	1.0×10^{-10} Pa (7.5×10^{-13} mm Hg) at 20° C
Octanol/Water Partition Coefficient(K_{ow}):	0.26

Water Solubility:

pH	Solubility (ppm)
2.5	5
5.0	40
7.0	1,500

Solubility in Organic Solvents:

Solvent	Solubility (ppm)
Acetone	16,000
Methanol	3,400
Methylenechloride	15,000
n-hexane	0.2
n-octanol	180
Xylene	166

2.2.2 Formulated Product

Trade Name:	AMBER® 75WG
Guarantee:	75% triasulfuron
Formulation:	wettable granules

3.0 Development and Use History

Triasulfuron is manufactured in Basle, Switzerland by Ciba-Geigy Ltd. The registrant of triasulfuron technical and the end-use product AMBER® 75WG is Ciba-Geigy Canada Ltd.

Field testing of triasulfuron was initiated in Canada in 1983, and applications to register the technical and end-use product were submitted in November, 1987.

Triasulfuron is currently registered for use in the United States as a post-emergence or pre-emergence treatment in wheat and barley (spring, winter) and as a post-emergence treatment on fallow land.

4.0 Biological Properties

Triasulfuron is a soil applied sulfonylurea herbicide which has characteristic uptake by both plant root and shoot. Rapid translocation of triasulfuron to the growing points of roots and shoots results in inhibition of cell division in susceptible species. After germination, susceptible seedlings in treated soil

usually fail to emerge from the soil surface. Adequate moisture is required after application to move triasulfuron into the seed germination zone of the soil. Tolerant plant species including wheat rapidly metabolize triasulfuron into inactive compounds.

5.0 Regulatory Position and Rationale

Triasulfuron (technical active ingredient and AMBER® 75WG formulation) was virtually nontoxic in various laboratory animals after acute exposure. At the doses tested, technical triasulfuron was not teratogenic in rats or rabbits. It was negative for oncogenicity in rats or mice, and did not adversely affect the reproductive capability of rats. Mutagenicity tests were also negative. Concerning occupational exposure, the range of toxicological studies on triasulfuron failed to demonstrate any major health hazards. The theoretical MOS for a typical farmer using an air conditioned closed cab tractor and wearing long sleeves and pants while applying the recommended label rate of AMBER® 75WG is considered to be acceptable. The MOS is substantially increased when chemical-resistant gloves are worn during mixing and loading operations, cleanup and repair.

An evaluation of residue data indicated that residues in the mature grain from wheat plants treated with triasulfuron at the maximum proposed rate are less than the detection limit of 0.01 ppm. Such residues are not considered to pose a hazard to consumers and could be covered by the General Regulation B.15.002(1) of the *Food and Drug Act*. However, taking international MRLs and/or tolerance limits into consideration, an MRL for triasulfuron on wheat at 0.02 ppm was proposed. In view of the very low acute and chronic toxicity of triasulfuron, no guideline for the consumption of drinking water is necessary.

Laboratory studies indicated that triasulfuron is moderately persistent to persistent in aerobic soils, weakly adsorbed to soils, soluble to very soluble and potentially mobile. Under Prairie field conditions, however, triasulfuron was observed to be slightly

persistent and did not leach appreciably. The major route of transformation of triasulfuron in the environment is by biotransformation by microorganisms, but hydrolysis may be increasingly important at pHs below 7. Field data have demonstrated that triasulfuron is persistent in the water of aquatic systems.

Triasulfuron was shown to have low toxicity to bees, earthworms, aquatic invertebrates, soil microorganisms and fish. Mammals and birds are not expected to be exposed to acute or chronic hazard from the ingestion of residues of triasulfuron on food sources. Risk to mammalian and avian reproduction is low. Triasulfuron was not indicated to have a potential to bioaccumulate. Toxicity of triasulfuron to many terrestrial and aquatic rooted plants is expected. The risk to the aquatic plant duckweed and green algae was determined to be very high and a direct overspray of triasulfuron is expected to cause wildlife habitat loss in both terrestrial and aquatic environments. Because triasulfuron use is limited to the brown and dark brown soils which are situated in southern Alberta and Saskatchewan where the density of potholes is less than in other prairie regions, effects to waterfowl habitat will be reduced. The impact of triasulfuron on aquatic and terrestrial wildlife will further be reduced by label contraindication of aerial application, and the requirement for the establishment of a 15-metre buffer zone around aquatic and wildlife habitats.

Acceptable crop tolerance and efficacy of triasulfuron in controlling the broadleaf weeds indicated on the label in spring wheats (Hard Red, Canada Prairie, Durum) when applied as a fall or spring soil applied treatment was demonstrated in field trials conducted in the proposed area of use.

The Pest Management Regulatory Agency has concluded after the review of all available information that the application of triasulfuron as the end-use product AMBER® 75WG is of economic benefit to Canadian spring wheat production and, if used according to label directions, will not pose an unacceptable risk to the user or to the environment.

6.0 Use Summary and Benefits

6.1 Description of Market

The proposed area of use of triasulfuron, the brown and dark brown soil zones of Alberta and Saskatchewan, represents approximately 7 and 2 million hectares of Hard Red Spring/Canada Prairie Spring and Durum wheat production, respectively.

A survey of weeds found in Saskatchewan spring wheat fields was reported by Thomas and Wise, (1987) and the most common broadleaf weed species are summarized in Table 1. Wild Buckwheat was reported to be the most common broadleaf weed in Saskatchewan spring wheat fields, and was reported in two out of three fields. Stinkweed, Redroot Pigweed, Russian Thistle and Lamb's-quarters were the next most common weeds, and were reported in at least one in five fields in Saskatchewan. The species Annual Smartweed sp., Perennial Sow Thistle, Bluebur, Thyme Leaved Spunge, Flixweed, Rose sp. and Kochia were reported in 5-10 percent of the cereal crops surveyed.

Table 1. Frequency of Occurrence of the Most Common Broadleaf Weed Species in Saskatchewan Spring Wheat Fields

	WEED SPECIES	FREQUENCY
1.	Wild Buckwheat	65.9
2.	Stinkweed	35.0
3.	Redroot Pigweed	31.3
4.	Russian Thistle	27.2
5.	Lamb's-quarters	23.7
6.	Cow Cockle	14.7
7.	Canada Thistle	14.0
8.	Wild Mustard	12.2
9.	Shepherd's-Purse	10.2
10.	Prostrate Pigweed	10.0

The frequency of broadleaf weed species found in cereal and oilseed crops grown in the brown and dark brown zones of Saskatchewan (Thomas and Wise, 1987) and Alberta (Thomas and Wise, 1985) is reported in Table 2 (see p. 6). These surveys indicate the frequent occurrence of Russian Thistle, Wild Buckwheat, Stinkweed and Redroot Pigweed in brown and dark brown soil zones. Some species may be more frequent in a particular soil zone; for example, Russian Thistle is more common in the brown soil zone of Alberta compared to other areas, while Lamb's-quarters and Canada Thistle are reported to be more frequent in the dark brown soil zone of this province.

6.2 Proposed Uses

Triasulfuron is proposed for use in the control of specific broadleaf weed species (Table 3) in long-term Hard Red Spring, Canada Prairie Spring and Durum wheat production systems in the brown and dark brown soil zone of Alberta and Saskatchewan only. Triasulfuron has been evaluated for efficacy, crop tolerance and rotational cropping under Canadian prairie field conditions since 1983. Application of triasulfuron is restricted to application by ground equipment only, and application by air is contraindicated on the label.

Triasulfuron should not be applied on snow-covered soil or frozen soil surfaces. Application of triasulfuron is limited to not more than two treatments within a 36-month period in the same field.

Table 2. Frequency of Occurrence of the Common Broadleaf Weed Species in Alberta and Saskatchewan Cereal and Oilseed Fields in the Brown and Dark Brown Soil Zones

	Alberta				Saskatchewan	
	Brown Soils		Dark Brown Soils		Brown Soils	Dark Browns
Weed Species	**chernozemic**	**solonetzic**	**chernozemic**	**solonetzic**	**chernozemic**	**chernozemic**
Russian Thistle	66.3	72.9	21.9	29.3	33.5	30.0
Wild Buckwheat	57.7	84.4	73.9	93.3	49.4	68.7
Stinkweed	45.4	64.6	78.9	86.0	33.1	39.7
Redroot Pigweed	44.2	49.0	35.4	40.7	42.2	33.2
Lamb's-quarters	27.0	51.0	54.7	74.0	16.0	26.1
Kochia	19.6	3.1	4.2	0.7	7.6	6.3
Canada Thistle	11.0	13.5	23.6	33.3	2.3	9.1
Flixweed	9.2	7.3	9.3	16.0	14.4	8.1
Cow Cockle	8.6	12.5	4.8	4.0	23.2	13.8
Wild Mustard	3.7	4.2	14.6	12.7	5.7	8.9

6.2.1 Application Timing

Triasulfuron is proposed as a soil applied treatment at one of the following application times:

(i) Fall application during September or October prior to freeze-up

(ii) Early spring application during April or May prior to weed germination and the seeding of wheat.

6.2.2 Incorporation

For acceptable efficacy, adequate moisture is required after application for movement or incorporation of the product into the seed germination zone of the soil. Adequate moisture is usually available following fall application to move triasulfuron into the seed

germination zone. If rainfall does not occur after spring application, a single shallow mechanical incorporation will be required prior to seeding.

Table 3. Weed Species Controlled or Suppressed With Triasulfuron

USE RATE	WEEDS CONTROLLED	WEED SUPPRESSED
20 grams a.i./ha	Common Peppergrass Cow Cockle Flixweed Redroot Pigweed Stinkweed Tumble Mustard Wild Mustard	Lamb's-quarters
20-25 grams a.i./ha	Kochia* Russian Thistle* Wild Buckwheat*	

* Use the higher rate when fields are known to have high populations, or when weeds have emerged at the time of spraying.

6.2.3 Application Rates/Weeds Controlled

Efficacy data submitted supported the control or suppression of weeds indicated in Table 3 at a rate of application of 20 g a.i./ha. Application of a higher rate up to 25 g a.i./ha for Kochia, Russian Thistle and Wild Buckwheat was determined to be necessary under conditions of heavy weed pressure or emerged weeds at the time of application.

The spectrum of broadleaf weeds controlled by triasulfuron was consistent with the most commonly occurring species reported in weed surveys of spring wheat in Saskatchewan and Alberta. The five most frequently occurring species were either controlled (Wild Buckwheat, Stinkweed, Redroot Pigweed and Russian Thistle) or suppressed (Lamb's-quarters) by triasulfuron application.

Tolerance of hard red spring and Canadian Prairie Spring wheats to triasulfuron application was acceptable. Durum wheat varieties showed variable response to application of triasulfuron, and were therefore considered on an individual basis. Durum wheat showed initial crop injury resulting from triasulfuron applied as a fall or spring application. This injury however, was demonstrated to have no significant effect on crop yield and was determined to be acceptable. Sufficient data was submitted to show acceptable tolerance of the durum wheat varieties Kyle, Medora, Sceptre and Wakooma to triasulfuron application.

6.3 Crop Rotation Intervals

Triasulfuron is proposed for use only in long-term spring wheat production systems due to the persistence of soil residues and the potential for injury to following crops. Persistence of triasulfuron may be influenced by soil characteristics including type, moisture content, temperature and pH. Triasulfuron degradation decreased with decreasing temperature. In alkaline soils the degradation of triasulfuron by hydrolysis is reduced and adsorption to soil is decreased with increasing soil pH. Potential for injury to rotational crops following triasulfuron application on spring wheat is therefore greater in soils with pH of 7.5 or greater.

Rotational cropping studies conducted in the proposed area of use have determined minimal intervals for which major rotational crops may be safely planted into soils treated with triasulfuron applied to the preceding spring wheat crop (Table 4).

Table 4. Interval Required Prior to Seeding Rotational Crops

ROTATIONAL CROP		
	pH 7.5 or less	**pH greater than 7.5**
Spring Wheat (Hard Red, Canada Prairie, Durum)	no restriction	no restriction
INTERVAL REQUIRED (MONTHS AFTER APPLICATION)		
Barley, Oats	10	10
Flax, Canaryseed Grass	22	bioassay
Canola, Peas	34	bioassay
Lentils	46	bioassay
All other crops	bioassay	bioassay

A field bioassay may be necessary to determine if a rotational crop can be planted without risk of injury from possible residues of triasulfuron in the soil. In the field bioassay, strips of the proposed rotational crop to be seeded in the following season are seeded into representative areas of fields with potential triasulfuron residues. Monitoring of the crop for injury symptoms through the growing season up to and including yield is required to determine if any triasulfuron residues in the soil would be injurious to the rotational crop prior to seeding the entire field.

6.4 Grazing Restrictions

Immature wheat crops treated with triasulfuron cannot be grazed, or the straw of mature wheat cannot be fed to livestock after grain harvest; there are not sufficient data available to support such uses.

6.5 Weed Resistance

Some weed biotypes may be present within a population which may not be controlled by triasulfuron application. These biotypes are similarly tolerant to the application of other registered sulfonylurea herbicides including ethametsulfuron-methyl, thifensulfuron-methyl, metsulfuron-methyl and tribenuron-methyl. To reduce selection in favour of sulfonylurea resistant weed biotypes and to slow the development of resistant populations, recommendation

for rotation of triasulfuron with herbicides having modes of action different from sulfonylurea herbicides is stated on the AMBER® 75WG label. In addition, recommendations for management strategies to prevent or delay selection of resistant weed populations are outlined on the label.

6.6 References

A.G. Thomas and R.F. Wise. 1985. Dew's Alberta Weed Survey. 1973-1977. Weed Survey Series, Publication 85.3. Agriculture Canada, Regina Research Station.

A.G. Thomas and R.F. Wise. 1987. Weed Survey of Saskatchewan Cereal and Oilseed Crops, 1986. Weed Survey Series, Publication 87-1. Agriculture Canada, Regina Research Station.

7.0 Toxicology and Occupational Exposure

7.1 Evaluation

The technical material currently being manufactured by Ciba-Geigy Switzerland has a guarantee of 92%. All impurities in the technical product have been identified and are related to the active ingredient and no single ingredient exceeded 1.21% of the total. The technical material has been assessed for nitrosamine contamination and no contaminants were found above the limit of detection of 0.1 ppm.

The formulation proposed for use in Canada, AMBER® 75WG, is a water dispersible granular. The product is marketed in a water soluble sac for direct introduction into the spray tank for mixing.

7.2 Toxicology

7.2.1 Product Chemistry

The technical compound used in the active ingredient (ai) toxicology data base ranged from 95 - 99% chemical purity.

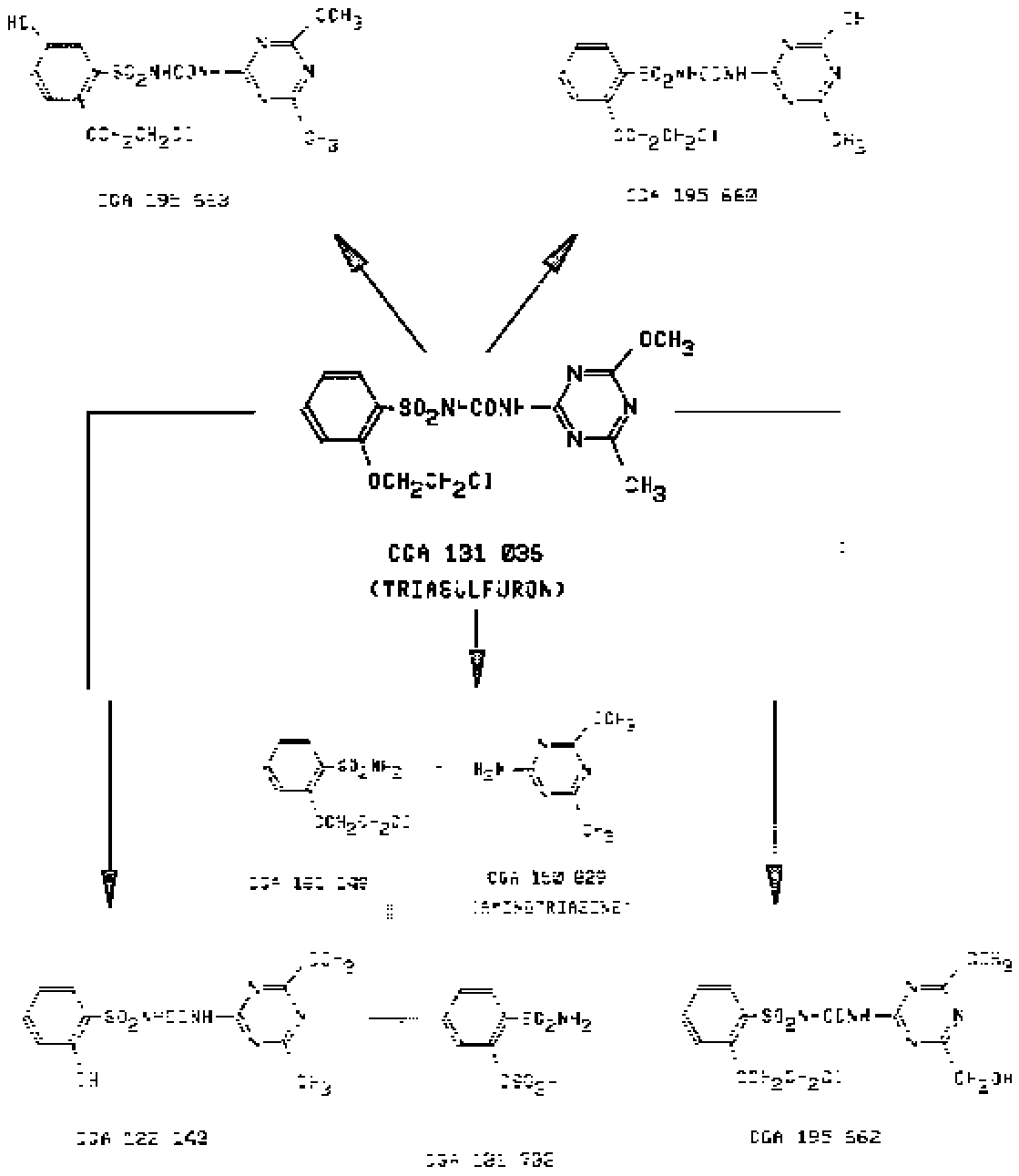
7.2.2 Absorption, Distribution, Excretion and Metabolism - Technical

a) Rat

Single oral doses of 0.5 or 50 mg/kg body-weight (bw) of triasulfuron ^{14}C-labelled on the phenyl ring (study #1) or triazine ring (study #2) were given to male and female Tif:RAIf(SPF) rats. The doses were readily absorbed through the gastrointestinal (GI) tract and most of the activity ($92% of the phenyl-labelled dose and $97% of the triazine label) was excreted within 24 hours, mainly in the urine. The excretion pattern and the rate of excretion were also similar for both sexes and both dose levels. After 168 hours: tissue residues were $\leq$0.1 ppm at the top dose and below the level of determination at the low dose; 83 - 90% of the phenyl-labelled dose was found in the urine, 1 - 16% in the feces and >0.1% in expired air; 70 - 90% of the triazine-labelled dose was in the urine, 4 - 31% in feces and less than 0.3% in expired air. In study #1 the parent compound represented 70 - 95% of urine activity and 72% of faecal activity; in study #2 it represented 86 - 95% and 73% of the urinary and faecal activities respectively. Initial one-dimensional thin layer chromatography (TLC) showed the remaining urine and faecal activity (2 - 13%) to be associated with three minor metabolites

for both ^{14}C label positions. Cleavage of the sulfonylurea bridge between the phenyl and triazine moieties did not occur to a significant extent: only 2% of the urinary radioactivity was present as single ring compounds (phenyl sulfonylurea) in study #1; no ^{14}C-aminotriazine was found in study #2, except in small amounts in body tissues. In a later report using ^{14}C-phenyl labelled triasulfuron, 7 of 14 compounds isolated from the rat urine in study 1 were characterized by 2-dimensional TLC: triasulfuron represented 68% of the urinary radio-activity and 6 minor metabolites each accounted for less than 3.7% (See Figure 1).

Figure 1. Proposed Metabolic Profile for Triasulfuron in Animals



Chemical Names of Metabolites from the Proposed Metabolic Scheme in Figure 1

CGA 131 036 1-[2-(2-chloroethoxy)phenylsulphonyl]-3-
(Parent triasulfuron) (4-methoxy-6-methyl-1,3,5-triazin-2-yl) urea

CGA 195 660 1-[2-(2-chloroethoxy)phenylsulphonyl]-3-(4-hydroxy-6-methyl-1,3,5- triazin-2-yl) urea

CGA 195 663 N-(6-methoxy-4-methyl-1,3,5-triazin-2-yl-aminocarbonyl)-2-
(2-chloroethoxy)-5-hydroxy-benzenesulfonamide

CGA 150 829 2-amino-4-methyl-6-methoxy-triazine

CGA 161 149 2-(2-chloroethoxy)-benzenesulfonamide

CGA 122 143 1-[2-(2-chloroethoxy)phenylsulphonyl]-3-(4-methoxy-6-methyl-1,3,5- triazin-2-yl) urea

CGA 131 733 2-sulfate-benzenesulfonamide

CGA 195 662 1-[2-(2-hydroxy)phenylsulphonyl]-3-(4-methoxy-6-methyl-1,3,5-triazin-2-yl) urea

Similar results were obtained with male and female Wistar rats given a single radio-labelled dose, repeated unlabelled oral doses (14 day) followed by a single radio-labelled oral dose of 0.5 or 300 mg/kg bw/day, or with a single intravenous i.v. labelled dose of 0.5 mg/kg bw. Elimination half-lives were observed to be 24, 8 and >8 hours respectively for single oral (0.5 mg/kg bw), repeated oral and i.v. administration. Only with the 300 mg/kg bw dose were low levels of radioactivity detected in plasma, whole blood and kidneys after 96 hours. Elimination was appreciably slower than at the lower dose level. Adaptation to repeated oral administration at 0.5 mg/kg bw/day was demonstrated by an increased rate of urinary elimination with no change in the metabolic capacity of the rat. One dimensional TLC of cumulative 48 hour urine and faecal extracts showed that the faecal metabolites corresponded to the urinary metabolites.

b) Hen

Repeated (14 day) dose administration of labelled triasulfuron (0.647 mg/bird/day of ^{14}C-phenyl labelled or 0.702 mg/bird/day of ^{14}C-triazine labelled) to laying hens resulted in the major portion of radioactivity being retrieved in the excreta of which up to 82% was the parent compound.

c) Goat

Following repeated (10 day) dose administration of labelled triasulfuron (5 mg/animal/day of either ^{14}C-phenyl labelled or ^{14}C-triazine labelled material) to two goats, approximately 75% of the daily dose was excreted in the urine and 25% in the feces with the majority (72 - 85%) of the radioactivity being the parent compound.

7.2.3 Absorption, Distribution, Excretion and Metabolism - AMBER® 75WG

a) Rat

An experimental preparation of AMBER® 75WG, containing ^{14}C-labelled triasulfuron, (95.3% radiochemical purity) was applied to the dorsal skin of 16 male rats at dose levels of 0.02 or 0.2 mg/rat. The dose sites were occluded and four animals from each group were sacrificed at 2, 4, 10 and 24 hours. Most of the absorption was seen to occur during the first 2 hours of contact. At the low-dose level no activity was detected in feces, blood or the carcass; activity (5 - 11% of the dose) was found in skin samples from sites not associated with application, in only 1 of 4 animals at 4, 10 and 24-hours; urinary loss represented approximately 1.0% of the dose over the 24 hour period. At the high-dose level no activity was found in the feces, blood or carcass; urine loss represented less than 0.5% of the dose throughout the study and >5.0% in non-application site skin samples. The extra-application site skin radioactivity may have been due to contamination from the application site occlusive dressings. Approximately 20% of the dermally applied radioactivity was absorbed over 24 hours, 97% of the absorbed dose was found in the solubilized skin. The fate of the radioactivity found in the application site tissue is uncertain since the observation period did not extend beyond the 24-hour contact interval. However, actual systemic absorption was less than 0.5% at 10 hours and was not appreciably increased at 24 hours.

7.2.4 Acute Toxicity - Technical

LD_{50} values indicated that triasulfuron (95 - 99% pure) was virtually nontoxic in several species tested and by all routes of administration.

Method	Species	Strain	LD_{50} mg/kg/bw
Oral[1]	Mouse (both sexes)	Tif:Mag(SPF)	>8,000
	Hamster (both sexes)	Chinese	>5,000
	Rabbit (both sexes)	NZW	>5,000
	Rat (both sexes)	Tif:RAIF(SPF)	>5,000
Dermal[2]	Rat (both sexes)	Tif:RAIF(SPF)	>2,000
Intraperitoneal[3]	Rat (both sexes)	Tif:RAIF(SPF)	> 200
			LC_{50} mg/L air
Inhalation[4]	Rat (both sexes)	Tif:RAIF(SPF)	>5.2
Primary Irritation[5]			
Sensitization[6]			

1 Clinical signs of toxicity (lasting 9 to 12 days post-administration) including dyspnea, ruffled fur, and c position were observed in all species; exophthalmos was also observed in mice and rats.

2 Observed clinical signs of toxicity (lasting from 2 to 12 days post-administration) were sedation, dyspn exophthalmos, ruffled fur and curved body position.

3 Clinical signs of toxicity, observed for up to 9 days post-administration, were sedation, dyspnea, exoph fur and curved body position.

4 Ruffled fur, the only observed clinical sign of toxicity, was transitory.

5 Triasulfuron was mildly irritating to the skin of NZW rabbits. Triasulfuron was non-irritating to NZW r

6 Triasulfuron did not demonstrate any dermal sensitization potential in Pirbright white guinea pigs using optimization test.

7.2.5 Acute Toxicity - AMBER® 75WG

Method	Species	Strain	LD_{50} mg/kg/bw
Oral[1]	Rat (both sexes)	Tif:Raif(SPF)	>5,000
Primary Irritation[2]			
Sensitization[3]			

1 Clinical signs of toxicity lasting 9 to 12 days after dosing were dyspnea and ruffled fur. Slightly curved was observed in the first four days of treatment.

2 In NZW rabbits, AMBER® 75WG was shown to be minimally irritating to the skin and eyes.

3 AMBER® 75WG did not demonstrate any dermal sensitization potential in Duncan-Hartley albino guinea Buehler test.

7.2.6 Short-Term Oral Toxicity - Technical

a) Rat

Triasulfuron (94.5% purity) was fed in the diet to 10 Tif:RAIF (SPF) rats/sex/group for 4 weeks at levels of 0, 1,000, 3,000 or 10,000 ppm (equal to 0, 79, 241 or 764 mg/kg bw/day for males, and 0, 78, 228 or 686 mg/kg bw/day for females). A No Observed Effect Level (NOEL) could not be established for this study because of a dose-related increase in thyroid weights in males at all dose levels. This finding was not considered to be an adverse effect since there were no observed histopathological lesions of the thyroid glands. A No Observed Adverse Effect Level (NOAEL) of 1,000 ppm (equal to 78 mg/kg bw/day) was assigned on the basis of significant dose-related decreased body-weight gain in males at 3,000 and 10,000 ppm and in females at the highest dose (not statistically significant in females but >10%). Increased kidney weights in females treated at 10,000 ppm were associated with lesions characterized pathologically as pyelonephritis (6/10), hydronephrosis (3/10), and chronic inflammation of the urinary bladder (4/10).

Triasulfuron (94.5% purity) was fed in the diet to 10 Sprague Dawley rats (CRL: COB CD (SD) BR)/sex/group for 13 weeks at levels of 0, 200, 10,000 or 20,000 ppm (equal to 0, 12.5, 643 or 1299 mg/kg bw/day for males and 0, 16.5, 796 or 1285 mg/kg bw/day for females). Additional groups of 5 rats/sex were given 0 or 20,000 ppm of triasulfuron for 13 weeks followed by a normal control diet for an additional 4 weeks. The NOEL was 200 ppm (12.5 mg/kg bw/day). Body-weight gains and food consumption were significantly reduced compared to controls throughout the feeding trial in mid- and high-dose groups. In females, formation of renal calculi and associated pathological changes such as increased hyperplasia and inflammatory infiltration of lymphocytes in renal pelvic and medullary atrophy were observed in mid- and high-dose groups. A number of laboratory parameters (clotting time, total bilirubin, creatinine, and inorganic phosphorus) and organ weights (heart, testes, and kidney) were also statistically significantly altered at the mid- and high-doses. The presence of renal calculi and associated inflammatory changes in recovery female rats after four weeks of control diet suggest that the pathological changes may not be reversible.

b) Mice

Triasulfuron (93.7% purity) was fed in the diet to 20 (Crl: CD-1 (ICR) BR) mice/sex/group for 4 and 13 weeks at levels of 0, 10,000, 20,000, 30,000, 40,000 or 50,000 ppm (equivalent to 0, 1500, 3,000, 4,500, 6,000 or 7500 mg/kg bw/day). Following one week of treatment, the 40,000 ppm level was reduced to 1,000 ppm and the 50,000 level to 5,000 ppm, until week 9 when the dietary levels of test material were returned to their original values. Reduced survival was noted at doses of 40,000 and 50,000 ppm. Based on the average of 91 day cumulative equivalent doses, the upper dose levels were estimated to be 2,400 and 3,346 mg/kg bw/day. The NOEL was 10,000 ppm (1,500 mg/kg bw/day). There was a dose-related increase in liver weights in all treated groups at both 4 and 13 weeks (not statistically significant at the low dose). At the doses of 20,000 and 30,000 ppm, enlarged liver cells and hepatocellular necrosis were observed at termination and prominent location of the liver at interim kill (four weeks).

c) Dog

Triasulfuron (94.5% purity) was fed in the diet to 2 beagle dogs/sex/group for 13 weeks and 6 dogs/sex/group for 52 weeks at levels of 0, 100, 1,000 or 10,000/5,000 ppm (equal to 0, 3.5, 33 or 195 mg/kg bw/day for males and 0, 4, 34 or 212 mg/kg bw/day for females). The high dose of 10,000 ppm was lowered to 5,000 ppm after 10 weeks because of significant weight loss. The NOEL was 1,000 ppm (33 mg/kg bw/day). A number of red blood cell (RBC) parameters (hemoglobin, red blood cells and packed cell volume) were significantly decreased at weeks 4, 13, 26 and 52 in the high-dose (5,000 ppm) female dogs. Histopathological examination revealed an increase in the incidence of hemosiderin-like pigment in the red pulp of the spleen of the high-dose males and females. At the high dose, there was an increased incidence of hepatocellular changes characterized by slight hepatocellular swelling and fine fibrillar vacuolated cytoplasm in the centrilobular areas, but this was not considered to be an adverse effect.

7.2.7 Short-Term Dermal Toxicity - Technical

a) Rabbit

Triasulfuron (95.5% purity) was applied to the dorsal skin of five rabbits/sex/dose group at dose levels of 0, 10, 100 or 1,000 mg/kg bw/day for 6 hours, 5 days/week for 3 weeks. The test sites were covered with a gauze dampened with a solution of carboxymethyl cellulose (0.5%) and Polysorbate (0.1%). There were no mortalities in any dose group. No signs of toxicity were observed in the control group or in low-dose males. Dyspnea and ruffled fur were observed in one female for 3 - 5 days mid-test. In the mid-dose group, dyspnea was observed in 3 males and 3 females and ruffled fur in 2 males and all females. At the high dose, all animals were dyspneic and had ruffled fur; all females and one male were sedated while one of each sex had curvature of the body. Inflammation of the dosing site was observed in most animals (control and treatment) at various times during the course of the study. The authors contend that the dose-related increase in dyspnea and ruffled fur were consistent with "stronger fastening of the dressings as the quantity of test article was increased" and should be considered reactions to the dressing rather than the test article itself. However, since these signs also were observed in the acute oral, dermal, intraperitoneal and inhalation studies, this rationale was not accepted. The authors proposed a NOEL of 100 mg/kg bw/day based on sedation and body curvature at the top-dose. An examination of the study and the toxicology data base indicates that

a NOAEL of 10 mg/kg bw/day is acceptable given the slight, transient and non-lethal nature of these signs observed in only 1/5 females at that dose level.

7.2.8 Long-Term Toxicity/Carcinogenicity - Technical

a) Rat

Groups of 70 Sprague-Dawley (Crl:COBS CD (SD) BR) rats/sex/group were fed triasulfuron (93.7% purity) at levels of 0, 10, 1,000 or 6,000 ppm (equal to 0, 0.3, 32 or 208 mg/kg bw/day for males and 0, 0.4, 41 or 274 mg/kg bw/day for females) for 104 weeks. A NOAEL of 1,000 ppm (32 mg/kg bw/day) was determined. Reduction in both incremental body-weight gain and percent incremental change was minor at this dose; it was also small at the top dose but the differences from the controls were statistically significant. Food consumption was minimally lower throughout the study at the high dose and for short periods at the middle dose. There was no effect of treatment on an increased incidence of specific tumour types.

b) Mice

Groups of 50 outbred (Crl:COBS CD-1(ICR) BR) mice/sex/group were fed diets containing triasulfuron (93.7%, 95.1% and 96.5% purity) for 104 weeks at levels of 0, 10, 1,000, 5,000 or
10,000 ppm (equal to 0, 1, 112, 585 or 1180 mg/kg bw/day for males and 0, 1, 133, 736 or 1378 mg/kg bw/day) for females. The NOAEL was 1,000 ppm (112 mg/kg bw/day). Although there was centrilobular hepatocytomegaly in high-dose females and in the male groups at 1,000 ppm and higher (dose-related), this was not considered to be an adverse effect. At the highest dose
(10,000 ppm) there was hepatocellular degeneration. There was significantly reduced food consumption in the females receiving 5,000 ppm and higher for the initial 11 weeks of the study. There was no effect of treatment on an increased incidence of specific tumour types.

7.2.9 Mutagenicity - Technical

The genotoxicity studies were negative. Triasulfuron was not mutagenic in bacterial, yeast, or mammalian cells; it did not induce nuclear anomalies in the bone marrow cells of Chinese hamsters; and it did not induce unscheduled DNA synthesis in rat hepatocytes or human fibroblasts. A mouse spot test could not be evaluated due to the lack of valid positive control data.

7.2.10 Reproductive Toxicity - Technical

a) Rat

Triasulfuron (95.1% and 96.5% purity) was administered in the diet at levels of 0, 10, 1,000 or 5,000 ppm (equivalent to 0, 0.5, 50 or 250 mg/kg bw/day) to 30 rats of Crl:CD(SD)BR strain/sex/group in a two generation, one-litter/generation reproduction study. The NOEL and the NOAEL for parental effects were 50 and 250 mg/kg bw/day respectively, based on the reduction in body-weight gains in F_0 and F_1 generations (no reduction in F_1 females); at 250 mg/kg bw/day these reductions were <10% and were not considered an adverse effect. The NOEL for embryo-fetal effects was 250 mg/kg bw/day, the highest dose tested.

7.2.11 Teratogenicity - Technical

a) Rat

Triasulfuron (94.5% purity) was administered by gavage at 0, 100, 300 or 900 mg/kg bw/day to groups of 24 mated pregnant Tif:RAIF(SPF) rats on days 6 to 15 of gestation. Triasulfuron was not teratogenic. The NOEL was 100 mg/kg bw/day for maternal toxicity. At doses of 300 and 900 mg/kg bw/day there was a decrease in body-weight gain and food consumption. At the high dose, increased early resorption, reduced fetal weight and increased incidence of minor skeletal anomalies were observed. The NOAEL for embryo-fetal toxicity was 300 mg/kg bw/day. The enhancement of delayed ossification at the middle and high dose was not considered an adverse effect.

b) Rabbit

Triasulfuron (94.5% purity) was administered by gavage at 0, 40, 120 or 240 mg/kg bw/day to groups of mated pregnant Chinchilla rabbits on day 6 to 18 of gestation. Triasulfuron was not teratogenic. The NOEL for maternal toxicity was 120 mg/kg bw/day based on body-weight loss and reduced food consumption in the high-dose group. The NOAEL for embryo-fetal toxicity was 240 mg/kg bw/day. The enhancement of delayed ossification of the forelimbs in the mid- and high-dose groups was not considered an adverse effect.

7.2.12 Toxicology Summary

Triasulfuron was virtually nontoxic in various laboratory animals after acute exposure. At the doses tested, triasulfuron was not teratogenic in rats or rabbits and was not oncogenic in rats or mice. Mutagenicity tests were also negative.

The main treatment-related effects were small decreases in body-weight gain, possibly related to food aversion due to irritation of the gastrointestinal tract in rats, mice, and dogs. The most sensitive species was the rat. In mice, there was liver centrilobular hepatocytomegaly, which is considered an adaptive response; in dogs, there was an effect on red blood cell factors (decreased red blood cells, hemoglobin and packed cell volume plus an increased incidence of hemosiderin-like pigment in the red pulp of the spleen); and in female rats at high doses (643, 1299 mg/kg bw/day), the formation of renal calculi and associated pathological changes such as increased epithelial hyperplasia.

The major route of excretion of orally administered triasulfuron in rats and goats was the urine (most within 24 - 48 hours) with the remainder in the feces. Because of the extent of renal excretion, it was concluded that extensive absorption through the gastrointestinal tract occurred. The predominant urinary and faecal product was the parent compound.

The NOAELs from the 28-day, 90-day, and 2-year studies were 78, 12.5, and 32 mg/kg bw/day, respectively. The Lowest Observed Adverse Effect Levels (LOAELs) in these studies were 228, 643, and 208 mg/kg bw/day, respectively.

7.3 Food Exposure

7.3.1 Acceptable Daily Intake (ADI)

The recommended ADI is 0.32 mg/kg bw/day. This is based on the NOAEL of 32 mg/kg bw/day from the 2-year rat study and a 100-fold safety factor. This decision was based on the fact that a chronic study should take precedence over a 90-day study. Moreover, the levels used in the 90-day study between the low dose (12.5 mg/kg bw/day) and the middle and high doses (643 and 1299 mg/kg bw/day) were far apart.

7.3.2 Residue Levels

a) Label

AMBER® 75WG is applied at a rate of 25 g ai/hectare (ha) either in the fall prior to freeze-up (September or October), or as early in the spring as possible prior to weed germination and seeding (April or May). AMBER® 75WG should not be used more than twice in a 36-month period on the same field.

b) Plant Metabolism

In the available plant metabolism studies, the detailed identification of metabolites was difficult due to the poor translocation and very low concentration of the radioactive residues. Field studies on winter wheat treated near the recommended rate with either ^{14}C-phenyl or ^{14}C-triazine labelled triasulfuron applied at the five-leaf stage, resulted in total residues in grain at harvest of <0.002 ppm total triasulfuron equivalents in both cases. Due to these very low ^{14}C-residues from the field studies, no metabolic pattern could be established.

Additional studies were done in an attempt to reach higher residual levels in grain using stem injection techniques. Plants were stem-injected with 0.3 mg/plant of either ^{14}C-phenyl or ^{14}C-triazine labelled triasulfuron. As in wheat plants treated by spray application, very little radioactivity was translocated from the straw to the grain in the injected plants. Total terminal residues of 0.02 ppm and 0.25 ppm triasulfuron equivalents for the ^{14}C-phenyl and ^{14}C-triazine label respectively, were detected in the harvested samples of wheat grain. For the phenyl label, 85% of the total radioactivity in the grain was non-extractable and the other 15% of the residues which were extractable did not resolve into known metabolites. Further characterization of these residues was not possible. The major metabolites in grain from the triazine label were characterized as CGA 150 829 (1.3%), CGA 183 859 (0.7%), G 28 521 (5.2%), and as 2,6-dihydroxy-4-hydroxymethyl-s-triazine (14.7%). Of the recovered radioactivity in grain, 35% (0.08 ppm triasulfuron equivalents) was attributed to unknowns and 26% was unextractable.

In summary, the degradation of triasulfuron in wheat involves hydroxylation of the phenyl ring, yielding the 5-hydroxy-phenyl derivative of the parent triasulfuron and hydrolytic cleavage of the urea bridge between the triazine and phenyl rings at two different positions, yielding CGA 150 829 and CGA 183 859. Conjugation of the 5-hydroxy-phenyl derivative of triasulfuron with sugar, demethoxylation of CGA 150 829 to form CGA 188 838 and deamination of the free amino group to form G 28 533 were the further degradation steps. Judging from the analysis of total residues however, only very low total radioactive residues will be found in grains even at excessive rates.

A proposed metabolic scheme for the plant metabolism follows.

c) Analytical Methodology

Two analytical methods are available: one to measure parent triasulfuron and one that determines the parent compound and its metabolites containing the phenyl-sulfonyl moiety. Although no analytical method has been developed for analyses of metabolites containing the triazine moiety, the likelihood of measurable residues of triazine metabolites occurring in grain is very low.

d) Crop Residues

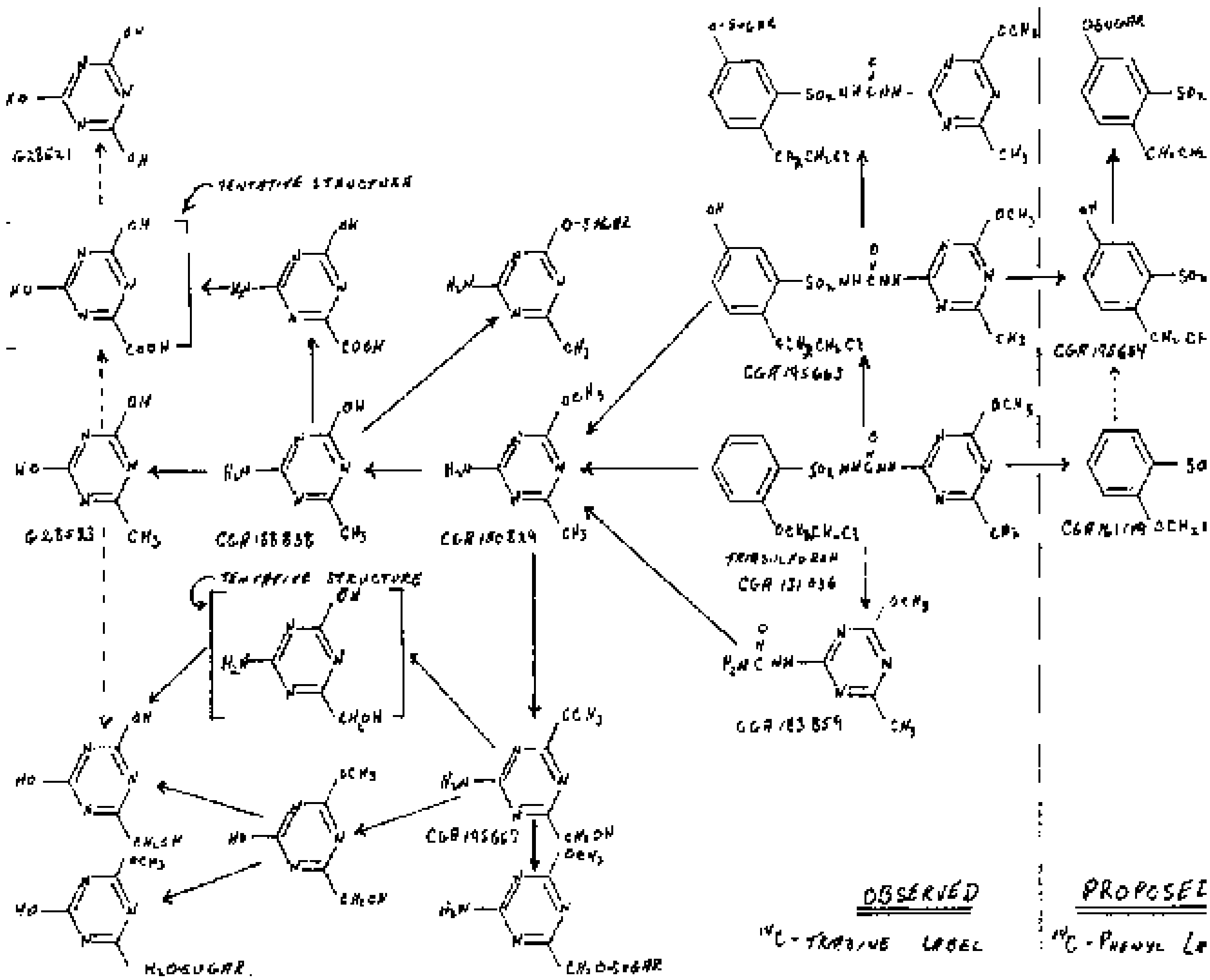
An evaluation of extensive Canadian, U.S. and European residue data utilizing the parent-only method indicates that residues in mature wheat grain and straw, from wheat plants treated at the proposed maximum application rate (25 g ai/ha), are less than the detection limit (0.01 ppm for grain, 0.02 ppm for straw). The data available from the radio-labelled field metabolism studies indicate that at the proposed application rate and pre-harvest interval residues should not exceed 0.002 ppm in grain.

Such residues could be covered under the general maximum residue limit (MRL) of 0.1 ppm. Other countries including the U.S., however, have established maximum residue limits for wheat at
0.02 ppm. This limit is essentially the practical general detection limit for the presently available analytical methodology. Taking these international MRLs and/or tolerance limits into consideration, the Health Protection Branch is proposing to promulgate a MRL for triasulfuron on wheat at 0.02 ppm.

Figure 2. Metabolic Pathway of Triasulfuron in Winter Wheat

Chemical Names of Metabolites from the Proposed Metabolic Scheme in Figure 2

CGA 131 036 (Parent triasulfuron)	1-[2-(2-chloroethoxy)phenylsulphonyl]-3-(4-methoxy-6-methyl-1,3,5-triazin-2-yl) urea
CGA 195 663	N-(6-methoxy-4-methyl-1,3,5-triazin-2-yl-aminocarbonyl)-2-(2-chloroethoxy)-5-hydroxy-benzenesulfonamide
CGA 150 829	2-amino-4-methyl-6-methoxy-triazine
CGA 183 859	4-methyl-6-methoxy-1,3,5-triazin-2-yl-urea
CGA 188 838	2-amino-4-methyl-6-hydroxy-triazine
G 28 533	2-6-dihydroxy-4-methyl-s-triazine
CGA 195 667	2-amino-4-methoxy-6-hydroxymethyl triazine
G 28 521	2,4,6-trihydroxy-triazine (cyanuric acid)
CGA 161 149	2-(2-chloroethoxy)-benzenesulfonamide
CGA 195 654	2-(2-chloroethoxy)-5-hydroxy-benzenesulfonamide


TENTATIVE STRUCTURE
TRIASULFURON
OBSERVED

e) Animal Residues

Although livestock metabolism studies have been submitted along with some residue studies on immature crop, relevant feeding studies and additional residue data on immature crop will be required to support the possible grazing of livestock on treated fields or the feeding of treated forage to livestock. The registrant has indicated a willingness to generate the required data for evaluation; however, in the interim, it has agreed to a label precaution not to graze livestock on treated crops or to feed straw from treated crops.

7.3.3 Dietary Risk Assessment

The present theoretical daily intake (TDI) for humans, calculated on the basis of the proposed 0.02 ppm MRL, is 0.000058 mg/kg bw/day or 0.018% of the ADI value of 0.32 mg/kg bw/day. No single plant metabolite exceeded 15% of the total terminal residues in grain and hence would contribute less than 0.009 ：g/kg bw/day to the TDI.

7.4 Drinking Water Exposure and Risk Assessment

No data are available on detection of triasulfuron in either ambient or drinking water. This compound is likely to be persistent in soils and water. In lab studies, it is potentially mobile and therefore may leach into ground water. However, in view of the very low acute and chronic toxicity of triasulfuron no guideline for the consumption of drinking water is necessary at this time.

7.5 Occupational Exposure and Safety Assessment

7.5.1 Qualitative Occupational Exposure Assessment

This product is to be used by wheat farmers in Alberta and Saskatchewan where typically farms can range from 200 to 2,000 ha in size. The product can be applied either in the fall or in the spring prior to weed emergence. Depending on the farm acreage, the farmer may have to apply the product over several days. Application is conducted via ground boom equipment.

7.5.2 Quantitative Occupational Exposure Assessment

Eleven workers were monitored during mixing, loading and application of AMBER® 75WG Herbicide at 11 different sites. The sites were 32 -40 ha in size and monitoring periods were 3 - 4 hours. Each worker performed all tasks as part of his typical work day including clean-up and minor repairs. All workers used closed-cab tractors with air conditioning during the ground boom application. Workers were monitored for dermal deposition by using cotton gauze patches attached to the outside of the inner clothing. Dermal deposition to the outside of the protective clothing was measured by analyzing sections cut from the coveralls and the hat patches. Neoprene gloves were worn for the handling and mixing of the product and during repair and clean-up activities. Hand washes before removing the gloves and then with bare hands provided estimates for deposition to the hands. To monitor inhalation exposure, workers were equipped with personal air sampling pumps attached to a sampling tube. Adsorbent material inside the tube collected triasulfuron in the sampled air. Analysis of urine samples was also conducted. On the day of the trial, a spot sample was collected from each worker followed by three consecutive 24-hour samples. Completeness of urine collection was monitored by creatinine excretion in comparison to a 24-hour sample collected one week prior to the trial. Due to limitations of the biological monitoring data, it was not used for purposes of the exposure calculations.

Field and laboratory recovery analyses were performed for all sampling media. Because some field recovery samples were <95%, some correction of data was necessary.

In a rat dermal absorption study, the average triasulfuron absorbed after 24 hours was 20%. The dermal deposition results from the worker exposure study were not corrected since a dermal study was used in the risk assessment (see below).

Water soluble bags are proposed for packaging this product although in the exposure study each operator was provided with the pre-measured product in a glass jar. Data on the integrity of water soluble packaging were provided by the registrant. The conditions of the tests were within those of Canadian use and showed that packaging is relatively durable and, on this basis, the exposure study was accepted for purposes of this petition. However, it was noted that handling the water soluble packaging with moist hands or gloves causes rupture within an average of 46 seconds (range: 36 - 53).

It was assumed that a wheat farmer or commercial applicator can treat approximately 120 ha/day (300 acres) using typical ground boom equipment and working an 8 - 10 hour day. Calculations of exposure to a 70 kg farmer wearing long-sleeved shirt and long pants and treating wheat at the recommended application rate of 25 g ai/ha were as follows:

Wearing Neoprene Gloves	0.01002 mg/kg bw/day Range: 0.00114 - 0.02439
Not wearing Gloves	0.08992 mg/kg bw/day Range: 0.01106 - 0.4149

7.5.3 Occupational Risk Assessment

The range of toxicological studies on triasulfuron failed to demonstrate any major health hazards. The main treatment-related effects were small decreases in body-weight gain, possibly related to food aversion due to irritation of the gastrointestinal tract, and liver centrilobular hepatocytomegaly, which was considered an adaptive response. The short-term toxicity studies were deemed to be the most relevant for risk assessment due to the short use season for this product. The occupational risk assessment was based on clinical signs of toxicity observed after repeat dermal exposure to triasulfuron. The 21-day dermal rabbit study was considered the most relevant study with a NOAEL of 10 mg/kg bw/day. Based on daily exposure estimates calculated above, the theoretical margins of safety for a typical 70 kg farmer using a closed-cab tractor with air conditioning, wearing long-sleeves, long pants, with and without gloves and using triasulfuron at the recommended label rate were as follows:

Margins of Safety (Range)

Wearing Neoprene Gloves	Not Wearing Gloves
998 (8700 - 410)	111 (900 - 24)

Given that water soluble packaging can rupture when handled with moist hands, gloves should be recommended during mixing and loading for added precaution. The calculated margins of safety are considered acceptable by Health Canada for the proposed use scenario.

In general, there would be decreasing adsorption of triasulfuron to soil or sediment with

increasing pH. Low values of the octanol/water partitioning coefficient (K_{ow}) over the range of pH 2.5 to 7 did not indicate a potential for bioaccumulation of triasulfuron.

The major pathway of triasulfuron transformation involves cleavage of the sulfonylurea bridge to yield the transformation products CGA 150 829 and CGA 161 149, while a minor pathway involves demethylation of triasulfuron to yield CGA 195 660. The latter compound is subsequently transformed to CGA 188 838 and then to G 28 533.

8.0 Environmental Aspects

8.1 Summary

Laboratory data indicated that biotransformation by microorganisms, rather than hydrolysis or phototransformation, would be the major route of triasulfuron transformation in the environment. Further laboratory data indicated that triasulfuron in soil was moderately persistent to persistent under aerobic conditions (and more persistent under anaerobic conditions), weakly adsorbed and potentially mobile. Terrestrial field studies of dissipation in light brown, dark brown and black soil zones of western Canada demonstrated, however, that triasulfuron was only slightly persistent and did not leach appreciably under Prairie field conditions. Although laboratory data from aquatic laboratory incubations were contradictory, an aquatic field study of dissipation demonstrated that triasulfuron was persistent in the water column of a pond located in the dark brown zone of Saskatchewan. Triasulfuron's high solubility in water and weak adsorption to soil indicate a high potential for contamination of aquatic environments by transportation in surface runoff water.

Direct adverse effects of triasulfuron exposure on fish, aquatic and terrestrial invertebrates and soil microbial processes are not expected. Mammals and birds are not expected to be exposed to an acute or chronic hazard from the ingestion of triasulfuron residues on food sources. The risk to mammalian and avian reproduction is low.

A thorough assessment of the impact of triasulfuron on terrestrial plants and aquatic emergent species could not be performed owing to the absence of the appropriate data. Consequently, the full potential for habitat loss in the terrestrial and aquatic environments is not known. Triasulfuron, however, is expected to be toxic to many terrestrial and aquatic rooted plant species. The risk posed to the duckweed, *Lemna gibba*, and the green alga, *Selenastrum capricornutum*, is very high. Very low concentrations of triasulfuron soil residues are sufficient to adversely affect the growth of several crop species for extended periods of time, particularly in soils with pH > 7.5 which are common in the Prairies. On the basis of the available information, therefore, triasulfuron would be expected to cause habitat loss in both terrestrial and aquatic environments. This could indirectly impair many wildlife species by the destruction of food and cover.

Because AMBER® 75WG will only be used on brown and dark brown soils which are situated in southern Saskatchewan and Alberta where the density of potholes is less than in the northern parts of these provinces, effects to waterfowl will be reduced. Furthermore, it is anticipated that triasulfuron will not be extensively applied in the Prairies because of weed resistance problems and the very high sensitivity of certain crops to this product will also limit the frequency of its use.

The impact of triasulfuron on aquatic and terrestrial wildlife will, however, be reduced by the following mitigation measures: a strict contraindication of aerial application and a 15-metre buffer zone around aquatic and other important wildlife habitats.

Triasulfuron applied in autumn would be exposed to autumn and spring rains as well as snow-melt and, thus, could be transported into aquatic systems by surface runoff water. This use pattern (i.e., fall application) would represent a greater environmental risk and is not favoured by the Environment Evaluation Division.

8.2 Environmental Chemistry and Fate

Triasulfuron is soluble in water at pH 5 and very soluble at pHs > 7, and would be expected to be mobile in soil. Based on a low vapour pressure, as well as low values for Henry's Law Constant over the range of pH 5 to pH 8.4, triasulfuron has a very low potential to volatilize from water and moist soil. Triasulfuron is a weak acid with a pK_a of 4.64. The neutral triasulfuron molecule would predominate at pH < 4.6, while the anion would predominate at pH > 4.6. In general, there would be decreasing adsorption of triasulfuron to soil or sediment with increasing pH. Low values of the octanol/water partition coefficient (K_{ow}) over the range of pH 2.5 to 7 did not indicate a potential for bioaccumulation of triasulfuron.

The major pathway of triasulfuron transformation involves cleavage of the sulfonylurea bridge to yield the transformation products CGA 150 829 and CGA 161 149, while a minor pathway involves demethylation of triasulfuron to yield CGA 195 660. The latter compound is subsequently transformed to
CGA 188 838 and then to G 28 533.

Laboratory studies indicated that biotransformation by microorganisms would be the major route of triasulfuron transformation in the environment. Chemical hydrolysis would not be an important route of triasulfuron transformation at
pH $ 7, but could become of increasing importance at pHs just below pH 7. Phototransformation would not be a significant route of triasulfuron transformation on soil or in aqueous solution.

Based on laboratory results, triasulfuron would be classified as moderately persistent to persistent in aerobic soil at 25° C. The rate of extractable triasulfuron loss decreased by a factor of 2.3 for a 10° C decrease in temperature. There was contradictory evidence regarding the influence of soil moisture content on the rate of triasulfuron biotransformation: in four out of six soils studied, the rate increased with an increase in moisture content. Further laboratory data indicated that the major transformation products CGA 150 829 and CGA 161 149 were persistent in aerobic soil and that CGA 150 829 had a potential to accumulate. In anaerobic soil, the pathway of triasulfuron transformation was similar to that in aerobic soil, but triasulfuron became more persistent. The persistence and potential accumulation of triasulfuron transformation products under anaerobic soil conditions could not be assessed owing to the short duration of the laboratory studies.

Based on results of adsorption/desorption, soil-column leaching and soil thick-layer chromatography laboratory studies, triasulfuron and its transformation products, CGA 150 829, CGA 161 149 and CGA 195 660, would be classified as potentially mobile in soil.

Data from four terrestrial field studies of triasulfuron dissipation at sites in the light brown, dark brown and black soil zones of western Canada demonstrated that the persistence of triasulfuron in soil under Prairie field conditions was considerably less than in soil incubated under laboratory conditions. On the basis of these field data, triasulfuron would be classified as slightly persistent in soil. Further, although laboratory data had indicated a potential for high mobility of triasulfuron in soil, there was little evidence of triasulfuron leaching in soil under field conditions. Only in isolated instances was triasulfuron detected below the 10-cm depth of soil at three field sites and below the 30-cm depth at the remaining site. In addition, contrary to predictions based on laboratory results, the analysis of soil samples from a **single** site did not indicate any persistence, accumulation or leaching of the triasulfuron transformation product, CGA 150 829, under field conditions.

Submitted data from laboratory incubations of triasulfuron in aquatic media were contradictory. Initial data had indicated that biotransformation of triasulfuron in stirred aerobic sediment/water suspensions was slow and would not be a major pathway of dissipation in natural aquatic systems. Subsequent laboratory data, however, indicated that triasulfuron would be considered slightly persistent in aerobic and anaerobic water/sediment. This conclusion conflicts not only with that from

the previous aquatic laboratory study, but also with those from the soil laboratory incubations. The reason for this conflict is not clear. Notwithstanding the foregoing, data from an aquatic field study of dissipation indicated that triasulfuron was persistent in the water column of a pond located in the dark brown soil zone of Saskatchewan. Owing to weak adsorption, there was very little partitioning of triasulfuron on to suspended solids under either laboratory or field conditions, and no detectable amounts of triasulfuron residues were found in the pond sediment field samples.

8.3 Environmental Toxicology

8.3.1 Wild Mammals

Triasulfuron is not expected to pose an acute risk to wild mammals from the ingestion of contaminated food or prey. Acute toxicity data indicated that triasulfuron is practically nontoxic to mice, rats, hamsters and rabbits when administered orally and, at worst, is moderately toxic to rats when administered intravenously. Triasulfuron is absorbed dermally and sublethal symptoms occurred at 2,000 mg/kg bw. A NOEL could not be established in any of the acute mammalian toxicity studies, however, because sublethal symptoms such as dyspnoea, exophthalmus, ruffled fur, and abnormal body positions were reported in all of the studies and persisted up to 12 days after treatment. The formulation appeared to be slightly more toxic than the technical active ingredient.

The chronic toxicity to mammals from the ingestion of triasulfuron is low. Using a NOEL of 78 mg triasulfuron/kg bw/d (established in the 28-day dietary rat study that represents a worst-case scenario of mammalian exposure), the calculated risk factors for a variety of representative mammalian species were between 0.005 and 0.01, which is well below the unacceptable limit of 0.2.

Several studies were available on the metabolism of radiolabelled triasulfuron in the rat and goat. With the oral administration of either 2,6-14C triazine- or U-14C phenyl-CGA 131036, the material was consistently and rapidly absorbed and excreted, mainly via the urine, and few residues remained in the tissues. No major differences in metabolism occurred between the sexes, labels, or species. Five metabolites identified in plants (CGA 150 829, CGA 195 663, CGA 183 859, CGA 188 838 and G 28 533) were not identified in the mammalian metabolism studies. The toxicity of these metabolites is unknown.

AMBER® 75WG is to be applied on wheat in late fall or early spring. Although the early spring application coincides with the reproduction of many mammalian species, a risk to mammalian reproduction is not expected. Using the NOEL established in the two-generation rat reproduction study (**.** 50 mg triasulfuron/kg bw/d) and the worst case scenario of a Meadow Vole ingesting residues on vegetation expected immediately after application (4.957 mg triasulfuron/kg bw/d), the resulting risk factor of 0.09 is below the level of concern.

Furthermore, no teratological effects were observed in the rat and rabbit teratology studies. In the rabbit study a NOEL of 120 mg triasulfuron/kg bw/d was established. From the rat teratology study, a conservative NOAEL of 100 mg triasulfuron/kg bw/d was proposed by Health Canada.

8.3.2 Wild Birds

An acute risk to birds is not expected from the ingestion of triasulfuron-contaminated material. All of the risk factors calculated for worst-case scenarios with a variety of species were between 0.0001 and 0.075, - which is well below the level of concern (0.2). In

addition, short-term risk to avian reproduction and subchronic risk to adult birds from the ingestion of residues are not expected.

The risk to birds from continual ingestion of triasulfuron residues is unknown, but is expected to be low. Based on the mammalian data, toxicity to birds would be expected to increase with continuous exposure and from exposure to AMBER® 75WG. Long-term residues would be expected to occur only on the target crop, however, because of the expected toxicity of triasulfuron to non-target plants. Triasulfuron is not expected to bioaccumulate in birds or their food sources with repeated exposure.

8.3.3 Fish

Triasulfuron is practically nontoxic to fish. Bluegill sunfish (*Lepomis macrochirus*), rainbow trout (*Oncorhynchus mykiss*), carp (*Cyprinus carpio*) and catfish (*Ictalurus punctatus*) were unaffected by 96-hour exposures to technical grade triasulfuron (94.5%) at nominal concentrations of 10 to 100 mg/L (measured concentrations ranged from 77 to 121% of the nominal concentrations).

8.3.4 Amphibians and Reptiles

Information was not available on the impact of triasulfuron on reptiles and amphibians. These organisms could be exposed by direct dermal exposure from overspraying or spray drift or by the ingestion of contaminated invertebrates or vegetation. Developing amphibian eggs laid in Prairie potholes would also be exposed to residues of this product.

8.3.5 Terrestrial Invertebrates

Triasulfuron was of very low acute toxicity (14-d LC_{50} > 1,000 mg/kg soil) to earthworms (*Eisenia foetida*). Triasulfuron was relatively nontoxic (48-h LC_{50}s > 100 ìg/bee), on acute oral and acute contact bases, to honeybees, *Apis mellifera*. No data on the effects of triasulfuron on predatory and parasitic insects were found in the submission.

8.3.6 Soil Microbial Processes

Triasulfuron, at 1 times and 10 times the expected initial concentration in soil, had very little inhibitory effect on the microbial processes of respiration and ammonification-nitrification in soil.

8.3.7 Aquatic Invertebrates

Triasulfuron is practically nontoxic to the water flea (*Daphnia magna*), which was unaffected by 48-hour exposures to technical grade triasulfuron at nominal concentrations of 10 to 100 mg/L (exposure concentrations were confirmed to be 101 to 116% of the nominal concentrations).

Although the triasulfuron transformation products, CGA 150 829 and CGA 161 149, are regarded as slightly toxic to *D. magna*, they are not expected to pose a hazard to aquatic invertebrates as the NOELs exceed the expected environmental concentration (EEC) by two to three orders of magnitude. For CGA 150 829 with *D. magna*, the 48-h EC_{50}, EC_{100} and NOEL were 16, 32 and 3.2 mg/L, respectively. Corresponding values for CGA 161 149 were 83.6, > 100 and 18.0 mg/L. Direct overspray of triasulfuron onto a body of water of 15-cm depth would result in an EEC of 18 ìg/L.

8.3.8 Algae

The toxicity of triasulfuron was investigated with the algae, *Anabaena flosaquae*, *Selenastrum capricornutum*, *Skeletonema costatum*, and *Scenedesmus subspicatus*, and the diatom, *Navicula pelliculosa*. Using the reported EC_{50}- values and the EEC for triasulfuron in water, the risk factors calculated for these species were 0.058, 6.0, 0.0008, 0.023, and 0.00017, respectively. Only the value for green alga, *S. capricornutum*, is above the acceptable limit of 0.2. Assuming a conservative estimate of 10% spray drift to adjacent waterways, an unacceptable risk (risk factor of 0.6) would still be posed to *S. capricornutum*,

Concentrations of chlorophyll a were estimated at 12 and 27 days post-treatment during an aquatic field study of triasulfuron dissipation conducted in limnocorrals in a man-made pond situated in the dark brown soil zone of Saskatchewan. The triasulfuron treatment did not appear to affect **total** algal growth. While separate measurements were not taken for different groups of algae (e.g., green, blue-green and diatoms), laboratory data had indicated that triasulfuron was most toxic to the green alga, *S. capricornutum*.

8.3.9 Non-Target Vascular Plants

One plant-screening study was submitted; however, the report was poorly documented and the study had no application to the Canadian environment. At present, a thorough assessment of the impact of triasulfuron (AMBER® 75WG) on terrestrial plants and aquatic emergent species cannot be performed because of the absence of plant-screening data required for the calculation of EC_{25}-values.

8.3.10 Aquatic

A study with the duckweed, *Lemna gibba*, was deemed incomplete and a thorough evaluation was not possible. On the basis of the available information, a significant loss of *L. gibba* is expected after the application of triasulfuron. Given an EEC in water of 18 ：g triasulfuron/L, and using the conservative 14-d EC_{50} value of 0.19 ：g triasulfuron/L, the risk to *L. gibba* would be 94. Assuming a spray drift of 10% of the application rate, an unacceptable risk (risk factor of 9.4) would still be posed to *L. gibba*.

During an aquatic field study of triasulfuron dissipation in Saskatchewan, qualitative observations were made on *Lemna minor* that had been introduced into the limnocorrals before treatment. Triasulfuron (applied as AMBER® 75WG) appears to have inhibited the growth and impaired the survival of *L. minor*.

8.3.11 Terrestrial

Submitted reports of seed germination, seedling emergence and vegetative vigour were reviewed. All of the species studied were affected in one or more of the parameters examined (i.e., radicle length, shoot length and fresh weight), but the results of these studies are of little utility for this review as the triasulfuron application rate (160 g/ha) was much greater than expected in the field (25 g a.i./ha). Although > 25% reduction was observed in many of the parameters examined, Tier 2 studies of vegetative vigour or seed germination were not submitted.

Although triasulfuron was found to be only slightly persistent in Prairie soil (DT_{50} < 30 d), very low concentrations are sufficient to affect the growth of several crop species for extended periods of time (up to 46 months for lentils). Crop rotation intervals may be longer in those soils with pH > 7.5 which are common in the Prairies (see Table 4, p. 8).

Submitted data from two greenhouse studies on crop rotation indicated that, following an application of 30 g triasulfuron/ha to soil that was subsequently cropped to winter wheat, triasulfuron residues persisted at levels sufficient to induce moderate to severe phytotoxicity to sugarbeets, soyabeans and lettuce, but not in corn.

Three available published studies of the effects of triasulfuron on non-target terrestrial plant species were reviewed.

The yields of corn, sunflowers, and sugarbeets were reduced 13 to 14 months after an application of 10 g triasulfuron/ha in a rotational-crop field study conducted in Greece (Efthimiadis *et al*., 1989, Brighton Crop Protection Conference - Weeds. 4C: 383-388).

Eight grass species contained in pots received post-emergence sprays of 5 to 40 g triasulfuron/ha. At harvest (30 or 60 d post-application), the dry shoot matter was < 25% and < 50% of the control values in one species at 10 g/ha and three species at 20 g/ha, respectively. Growth was < 50% of the control values in four species at 40 g/ha (Standell and West, 1989, Brighton Crop Protection Conference - Weeds 7D-5: 903 - 908).

In a field study conducted in Belgium, 21 species of rotational crops were planted in sandy, loamy soil (pH 5 - 6) (Van Himme *et al*., 1989, Med. Fac. Landbouww. Rijksuniv. Gent 54/2a: 289-302). Triasulfuron was soil-incorporated to a depth of 8 to 12 cm at 1) 20 g/ha in the autumn with the crops planted in April of the following year and 2) at 10 g/ha at the end of winter with the crops planted 5 weeks later. At 20 g triasulfuron/ha, there was pronounced (35 to 80% reduction) and very heavy damage (> 80% reduction) in 8 and 7 crop species, respectively. None of the species were considered to be tolerant, although slight to temporary (0 to 10% reduction) occurred in the spring barley. At 10 g triasulfuron/ha, pronounced to very heavy, visible to clearly visible (10 to 40% reduction) and slight damage occurred in 15, 4 and 2 species, respectively. Although the application rate in the spring was half of that in the autumn, the toxicity to the crop species was greater owing to the shorter time between application and planting.

Differences in the uptake, translocation, and metabolism of triasulfuron between plant species is believed to be the reason for the selective toxicity of this compound in terrestrial plants.

8.3.12 Aquatic and Wildlife Habitat Considerations

The impact of triasulfuron on terrestrial plants and aquatic emergent species could not be thoroughly assessed owing to the absence of appropriate data. Laboratory data on the persistence of triasulfuron in aquatic media were contradictory.

Field data have demonstrated that triasulfuron is persistent in the water of aquatic systems. This result confirmed laboratory data on triasulfuron transformation. Even though laboratory and field studies provided conflicting evidence concerning the persistence and leaching of triasulfuron in soil, the compound's high water solubility and weak adsorption to soil indicated a high potential for transportation in runoff. Moreover, fall application provides an increased potential for transport in spring runoff water during snow-melt.

Comparison of the LC_{50}-values for fish and daphnids with the EEC for triasulfuron indicated that the use of triasulfuron can be expected to present minimal hazard to these organisms.

There is a concern, however, regarding triasulfuron's persistence in aquatic environments and its toxicity to susceptible aquatic plants. In aquatic habitats, phytoplankton and duckweed form the basis of the food chain. A short-term disruption in this community, as

well as damage to emergent species, would affect the invertebrate populations which are an important food source to breeding waterfowl. Green algae and duckweed are important sources of plant material in the diet of ducklings, such as the Gadwalls and the American Widgeon. Emergent plant species are also essential for cover to waterfowl.

Twenty-two mammals can be found either living or foraging in grain fields within the Prairie ecozone. Furthermore, an additional 11 species can be found in adjacent fence rows. These include game species and carnivores useful in pest control. The vulnerable Plains Pocket Gopher is also found in the grain fields and fence rows within this ecozone. Additional species, such as the vulnerable Grey Fox and the rare Red-Tailed Chipmunk, are found in woodlots adjacent to the fields. Over 23 bird species can be found foraging in Prairie wheat fields. Waterfowl, shorebirds, and songbirds make extensive use of Prairie-pothole wetlands. The Prairie wheat fields contain the largest proportion (35%) of ducks associated with any cropland, mainly in the parkland area. Wildlife living in the vicinity of Prairie wheat fields, particularly breeding waterfowl, could be affected by a reduction in food invertebrates or a reduction in food and cover from the damage or destruction of plants. Consequently, a loss of habitat (food and cover) in those areas adjacent to treated fields, such as fence rows or shelterbelts, and nearby woodlots, would affect a variety of bird and mammal species foraging or nesting in these areas.

Measures are therefore required to mitigate the potential environmental impact of triasulfuron application and to maintain the integrity of aquatic and wildlife habitat. Such measures should include a contraindication of aerial application (i.e, limitation of application to ground equipment only) and the establishment and observation of a 15-metre buffer zone adjacent to aquatic and important wildlife habitats.