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WASHINGTON D.C., 20460

OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

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Date: September 10, 2004

MEMORANDUM

SUBJECT:	Ecological Risk Assessment in Support of the Reregistration Eligibility Decision for Chlorsulfuron
TO:	Susan Jennings, Chemical Review Manager Michael Goodis, Product Manager Special Review and Reregistration Division
FROM:	Dirk Y. Young, Ph.D., Environmental Engineer Dan Balluff, Wildlife Biologist Environmental Risk Branch 4
THROUGH:	Elizabeth Behl, Chief Environmental Risk Branch 4 Environmental Fate and Effects Division

The Environmental Fate and Effects Division (EFED) has revised its ecological risk assessment of chlorsulfuron in response to the 30-day error correction comments (DP Barcode D295494) received from the technical registrant. Based on available data, exposure to terrestrial or aquatic animals is not expected to exceed either acute or chronic levels of concern (LOC's). However, the chlorsulfuron uses modeled in the assessment exceed acute risk levels of concern for non-target plants by over three orders of magnitude while LOC's for threatened/endangered plants are exceeded by over four orders of magnitude. Additionally, estimated peak concentrations in surface and groundwater-derived drinking water are 1.9 μg/L and 1.6 μg/L, respectively. If you have any questions regarding this document, please do not hesitate to contract the risk assessors.

REGISTRATION ELIGIBILITY DECISION

September 10, 2004 (revised)

ENVIRONMENTAL FATE AND ECOLOGICAL EFFECTS RISK ASSESSMENT

for

CHLORSULFURON

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EXECUTIVE SUMMARY

Chlorsulfuron Usage

Chlorsulfuron is a broad spectrum, pre-emergent and post-emergent sulfonylurea herbicide used on small grains such as wheat, barley and oats. It is also registered for use on pastures, rangeland and fallow. Non-crop sites include: unimproved turf, industrial turf, industrial sites, ornamentals, and non-crop restoration. Chlorsulfuron is applied to agricultural crops as a spray by aircraft or ground equipment at single application rates ranging from 0.0078 to 0.0625 lbs ai/acre; application rates to non-crop sites are the highest, ranging from 0.0078 to 0.25 lbs ai/acre(**Table 1**). Chlorsulfuron may be tank-mixed with other sulfonylurea herbicides.

Chlorsulfuron Risk

The results of this screening level ecological risk assessment indicate that chlorsulfuron exceeds EFED's Levels of Concern (LOC) for non-target plants by over three orders of magnitude. LOCs for endangered plants are exceeded by over four orders of magnitude. Risk quotients (RQs) were calculated using seedling emergence, vegetative vigor and aquatic plant laboratory toxicity tests. Based on available data, exposure to mammals, birds, and aquatic organisms are not expected to exceed either acute or chronic risk levels of concern (**Table 8**). Exposure scenarios were based on exposure via spray drift, surface runoff, and irrigation.

Toxicity and Risk to Non-target and Endangered Plants

Chlorsulfuron is toxic to non-target plants with EC_{25} equivalent to an application rate 4 x10^{-6} lbs a.i./acre and an $EC_{05}EC_{05}$ equivalent to an application rate 4.6 x 10^{-8} lbs a.i. /acre based on vegetative vigor studies of the herbicide. A single aerial application of chlorsulfuron, assuming 5% of the applied drifts into non-target areas, results in screening level RQs ranging from 267 to 1042 for non-target plants and from 17,532 to 68,488 for endangered plants (**Tables 11** and **13**). Additionally, for fields irrigated with ground or surface water contaminated with chlorsulfuron, non-endangered plant RQs range from 91 to 341 (**Table 14**). In regions where chlorsulfuron has been used historically, modeling results indicate that groundwater and surface water irrigation may result in damage to agricultural crops that are sensitive to chlorsulfuron.

The risk to nontarget plants from direct application of chlorsulfuron has not been estimated quantitatively in this risk assessment, but are expected to be higher than those estimated for indirect exposure through runoff and drift. In addition, risk from use on golf courses, sod farms, and nurseries were not assessed quantitatively (as usage is low) but estimated risk would be higher as application rates for those uses are higher.

A refined assessment was conduced on effects of chlorsulfuron spray drift on non-target plants. Refinements are intended to accurately reflect the most important application conditions actually used in applying chlorsulfuron. To estimate a range of spray drift levels, application parameters employed by aerial applicators in Washington and Oregon were used; ground boom configurations were assumed to include the range of values available in the AgDRIFT model. Risks to non-target plants resulting from spray drift from ground and aerial applications of chlorsulfuron are dependent upon a number of factors. This analysis suggests that most plant species are likely to be affected at low levels (10% reductions in shoot weight) more than 1000 feet downwind of applications conducted in winds speeds of 10 mph. Under certain conditions, 80% effect levels may occur to more sensitive species at 1000 feet or more downwind. Higher effect levels are triggered more frequently by aerial applications than with ground boom applications and more frequently with finer sprays.

Field Studies and Greenhouse Studies

A number of field studies have been conducted with chlorsulfuron (see Section 3.7). Several researchers have concluded that small quantities of the chemical, such as might be found in airborne particles traveling long distances, may affect plant reproduction without altering vegetative growth. If the effect of chlorsulfuron on cherry trees is characteristic of other plant species, drift may severely reduce both the crop yields and fruit development on native plants, an important component of the habitat and food web for wildlife. Reproductive effects from chlorsulfuron exposure are difficult to recognize in the field and virtually impossible to associate with chlorsulfuron because the amounts of material required to induce yield reduction are below the detection level of conventional chemical analysis.

Non-target Plant Incident Reports

There are three non-target plant incidents attributed to offsite drift of chlorsulfuron (Glean®) in the EPA's EIIS incident database. One incident occurred in the spring of 1990, near Benton City Washington, orchard growers alleged that herbicides applied to wheat fields in Horse Heaven Hills drifted onto orchards in Badger Canyon and damaged cherry, apple, plum, and apricot crops. Growers contended that sulfonylurea herbicides were most likely responsible because damage of this magnitude never occurred prior to the use of sulfonylurea herbicides on Horse Heaven Hills (see Section 3.7.3).

Endangered Plant Species

Screening level (Tier 1) deterministic risk quotients (RQs) for direct effects to endangered plants exceed the endangered species level of concern (LOC) by several orders of magnitude. For aquatic plants RQs for endangered species range from 18 to 31. For endangered plants in wetlands RQs range from 1200 to 5056. RQs for endangered terrestrial plants range from 3507 for ground applications to wheat to 68,488 from spray drift resulting from aerial applications to rangeland and pastures.

In order to determine the potential risk of chlorsulfuron uses to endangered/threatened plants, further refinements are needed in the risk assessment. Possible areas of refinement could include: investigating the extent of overlap between species habitat relative to chlorsulfuron use areas and refining site-specific exposure scenarios for runoff and spray drift.

Drinking Water Assessment for Human Health

Concentrations of parent chlorsulfuron in drinking water sources were estimated using PRZM/ EXAMS for surface sources. Four standard EFED agricultural scenarios (PA turf, FL turf, ND wheat, TX wheat) were selected to simulate a broad range of chlorsulfuron uses. The estimated concentrations include a reduction by the percent crop area (PCA) factor. The Florida turf scenario gave the highest concentrations. Ground water concentrations were estimated with the SciGrow model. Using standard operating guidance for SciGrow inputs, the estimated the groundwater concentration was 1.6 ppb. The 1-in-10 year concentrations are provided below.

Drinking Water Estimated Environmental Concentrations for Chlorsulfuron

	Acute Concentration (upper 1-in-10 year peak concentration)	**Chronic Concentration (upper 1-in-10 year annual mean concentration)**
Surface Water	1.9 µg/L	0.96 µg/L
Groundwater	1.6 µg/L	1.6 µg/L

1. PROBLEM FORMULATION

1.1 Conceptual Model

In agricultural ecosystems there is a patchwork of row crops intermixed with pasture and natural plant communities. Chlorsulfuron poses a potential threat to vegetation growing on adjacent land if the herbicide is applied to crop land and inadvertently drifts and/or runs off into non-target areas. Adverse consequences of such an event will vary depending on the extent of exposure (aerial vs ground application), plant species involved, habitat (aquatic vs terrestrial), plant size, and stage of development of the plant. The response may range from plant death to no apparent alteration of plant growth and development, depending on different combinations of these variables.

It is often difficult to distinguish between herbicide damage and plant damage caused by insects, pathogens, frost, and nutrient deficiency. Positive proof of drift or runoff damage on many occasions requires chemical identification of the suspected herbicide on the plants and/or the soil at the non-target site. Complaints have arisen in numerous parts of the country that herbicides such as the sulfonylureas which are used at $1/20^{th}$ the application rate of older herbicides cause plant damage at chemical concentrations below the level of analytical detection (Fletcher 1991).

1.2 Identification and Mechanism of Action

Chlorsulfuron is a broad spectrum herbicide, structurally classified as a sulfonylurea. Its mode of action is the inhibition of amino acid synthesis in plants through inhibition of acetolactate synthase (ALS). Chlorsulfuron's herbicidal effect results from its inhibition of an enzyme involved in amino acid biosynthesis. It may be absorbed either through the roots or the foliage and is mobile within the plant and binds to the acetolactate synthase enzyme. Inhibiting this process adversely affects plant growth and reproduction. This enzyme pathway does not exist in animals making the herbicide far less toxic to animals than plants.

Soil moisture increases the phytotoxicity of chlorsulfuron by increasing availability and absorption by the roots. Although chlorsulfuron is herbicidal when absorbed by roots, herbicide which contacts foliage is also phytotoxic. Foliar absorption may increase when chlorsulfuron is tank mixed with an oil or surfactant. Chlorsulfuron may be applied either pre- or post emergence. Phytotoxicity data shows that chlorsulfuron affects plants in both seedling emergence and the vegetative vigor tests at low levels. Chlorsulfuron tolerant plants, such as grains, resist herbicidal effects by metabolizing the herbicide before it causes toxicity (Weed Science Society 1989). Chlorsulfuron exposure may cause visible symptoms in days or weeks or delayed effects on reproduction (fruit and seed production) may occur weeks or months after exposure.

Plants that have absorbed sufficient chlorsulfuron on their foliage, in the short term, may show initial symptoms of spotting, and leaf puckering or twisting (Felsot et al 1996). Exposed plants also may show chlorosis and discolored veins. Chlorsulfuron symptoms may become more pronounced and lead to plant death or the plant may outgrow the symptoms in 1 to 2 months depending on the sensitivity of the plant and the magnitude of the exposure. Developmental/reproductive effects of chlorsulfuron exposure may not be apparent for three or more months after exposure. Reduced seed and fruit development resulting from chlorsulfuron exposure has been documented in canola, smartweed, soybean, and sunflower (Fletcher et al 1996). Because reproductive effects may occur in the absence of other more immediate symptoms of herbicide exposure, it is expected to be difficult to recognize delayed chlorsulfuron toxicity in the field.

1.3 Use Characterization and Formulations

Chlorsulfuron-containing products were first registered in the United States in the early 1980s. There are six products currently registered for use in the U.S. including: TELAR DF®, GLEAN FC®, FINESSE®, Chlorulfuron Technical®, LANDMARK MP®, LANDMARK II MP®, and CORSAIR®. Over 80% of chlorsulfuron use is on cereal grains (wheat, oats and barley) to control a wide variety of weed pests. Over 5 million acres are treated annually. Most of the acreage is treated with 0.01 lbs ai/acre or less. The vast majority of chlorsulfuron is applied to winter wheat. The remaining use is primarily spring wheat, and oats. Registered use sites with little or no usage include lawn and ornamental turf. Most chlorsulfuron usage is in Oklahoma, Texas, Washington, Kansas, Montana, and California.

For cereal grains, the greatest chlorsulfuron usage is in Kansas, followed by Oklahoma, Montana, Washington, Texas, Nebraska, North Dakota, and California. For the non-crop market, the greatest usage is in Iowa, followed by Washington, Oregon, Colorado, Idaho, Minnesota, Mississippi, and Nebraska. Chlorsulfuron is also registered for use on pasture and rangeland. The non-crop land and industrial turf sites includes use on roadsides, railroads, industrial sites, rights of way, airports, fence rows, and lumberyards for control of noxious weeds.

1.4 Rate and Method of Application

Chlorsulfuron is used predominately on grain crops such as barley, wheat, and oats. According to the USGS and USDA, this use accounts for more than 98% of agricultural chlorsulfuron usage (http://ca.water.usgs.gov/pnsp/use92/chlrsulf.html). Chlorsulfuron may be broadcast applied by air or ground equipment to small grains at application rates that range from 0.0078 to 0.023 lbs ai/acre. Acreage may be treated once per crop cycle to once every 36 months.

Chlorsulfuron may be broadcast applied by air or ground equipment to fallow, pasture, and rangeland at rates that range from 0.0078 to 0.0625 lbs ai/acre. Other non-crop uses (unimproved turf, non-crop, sod farms, ornamentals) may only be applied by ground equipment. Application rates range from 0.012 to 0.25 lbs ai/acre. Acreage may be treated twice per year for some uses; for other uses labels do not specify a maximum number of applications per year. **Table 1** summarizes application methods and maximum rates for chlorsulfuron.

Table 1. Chlorsulfuron Use Information

Crop	Application Method	Application Rate (lbs ai/acre)	Maximum number of applications per season	Maximum seasonal/yearly application rate
Barley Post-emergent	Broadcast aerial or ground	0.0078 - 0.016	Ranges from once per crop season to once every 36 months (Finesse label does not specify)	0.016 lbs ai/acre (Finesse label does not specify)
Oats pre-emergent	Broadcast aerial or ground	Up to 0.023	Range of once per crop season to every 36 months	0.023 lbs ai/acre
Oats Post-emergent	Broadcast aerial or ground	0.0078 - 0.016	Range of once per crop season to once every 36 months	0.016 lbs ai/acre
Wheat Pre-emergent	Broadcast aerial or ground	0.0195 - 0.023	Range of once per crop season to once every 36 months (Finesse label does not specify)	0.023 lbs ai/acre (Finesse label does not specify)
Wheat Post-emergent	Broadcast aerial or ground	0.0078 - 0.016	Range of once per crop season to once every 36 months (Finesse label does not specify)	0.016 lbs ai/acre (Finesse label does not specify)
Pastures and rangeland	Broadcast aerial or ground	0.012 - 0.0625	Label does not specify	0.0625 lbs ai per acre per 12 month period
Fallow	Broadcast aerial or ground	0.0078 - 0.016	Label does not specify	Label does not specify
Unimproved turf	Broadcast ground only	0.012	Label does not specify	0.023 lbs ai/acre/year
Unimproved industrial turf	Broadcast ground only	0.012 - 0.0234	2 per year (Telar DF label does not specify)	0.0234 lbs ai per acre per 12-month period
Non-crop sites	Broadcast ground only	0.021 - 0.047	Label does not specify	0.12 lbs ai/acre/year
Non-crop (industrial) sites	Broadcast ground only	0.021 - 0.14	Label does not specify	0.125 lbs ai/acre (Telar DF label does not specify)
Non-cropland restoration	Broadcast ground only	0.021 - 0.031	Label does not specify	0.125 lbs ai/acre/year
Sod farms and golf courses	Handheld or boom sprayer	0.047 - 0.25	2 per year (60 day interval)	0.50 lbs ai/acre/year
Ornamentals/fine turf	Broadcast ground only	0.13 -0.25	2 per year	0.25 - 0.50 lbs ai/acre per year

1.5 Current Label Restrictions

Current chlorsulfuron labels contain a number of restrictions that may tend to mitigate to some degree the potential impacts of chlorsulfuron on non-target and endangered plant species. For example, statements on the label for Finesse® (EPA Reg. No. 352-445) indicate that "Finesse herbicide is recommended for use on land primarily dedicated to the long-term production of wheat and barley". This recommendation may serve to decrease the likelihood that irrigation water contaminated with chlorsulfuron will be inadvertently applied to agricultural crops that are sensitive to chlorsulfuron. Finesse labels provide the following precaution: "Do not apply to irrigated land where tailwater will be used to irrigate other cropland." The extent to which this statement serves to decrease chlorsulfuron contamination of surface water used for irrigation is uncertain.

An indication of the persistence of chlorsulfuron under actual field conditions is provided in the label for Finesse®, in the table on rotation intervals. The table indicates that the rotation interval for non-cereal crops in non-irrigated land ranges from 11 months for field corn to 48 months for sorghum. These intervals indicate that chlorsulfuron may persist in the soil at levels that are toxic to plants for extended periods of time. Additionally, labels for Finesse® provide the following precaution: "To reduce the potential for movement of treated soil due to wind erosion, do not apply to powdery, dry, or light sandy soil until they have been stabilized by rainfall, trashy mulch, reduced tillage or other cultural practices. Injury to adjacent crops may result when treated soil is blown onto land used to produce crops other than cereal grains." The extent to which this statement serves to decrease the movement of chlorsulfuron contaminated soils into nearby fields in which non-cereal crops are grown is uncertain.

Several labels have restrictions based on soil pH. Primarily these restrictions are to protect replanted crops after chlorsulfuron application. Several labels (*e.g.*, Dupont Glean® and Finesse®) prohibit the use of chlorsulfuron on soils with pH greater than 7.9 because chlorsulfuron is quite persistent at high pH and re-planting may suffer the effects of residual chlorsulfuron. In certain states these labels require a field bioassay if pH is above 6.5 to determine whether planting is feasible. Crop rotation intervals are pH dependent in some states. Supplemental labels may imply that the maximum pH limitation is less for certain state/crop conditions. Some labels (*e.g.*, Dupont Telar® and Landmark MP®) appear not to restrict the use chlorsulfuron based on soil pH, but instead only restrict the replanting interval. Other labels (*e.g.*, Lesco TFC® and Riverdale Corsair®) specify reduced application rates on soils with pH above 7, but do not prohibit use at any specific soil pH.

Some label precautions suggest that synergistic effects may occur if chlorsulfuron is applied to fields to which certain other insecticides have been applied. The label for Finesse® states that "Finesse should not be used within 60 days of crop emergence if an organophosphate insecticide (such as "Di Syston®") was used as an in-furrow treatment, or crop injury may result." Presumably, neither of these two pesticides if used alone will cause crop injury to wheat or barley. However, the Finesse label indicates that they apparently do cause crop injury when used together. This suggests that there may be synergistic effects to plants when chlorsulfuron is applied to fields along with organophosphate insecticides. The label for Finesse® also indicates that "Tank-mix applications of Finesse® plus Assert® may cause temporary crop discoloration/stunting or injury when heavy rainfall occurs shortly after application." Additionally, the label restricts the use of Finesse® plus Malathion® and the use of Finesse® plus Lorsban® in the Northwest, as crop injury may result. The Finesse® label includes the following statement "Do not apply Finesse during the boot stage or early heading stage, as crop injury may result." This statement suggests that chlorsulfuron may adversely effect plant reproduction.

Several statements have been placed on chlorsulfuron labels to reduce the likelihood of spray drift. The label for Finesse® provides the following statement: "When applying Finesse by air in areas near sensitive crops, use solid-stream nozzles oriented straight back. Adjust swath to avoid spray drift damage to downwind sensitive crops and/or use ground equipment to treat border edges of fields." A refined analysis of effects of spray drift is provided in this assessment, however, the extent to which these statements reduce risk to plants from spray drift cannot be determined based on the level of detail provided.

1.6 Assessment Endpoints and Analysis Plan

Laboratory toxicity tests indicate that chlorsulfuron is practically nontoxic to terrestrial and aquatic animals. However, results of toxicity tests for non-target terrestrial and aquatic plants indicate that chlorsulfuron is acutely toxic. Very little data exist on levels that cause chronic toxicity to plants. Therefore, the screening level assessment focuses on endpoints related to acute effects to plants. For terrestrial plants, endpoints include vegetative vigor and seedling emergence. Effects on growth is the endpoint used for aquatic plant risk. Chronic (reproductive) endpoints for plants were not used in the assessment because current plant test guidelines include only acute endpoints. However, results of field studies indicate that chlorsulfuron may adversely affect plant reproduction at low concentrations (Section 3.7).

In this screening-level assessment, exposure was estimated based on maximum label rates. Acute risk quotients for terrestrial and endangered plant species were calculated for three different habitat types adjacent to application sites: aquatic habitats, wetlands, and terrestrial areas. PRZM/EXAMS modeling was utilized to evaluate potential exposure to aquatic plants (Section 2.2). For non-target and endangered terrestrial plant spray drift exposure values, 1 or 5% of the application rate was assumed, depending on whether the application method was aerial or with ground equipment. When runoff was included in the RQ calculations for semi-aquatic/wetland exposures, the exposure was assumed to be 5% of the application, based on chlorsulfuron's solubility. Runoff exposure was then added to spray drift exposure. For the pasture/rangeland use, a direct application scenario was not assessed; however, exposure would be expected to be higher than that estimated to result from spray drift.

This ecological risk assessment focuses on the small grain, turf, rangeland, and pasture use sites because they represent the use sites with the largest amount of current or potential chlorsulfuron use. However, some of the non-crop uses have higher application rates than the crop uses. If risk quotients were to be calculated for the chlorsulfuron non-crop uses with the higher application rates, they would likely result in higher risk estimates than were calculated for the crop uses. Several of the chlorsulfuron labels do not specify application frequency. This risk assessment assumes a single application where the label is not specific; actual exposure may be substantially higher.

2.0 ENVIRONMENTAL FATE CHARACTERIZATION

Chlorsulfuron (2-chloro-N-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl] benzenesulfonamide, see **Figure 1**) is persistent and highly mobile in the environment. It may be transported by runoff or spray drift. Degradation by hydrolysis appears to be the most significant mechanism for degradation of chlorsulfuron, but is only significant in acidic environments (23 day half-life at pH = 5); it is stable to hydrolysis at neutral to high pH. Degradation half-lives in soil environments were quite variable and ranged from 14 to 320 days.

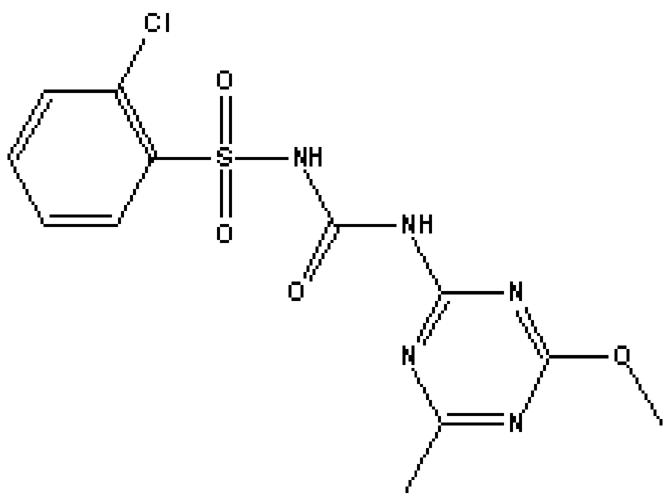

Figure 1. Chemical structure of chlorsulfuron.

2.1 Chlorsulfuron Fate Studies

2.1.1 Hydrolysis

Chlorsulfuron degraded with a half-life of 23 days in the pH 5 solution, but was stable in the pH 7 and 9 solutions. Hydrolysis tests (MRID 421567-01) were performed in buffered solutions at pH values of 5, 7, and 9 at 25° C. Buffered solutions were made from Milli-Q water and acetate, phosphate, and borate buffers, respectively. Initial chlorsulfuron concentrations were 5 mg/L. Chlorsulfuron concentrations were measured at 3, 7, 14, 21, and 31 days. Major degradates were from the pH 5 test were chlorosulfonamide (33% of applied), ring-opened chlorsulfuron (16% of applied), o-desmethylchlosulfuron (10% of applied), and lesser amounts of triazine and dihydroxy triazine.

2.1.2 Photodegradation in Water

Chlorsulfuron does not readily photodegrade in water. Tests were conducted at pH 5, 7 and 9 at temperature of 25°C over 31 days (MRID 421567-02).

2.1.3 Soil Photodegradation

Soil photolysis tests (MRID 421567-03) showed that chlorsulfuron degraded with a half-life of 65 days. The test soil was a Nora silty clay (20% sand, 52% silt, 29% clay, 2% organic matter, CEC 19.6 meq/100 g, pH 8). Minor degradates were observed at less than 10% of the applied and included: dihydroxy triazine, triazine amine, triazine urea, and o-desmethyl chlorsulfuron.

2.1.4 Aerobic Soil Metabolism

Soil metabolism tests (MRID 422142-01) conducted at 25°C showed a wide range in variability of the aerobic soil half life of chlorsulfuron. In a silt loam soil (21% sand, 63% silt, 17% clay, 2.75% organic matter and a of pH 6.4), chlorsulfuron had a half-life of 14 days. In another soil (24% sand, 68% silt, 8% clay, 2.6% loam, pH 9, CEC 15.03 meq/100g), chlorsulfuron had a half-life of 11 months. In older submitted studies (MRID 0113-0013 and 0113-0024), chlorsulfuron half-lives were 1 to 2 months. In more recent publications, Andersen et al. (2001) reported chlorsulfuron half-lives of 50 days for soil taken from 30 to 35 cm below surface, 160 days for soil taken 40 to 45 cm below surface and 230 days for soil taken at 70-75 cm below surface. One reason for the decrease in degradation rates is possibly due to a decrease in microbial activity with depth. Andersen et al. (2001) did not report near-surface soil data due to interference problems. Major degradates were 2-chlorobenzenesulfonamide (30-35%), 2-amino-4-methoxy-6-methyl-1,3,5-triazine, and 2-chloro-N-[[(4-hydroxy-6-methyl-1,3,5-triazin-2-yl) -amino]carbonyl]benzenesulfonamide (15%). In all of the studies, it is not clear how much degradation occurred by microbial metabolism or by hydrolysis.

2.1.5 Anaerobic Aquatic Metabolism

Chlorsulfuron is relatively stable under conditions of anaerobic metabolism. Controls degraded faster than test systems. Hydrolysis was likely the dominant mechanism in the system (MRID 421467-04). In recent literature, Berger and Wolfe (1996) found an anaerobic sediment half life of 89 days and 301 days for unsterile and sterile sediment respectively; however, for another sediment system it was 182 days and only 101 days for the sterile system. These counterintuitive results were attributed to increased hydrolysis due to lowing of pH during heat sterilization.

2.1.6 Bioaccumulation

Preliminary fish bioaccumulation studies (MRID 422142-04) showed channel catfish accumulation factors of 1.5X in edible tissue, 12X in viscera, and 7X in liver. Residues declined by 90-95% during the depuration phase. In preliminary bluegill sunfish studies the bioaccumulation was 4X in the viscera and 6X in the liver with a residue decline of 70-90 % in the depuration phase. Chlorsulfuron has a relatively low K_{ow} of 2.13 at pH 5, 0.10 at pH 7, and 0.04 at pH 9 at 25^{o}C. This information is sufficient to indicate that chlorsulfuron has a low potential to bioaccumulate.

2.1.7 Field Dissipation

Although guideline field studies were not submitted, older lysimeter studies were available and provide sufficient information to evaluate chlorsulfuron field dissipation for this assessment. In the field lysimeter studies (MRID 422142-02)**,** estimated half-life ranged from 20 days to several months. MRID 422142-02 is a compilation of several studies identified by the registrant-assigned report numbers in parenthesis that follow. Lysimeter studies in Delaware, North Dakota, and Nebraska (Report No. 63-82) were conducted on both an alkaline and an acidic soil. For the acidic soils the dissipation half-life ranged from 1 to 2 months, and for the alkaline soils, dissipation half- lives were reported to be 2 - 4 months. Another study (Report No. AMR 307-84) was carried out in the Fall in Ohio, Idaho, North Dakota, and in the Spring in Alberta, Manitoba and Saskatchewan, Canada. Dissipation half-lives were reported to be 1 to 3 months for the Spring studies and 5 to 11 months for the Fall studies. Leaching of chlorsulfuron was apparent. The time for detectable levels of chlorsulfuron to reach 22 - 35 cm ranged from 1 to 40 months. In another lysimeter study (Report No. AMR 1417-89) leaching was also apparent down to the 18-24 inch range. The reported dissipation half-life was 20 days. In all the studies, only minor amounts (<10%) of two degradates (2-chlorobenzenesulfonamide and 2-amino-4-methoxy-6-methyl-1,2,3,5-triazine) were observed.

2.1.8 Sorption

A summary of batch sorption tests is given in **Table 2**. Batch studies (MRID 421567-05) were conducted on four soils with an equilibration time of 24 hours at 25^{o} C. From the sorption parameters chlorsulfuron can be considered mobile (**Table 2**). It is expected (as with many chemicals that become increasingly anionic with increasing pH) that the mobility of chlorsulfuron will increase with increasing pH.

Table 2. Summary of Submitted Sorption Studies

Registrant's Name for Soil	texture	% sand	% silt	% clay	% om	CEC meq/100g	soil pH	K_f mg/l/(mg/kg) $^{1/n}$	1/n	Koc [a] (ml/g)
Madera	loam	48	35	17	0.8	19.6	8	0.28	0.9	60
Woodstone	sandy loam	60	33	7	1.1	5.3	6.6	0.09	0.85	14
Keyport	silt loam	20	39	21	1.9	6.4	5.7	0.38	0.88	34
Flanagan	silt loam	2	81	17	4.3	21.1	5.4	0.91	0.91	36

[a] K_{oc} is based on the sorption coefficient at 1 mg/L.

2.2 Water Resource Assessment

Due to its mobility and persistence, chlorsulfuron may contaminate surface and groundwater. Fate studies show that chlorsulfuron is mobile, and that mobility should increase as the environmental pH increases (chlorsulfuron becomes more anionic as pH increases, see for example the variation in Kow with pH in the bioaccumulation section). Chlorsulfuron is also persistent, and its persistence should also increase with increasing pH.

Few monitoring data are available on chlorsulfuron. Due to its very low application rate and expected low concentrations in the environment it is not often included as a analyte in monitoring programs. To obtain information about the occurrence of sulfonylurea (SU), sulfonamide (SA), and imidazolinone (IMI) herbicides in the Midwestern United States, the USGS collected 212 water samples from 75 surface water sites (177 samples taken) and 25 ground-water sites (29 samples taken) in 1998 (Battaglin et al., 2000). Samples were collected from streams, large rivers, reservoir outflows, and wells. All reconnaissance samples were analyzed for 16 different herbicides. The 75 surface water sites were located in the Upper Mississippi, Missouri, and Ohio River basins. Twenty ground-water samples were collected from a network of municipal wells in Iowa. The depths of the wells ranged from 6 to 83 m. with most wells less than 30 m. Samples were also collected from five observation wells in Lower Illinois; these wells were less than 8 m deep.

Of the 130 samples taken from Midwestern rivers and streams, only one sample contained chlorsulfuron (0.013 μg/L) above the method reporting limit of 0.01 μg/L. The USGS scientists reported no detections of chlorsulfuron in the 25 ground-water samples. It is unclear to what extent the location of sampling sites overlapped with areas of chlorsulfuron usage. Because of limitations in the monitoring data, estimated environmental concentrations in this assessment were calculated using the models PRZM/EXAMS and SciGrow.

2.2.1 Ambient Surface Water (Farm Pond)

Surface water concentrations resulting from chlorsulfuron application to wheat and turf were estimated with PRZM (version 3.12 beta) coupled to EXAMS (version 2.98.04). Four scenarios were simulated—one for North Dakota wheat, one for Texas wheat, one for Pennsylvania turf, and one for Florida turf. Application timing was estimated from the product labels, and a range of application dates were used. A summary of chemical properties used as PRZM/EXAMS inputs is given in **Table 3**, and copies of input files are in **Appendix 1**. Because of its low degradation rate, chlorsulfuron concentrations continually increased over the simulation period and chronic and peak concentrations are nearly the same for all scenarios tested. **Table 4** presents the peak and average concentrations for the simulated farm pond. Note that the standard EFED pond is confined such that flushing by external flows does not occur, and therefore, concentrations may accumulate over time to a higher degree than would a pond with flow into and out of the system. The date chosen for the application had a small (absolute) effect on the output, as EEC values are within about 1 ppb (the relative difference however is substantial–up to about 30%). For a conservative assessment, the highest of these values is used.

Table 3. Salient Chemical Properties of Chlorsulfuron Used for PRZM/EXAMS Modeling

Parameter	Value	Notes
Molecular Weight	357.8	
Solubility	31800 mg/l	
Vapor Pressure	4.6 e-6 torr	
K_{oc}	36 ml/g	MRID 421567-05 (mean of values in Table 2)
Aerobic Soil half life	320 days	90 % ci of submitted studies (half life data :14, 330, 60 days) MRID 422142-01
Aerobic aquatic half-life	stable	MRID 421467-04
Photodegradation	stable	MRID 421567-052; MRID 421567-03
Anaerobic metabolism	stable	assumption
Hydrolysis	stable	MRID 421567-01 (scenarios are performed at pH =7)

Table 4. Summary of Ecological Concentrations Modeled with PRZM/EXAMS. Chlorsulfuron applied once per season at maximum labeled rate. All values in ppb.

scenario	formulation and application	Date Applied	peak	96 hr	21-day	60-day	90-day	year
ND wheat	Glen 0.023 lb/acre aerial application	1-Apr	4.2	4.2	4.2	4.2	4.2	4.2
		1-May	4.1	4.1	4.1	4.1	4.1	4.1
TX wheat	Glean 0.023 lb/acre aerial application	1-Aug	5.5	5.5	5.5	5.5	5.5	5.5
		1-Sep	5.8	5.8	5.8	5.8	5.8	5.7
		15-Sep	6.0	6.0	6.0	6.0	6.0	5.9
		1-Oct	6.3	6.3	6.3	6.3	6.3	6.3
PA turf	Telar 0.0625 lb/acre aerial application	15-Mar	4.0	4.0	4.0	4.0	4.0	4.0
		1-Apr	5.0	5.0	5.0	5.0	5.0	5.0
		15-Apr	4.5	4.5	4.5	4.5	4.5	4.5
		1-May	5.9	5.9	5.9	5.9	5.9	5.8
		15-May	5.2	5.2	5.2	5.2	5.2	5.0
FL turf	Telar 0.0625 lb/acre aerial application	1-Mar	6.8	6.8	6.8	6.8	6.8	6.8
		1-Apr	9.5	9.5	9.5	9.5	9.5	9.5
		1-May	7.5	7.5	7.5	7.5	7.5	7.4

2.3 Drinking Water Assessment

2.3.1 Surface Water Source

This drinking water assessment estimates exposure to parent chlorsulfuron only. If metabolites of concern are identified a revised assessment will be prepared. EFED previously conducted a Tier 1 human drinking water assessment which can be found in **Appendix 8**. The tier 1 drinking water estimates for ground and surface water source drinking water used higher application rates, which bracket all label rates in Table 1. Although HED did not indicate problems with the concentrations from the Tier 1 assessment, EFED performed a Tier 2 human drinking water assessment in order to be consistent with the Tier 2 ecological water assessment described above. Concentrations of chlorsulfuron in drinking water sources for the Tier 2 assessment were estimated with PRZM/EXAMS for surface sources. Four standard scenarios were investigated.. Because the scenarios are the same as those used for the ecological assessments, the application date chosen was the date that gave the highest exposure values, as determined from the ecological assessment PRZM/EXAMS runs. The final drinking water estimated concentrations reported in **Table 5** are reduced by the percent crop area (PCA) factors reported in the table.

Table 5. Summary of estimated screening level surface water drinking water concentrations. Based on one application

scenario	formulation	PCA	application date	peak (upper 1-in-10 year peak concentration) [ppb]	chronic (upper 1-in-10 year annual mean concentration) [ppb]
ND wheat	Glean 0.023 lb/acre	0.56	May 1	0.32	0.23
TX wheat	Glean 0.023 lb/acre	0.56	Sep 15	0.95	0.25
PA turf	Telar 0.0625 lb/acre	1.0	April 1	1.5	1.1
FL turf	Telar 0.0625 lb/acre	1.0	April 1	2.2	1.1

2.3.2 Ground Water Source

Groundwater concentrations were estimated with SciGrow, which is EFED's standard model for estimating groundwater concentrations of pesticides. For further information on this model see the EFED water model website at http://www.epa.gov/oppefed1/models/water/. The following model inputs were used: application rate = 0.0625 lb/acre, one application per year, half-life = 320 days, and K_{oc} = 36. With these inputs, SciGrow estimates the groundwater concentration to be 1.6 ppb.

2.3.3 Drinking Water Estimated Concentrations

The surface water EECs in **Table 6** were based on a PRZM/EXAMS simulation using EFED's standard Index Reservoir. The Pennsylvania turf scenario was found to provide the highest EECs among the scenarios tested. For groundwater, the SciGrow-derived model estimated concentration of 1.6 µg/L was derived from the turf scenario (see previous section). **Appendix 8** provides additional details on the Tier 1 drinking water assessment for chlorsulfuron.

Table 6. Drinking Water Estimated Environmental Concentrations for Chlorsulfuron.

	Acute Concentration	Chronic Concentration
Surface Water	2.2 µg/L	1.1 µg/L
Groundwater	1.6 µg/L	1.6 µg/L

3. ECOLOGICAL EFFECTS CHARACTERIZATION

This screening level ecological risk assessment was performed to evaluate the potential impact to non-target mammals, birds, fish, and aquatic invertebrates resulting from the registered uses of chlorsulfuron. Based on available toxicity and environmental fate data, risks to mammals, birds, and aquatic organisms are not expected to exceed EFED's Levels of Concern. Thus risks to birds and aquatic animals resulting from chlorsulfuron use are expected to be low.

3.1 Toxicological Profile for Terrestrial and Aquatic Animals

Table 7 provides eco-toxicity values for terrestrial and aquatic animals that were used to calculate acute and chronic risk quotients for non-target terrestrial and aquatic animals. Based on results of toxicity testing, chlorsulfuron appears to be practically nontoxic to most of the terrestrial and aquatic animals tested.

Adverse reproductive effects were observed in both the avian (northern bobwhite) and mammalian reproduction studies, although at test concentrations well above the estimated environmental concentrations (EEC). The NOAEC for northern bobwhite was determined to be 174 mg ai/kg bw diet based on significant reductions in female body weight, 14 day old survivors/normal hatchlings, viable embryos/eggs set, and 14 day hatchling survival/eggs set at the highest treatment level when compared to the control.

Table 7. Chlorsulfuron Toxicity Tests Used to Calculate RQs For Terrestrial and Aquatic Animals
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Study Type (%Active Ingredient)	Species	Toxicity Value (ai)	Toxicity Category	MRID/Acc.# Author (Year)	Study Classification
Dietary LC_{50} (91%)	Mallard duck *(Anus platyrhynchos)*	LC_{50}>5,000 ppm	Practically nontoxic	099462 (1979)	Core
Avian Reproduction (97.5%)	Northern bobwhite *(Colinus virginianus)*	NOAE = 174 ppm LOEAL= 961 ppm	Not applicable	42634001 Beavers, J.B. *et al.* (1992)	Core
Rat two generation reproduction	Laboratory rat	NOAEL = 35 mg/kg/day	Not applicable	40089316	Not Applicable
Rat acute oral	Laboratory rat	LD_{50} = 5.5 g/kg	Not applicable	00031406	Not Applicable
Acute LC_{50} (91%)	Rainbow trout	LC_{50} >250 ppm	Practically nontoxic	099462	Core
Acute LC_{50} (Technical)	*Daphnia magna*	LC_{50} >370 ppm	Practically nontoxic	099462	Core
Early life-stage (97.6%)	Rainbow trout	NOAEC = 32 mg/l	Not applicable	419764-05 Pierson, K.B. (1991)	Core
Life-cycle (95.4%)	*Daphnia magna*	NOAEC = 20 mg/l	Not applicable	419764-08 Hutton, D.G. (1989)	Supplemental [1]
Acute LC_{50} (98.2%)	Mysid *(Mysidopsis bahia)*	LC_{50} = 89 mg/l	slightly toxic	419764-02 Ward, T.J. and R.L. Boeri (1991)	Core
Acute LC_{50} (98.2%)	Sheepshead minnow (Cyprinodon	LC_{50} >980 mg/l	practically nontoxic	419764-01 Ward, T.J. and R.L.	Core

1/ This study is scientifically sound. However, it does not fulfill test guideline requirements. It is repairable if additional information on the solvent control and dilution water is submitted.

A summary of guideline ecological toxicity studies is provided in **Appendix 2**.

3.2 Risk Quotients for Terrestrial and Aquatic Animals

Table 8 provides risk quotient values for terrestrial and aquatic animals**.**

Table 8. Chlorsulfuron Risk Quotients for Terrestrial and Aquatic Animals.

Species	Toxicity	EEC range	Risk Quotients acute / chronic
Birds	Acute LC_{50} > 5,000 ppm Chronic NOAEL = 174 mg/kg/day	1.9 - 15 ppm	<0.01 / < 0.01
Mammals	Acute LD_{50} = 5,500 ppm Chronic NOAEC = 35 mg/kg/day	1.9 - 15 ppm	<0.01 / < 0.01
Freshwater fish	Acute LC_{50} = >50 ppm Chronic NOAEC = 32 ppm	0.003 - 0.0096 ppm	<0.01 / < 0.01
Freshwater invertebrate	Acute LC_{50} = >370 ppm Chronic NOAEC = 20 ppm	0.003 - 0.0096 ppm	<0.01 / < 0.01
Marine fish	Acute LC_{50} = >950 ppm Chronic NOAEC = N/A	0.003 - 0.0096 ppm	<0.01 / N/A
Marine invertebrate	Acute LC_{50} = 89 ppm Chronic NOAEC = N/A	0.003 - 0.0096 ppm	< 0.01 / N/A
Honey bee	Acute LD_{50} > 25 μg/bee	N/A	N/A

3.2.1 Birds and Mammals

Acute and chronic risk quotients do not exceed Levels of Concern (LOC) for birds and mammals. With acute toxicity values (LC_{50}) greater than 5,000 ppm and relatively low EECs, based on 240 ppm per lb ai applied (**Appendix 3**) chlorsulfuron is not expected to pose an acute risk to avian species. The NOAEC for avian reproduction (174 mg/kg/day) is more than an order of magnitude above the highest EEC (15 ppm). Because of low acute and chronic toxicity to laboratory rats, risk quotients do not exceed the LOCs for mammals. Therefore, chronic risks to birds and mammals are not expected to exceed the Levels of Concern.

3.2.2 Freshwater and Marine/estuarine Fish and Invertebrates

Acute and chronic risk quotients do not exceed the LOC for freshwater or marine/estuarine fish and invertebrates. With acute toxicity values (LC_{50}) greater than 50 ppm and EECs less than 0.010 ppm, chlorsulfuron is not expected to pose an acute risk to aquatic animal species. Chronic toxicity tests provide NOAECs that are greater than or equal to 20 ppm. Therefore, chlorsulfuron is expected to present low acute or chronic risks to freshwater and marine/estuarine fish and invertebrates.

3.3 Risk Characterization for Terrestrial and Aquatic Wildlife

Toxicity tests and estimated environmental concentrations indicate those chlorsulfuron risks resulting from direct exposure to terrestrial and aquatic animals are expected to be low. However, the potential exists for indirect impacts because animals ultimately depend on plants and plant communities for survival.

3.4 Plant Effects Assessment

A screening level risk assessment for terrestrial and aquatic plants is provided below. Laboratory toxicity values for plants are compared with estimated environmental concentrations to give deterministic risk quotients.

3.4.1 Toxicological Profile for Terrestrial and Aquatic Plants

The standard toxicity level EFED uses for calculating risk quotients for non-endangered terrestrial plants is the EC_{25}. For endangered plants, the EC_{05} or the no observable adverse effect level (NOAEL) is used. The EC_x effect level represents an X% effect to a group of plants. The dose required to cause a 25% reduction in the average shoot height of a group of plants is an example of an EC_{25} toxicity level. Reduction in the dry weight of the plant can also be used in calculating the EC_x. Visual effects, such as spotting or chlorosis, are not generally assessed because of difficulty in quantifying the magnitude of the effect.

Table 9 provides laboratory toxicity values for terrestrial and aquatic plants. Chlorsulfuron is toxic to nontarget terrestrial plants with EC_{25} values as low as 4×10^{-6} lbs a.i./acre and an EC_{05} value of 4.6×10^{-8} lbs a.i. /acre (vegetative vigor). Based on available data, the slope of the dose-response curve for chlorsulfuron has a low value; toxicity does not decrease rapidly with decreasing concentration. As a result, terrestrial plant treatment concentrations were not low enough in the seedling emergence and vegetative vigor studies to determine the NOAEC for several plant species. More detailed summaries are provided in **Appendices 4** and **5**. Aquatic plant toxicity ranged from practically nontoxic to very highly toxic. The most sensitive aquatic plant was *Lemna gibba* (duckweed), with an EC_{50} of 0.00035 mg ai/L and a NOAEC of 0.00024 mg ai/L.

The plants used in phytotoxicity tests are chosen primarily for due to the availability of validated protocols and seed sources. Registrants routinely screen potential products using a wide variety of economically important plants to determine if phytotoxicity concerns exist. The Pesticide Assessment Guideline Subdivision J (EPA-540/9-82-020) states that flexibility is allowed in choosing species in order to maximize use of "...tests that are normally performed by the developer/registrant during screening and initial field testing...." The registrant must test corn and soybeans primarily because of their economic importance in US agricultural. A dicot root crop must also be tested along with an approximately even ratio of dicots and monocots.

Laboratory toxicity data used in this analysis were limited to effects occurring in a relatively short amount of time after a single exposure. A number of published reports suggest that chlorsulfuron, and other herbicides with the same mode of action, may result in delayed effects on crop yield and plant reproduction at levels lower than those noted to cause short-term visible effects (for a review see Ferenc 2001).

Table 9. Summary of Chlorsulfuron Toxicity Tests for Terrestrial and Aquatic Plants.

Study Type (%Active Ingredient)	Species	Toxicity Value (reported application rate)	MRID/Acc.# Author (Year)	Study Classification
Seedling emergence and Vegetative vigor (98.2% chlorsulfuron purity) All chlorsulfuron stock and test solutions were prepared in pH 7 buffer or HPLC-grade acetone. Valent 0.25% X-77 surfactant was used in some test solutions.	Seedling emergence: (onion, sugarbeet, soybean, sorghum, pea, rape, cucumber, corn, and tomato) Vegetative vigor: (Wheat, onion, sugarbeet, soybean, sorghum, pea, rape, cucumber, corn, and tomato)	Seedling emerge: (sugarbeet, shoot height) EC_{25} = 3.06 x 10^{-5} lbs ai/A NOAEC = 6.8 x 10^{-6} lbs ai/A Vegetative Vigor: (onion, shoot weight) EC_{25} =4.0 x 10^{-6} lbs ai/A EC_{25} =4.56 x 10^{-8} lbs ai/acre	425872-01 and 422010-01 McKelvey, R.A., and H. Kuratle (1992)	Supplemental [1]
Aquatic plant growth (98.2%)	*Selenastrum capricornutum*	EC_{50} = 0.05 mg ai/L NOAEC = 0.0094 mg ai/L	421868-01 Blasburg, J. *et al.* (1991)	Supplemental [2]
Aquatic plant growth (97.8%)	*Skeletonema costatum*	NOAEC =126 mg ai/L EC_{50} >126 mg ai/L	45832902 R.L.Boeri *et al.* (2001)	Core
Aquatic plant growth (97.8%)	*Navicula pelliculosa*	NOAEC =126 mg ai/L EC_{50} >126 mg ai/L	45832904 R.L.Boeri *et al.* (2001)	Core
Aquatic plant growth (97.8%)	*Anabaena flos-aquae*	NOAEC = 0.236 mg ai/L EC_{50} = 0.609 mg ai/L	45832903 R.L.Boeri *et al.* (2001)	Core
Aquatic plant growth (97.8 %)	*Lemna gibba*	NOAEC = 0.00024 mg ai/L EC_{50} = 0.00035 mg ai/L	45832901 R.L.Boeri *et al.* (2001)	Supplemental [3]

1/ This study is scientifically sound but does not fulfill the guideline requirements for seedling emergence and vegetative vigor studies

2/ This study could be upgraded to core if raw data are submitted.

3/ This study was conducted under static conditions.

Because of deficiencies in the plant studies, several are classified as supplemental and do not fulfill data requirements for plant toxicity testing. However, these studies were determined to be scientifically sound and are suitable for use in the screening level risk assessment for non-target and endangered plants.

3.5 Risk Quotients for Aquatic and Terrestrial Plants

3.5.1 Aquatic Plant Assessment

Table 10 provides screening level risk quotients for non-target and endangered/threatened aquatic plants. PRZM/EXAMS was used to estimate environmental concentrations (EECs). The assumptions used in this modeling are provided in Section 2.2. For this assessment the peak EEC was used. However, as **Table 4** indicates, the EECs after a year are essentially the same as the peak EECs. The duration of exposure in the aquatic plant toxicity testing typically ranges from 5 to 14 days. Therefore, if the long-term EECs were used instead of peak, risk quotients would remain the same.

The Level of Concern (LOC) for non-target plants is 1.0. For use on wheat, non-target aquatic plant RQs range from 12 to 18 and from 18 to 26 for endangered aquatic plant species. For use on turf (pasture/rangeland and fallow), RQs range from 17 to 27 for non-target aquatic plants and from 26 to 40 for endangered aquatic plants.

Table 10. Chlorsulfuron Risk Quotients (RQs) for Non-target and Endangered/ Threatened Aquatic Plants Using a E_{50} of 0.35 μg/L and a NOAEC of 0.24 μg/L for *Lemna gibba*. (Single Application).

Crop (state)	Application rate (lbs ai/acre)	Peak EEC (ppb) (PRZM/EXAMS)	RQs for non-target aquatic plants [1]	RQs for endangered aquatic plants [2]
Wheat (ND)	0.023	4.2	12	18
Wheat (TX)	0.023	6.3	18	26
Turf (PA)	0.0625	5.9	17	26
Turf (FL)	0.0625	9.5	27	40

1/ EEC/E_{50}
2/ EEC/NOAEC

Exposure from the sod/ golf course and nursery uses were not estimated due to low overall usage; however, because the maximum application rates for those uses are higher than for the uses modeled, the LOCs would be exceeded for these uses as well.

3.5.2 Terrestrial Plant Assessment

The screening level terrestrial assessment consists of the following four scenarios:

1) **Off-target drift and runoff** of chlorsulfuron from a ten-acre application site to an adjacent one acre semi-aquatic area (wetland) using **seedling emergence** toxicity data to calculate risk quotients (**Table 11**), based on a single application of chlorsulfuron.

2) **Off-target drift and runoff** of chlorsulfuron from a one-acre application site to an adjacent one acre terrestrial area using **seedling emergence** toxicity data to calculate risk quotients (**Table 12**), based on a single application of chlorsulfuron.

3) **Off-target drift and no runoff** of chlorsulfuron from a one-acre application site to an adjacent one-acre terrestrial area using **vegetative vigor** toxicity data to calculate risk quotients (**Table 13**), based on a single application of chlorsulfuron.

4) **Application of contaminated irrigation water** (groundwater or surface water inadvertently containing chlorsulfuron) using the **vegetative vigor** toxicity data to calculate risk quotients (**Table 14**), based on a single irrigation event.

Table 11 provides screening level RQs for semi-aquatic areas (wetlands) resulting from off-target drift (concentrations estimated at the edge of the treated field) and runoff of chlorsulfuron from the application site (ten acres to one acre). The toxicity endpoint used in the RQ calculations is seedling emergence. A ten-acre application area running off into a one-acre wetland is simulated to determine the estimated environmental concentrations from runoff into wetlands.

RQs for ground application of chlorsulfuron to small grains (wheat, barley, and oats), pasture and rangeland range from 267 to 1,042 for non-target plants and from 1200 to 4,688 for endangered/threatened plants. RQs for aerial application to small grains, pasture and rangeland range from 288 to 1123 for non-target plants and from 1,294 to 5,056 for endangered/threatened plants. Therefore, for this scenario, (which assumes 10 acres treated to one acre runoff), risk quotients for aerial applications are approximately 8% higher than the risk quotients from ground applications. Since the LOC (1.0) is exceeded by over three orders of magnitude, the application of chlorsulfuron to small grains, rangeland and pasture greatly exceeds levels of concern for non-target and endangered/threatened plants found in semi-aquatic areas (wetlands). The highest calculated RQs are from non- crop uses: industrial sites and pasture/rangeland Exposure from the sod/ golf course and nursery uses were not estimated due to low overall usage; however, because the maximum application rates for those uses are higher than for the uses modeled, the LOCs would be exceeded for these uses as well. Direct exposure scenarios were also not calculated, but RQs for plants and endangered plants would be higher than those estimated from exposure via spray drift or runoff.

Table 11. Chlorsulfuron Risk Quotients (RQs) for Non-Target Semi-Aquatic Areas (Wetlands) Using a EC_{25} of 3.06 x 10^{-5} lbs ai/acre for Non-Target Plants and a NOAEC of 6.8 x 10^{-6} lbs ai/acre for Endangered Plants (Using Sugarbeets, Seedling Emergence, Shoot Height) with Ten Acres to One Acre Runoff.

Crop	Appl. rate (lbs ai/A)	EEC for ground appl.[1] (lbs ai/A)	EEC for aerial appl.[2] (lbs ai/A)	RQs for ground application		RQs for aerial application	
	Single application			Non-target plants [3]	Endangered plants [4]	Non-target plants [5]	Endangered plants [6]
Barley (post emergent)	0.016	0.00816	0.0088	267	1200	288	1294
Oats (pre-emergent)	0.023	0.01173	0.01265	383	1725	413	1860
Oats (post-emergent)	0.016	0.00816	0.0088	267	1200	288	1294
Wheat (pre-emergent	0.023	0.01173	0.01265	383	1725	413	1860
Wheat (post-emergent	0.016	0.00816	0.0088	267	1200	288	1294
Pastures and rangeland	0.0625	0.03188	0.03438	1042	4688	1123	5056
Fallow	0.016	0.00816	0.0088	267	1200	288	1294
Unimproved turf	0.012	0.00612	N/A	200	900	N/A	N/A
Unimproved industrial turf	0.023	0.01173	N/A	383	1725	N/A	N/A
Non crop sites	0.047	0.024	N/A	783	3530	N/A	N/A
Non-crop (industrial sites)	0.14	0.0714	N/A	2333	10500	N/A	N/A
Non-crop land restoration	0.031	0.01625	N/A	531	2390	N/A	N/A

1/ EEC for ground applications = drift + runoff = total load
Drift = application rate (lbs ai/acre) x 0.01 (drift)
Runoff = application rate (lbs ai/acre) x 0.05 (based on solubility) x 10 (10 acres to one)
2/ EEC for aerial applications = drift + runoff = total load
Drift = application rate (lbs ai/acre) x 0.05 (drift)
Runoff = application rate (lbs ai/acre) x 0.05 (based on solubility) x 10 (10 acres to one)
3/ RQ = EEC for ground application / EC25
4/ RQ = EEC for ground application / NOAEC
5/ RQ = EEC for aerial application / EC25
6/ RQ = EEC for aerial application / NOAEC

Table 12 provides risk quotients for non-target and endangered terrestrial plants. This scenario uses toxicity endpoints from the seedling emergence study and assumes one acre to one acre runoff.

RQs for ground application of chlorsulfuron to small grains, pasture and rangeland range from 31 to 123 for non-target plants and from 141 to 551 for endangered/threatened plants. RQs for aerial application to small grains, pasture and rangeland range from 52 to 204 for non-target plants and from 235 to 919 for endangered/threatened plants. Therefore, for this scenario, (which assumes one acre to one acre runoff), risk quotients for aerial applications are approximately 67% higher than the risk quotients for ground applications.

RQs for non-target plants range from 31 to 204 for small grains, rangeland and pasture. For endangered plants they range from 141 to 919. The highest RQs are for non-crop industrial sites (275 to 1,235). The LOC for non-target and endangered terrestrial plants is 1.0. Therefore, the application of chlorsulfuron to small grains, rangeland, pasture and non-crop sites greatly exceeds LOCs for non-target and endangered/threatened terrestrial plants. Exposure from the sod/ golf course and nursery uses were not estimated due to low overall usage; however, because the maximum application rates for those uses are higher than for the uses modeled, the LOCs would be exceeded for these uses as well. Direct exposure scenarios were also not calculated, but RQs for plants and endangered plants would be higher than those estimated from exposure via spray drift or runoff.

Table 12. Chlorsulfuron Risk Quotients (RQs) for Non-Target and Endangered Terrestrial Plants Using an EC_{25} of 3.06 x 10^{-5} lbs ai/acre for Non-Target Plants and a NOAEC of 6.8 x 10^{-6} lbs ai/acre for Endangered Plants (Using Sugarbeets, Seedling Emergence, Shoot Height) with One Acre to One Acre Runoff.

Crop	Appl. rate (lbs ai/A)	EEC for ground appl.[1] (lbs ai/A)	EEC for aerial appl.[2] (lbs ai/A)	RQs for ground application		RQs for aerial application	
	Single application			Non-target plants [3]	Endangered plants [4]	Non-target plants [5]	Endangered plants [6]
Barley (post emergent)	0.016	0.00096	0.0016	31	141	52	235
Oats (pre-emergent)	0.023	0.00138	0.0023	45	203	75	338
Oats (post-emergent)	0.016	0.00096	0.0016	31	141	52	235
Wheat (pre-emergent	0.023	0.00138	0.0023	45	203	75	338
Wheat (post-emergent	0.016	0.00096	0.0016	31	141	52	235
Pastures and rangeland	0.0625	0.00375	0.00625	123	551	204	919
Fallow	0.016	0.00096	0.0016	31	141	52	338
Unimproved turf	0.012	0.00072	N/A	24	106	N/A	N/A
Unimproved industrial turf	0.023	0.00138	N/A	45	203	N/A	N/A
Non crop sites	0.047	0.0028	N/A	92	412	N/A	N/A
Non-crop (industrial sites)	0.14	0.0084	N/A	275	1235	N/A	N/A
Non-crop land restoration	0.031	0.00186	N/A	61	274	N/A	N/A

1/ EEC for ground applications = drift + runoff = total load
Drift = application rate (lbs ai/acre) x 0.01 (drift)
Runoff = application rate (lbs ai/acre) x 0.05 (based on solubility)
2/ EEC for aerial applications = drift + runoff = total load
Drift = application rate (lbs ai/acre) x 0.05 (drift)
Runoff = application rate (lbs ai/acre) x 0.05 (based on solubility)
3/ RQ = EEC for ground application / EC25
4/ RQ = EEC for ground application / NOAEC
5/ RQ = EEC for aerial application / EC25
6/ RQ = EEC for aerial application / NOAEC

Table 13 provides RQs for non-target and endangered terrestrial plants resulting from spray drift alone (no runoff). RQs resulting from aerial application of chlorsulfuron were five times greater than for ground application. RQs for non-target plants range from 40 to 156 for ground applications to small grains, rangeland and pasture. For endangered plants they range from 3,507 to 13,698. For aerial applications RQs for non-target plants range from 200 to 800 for small grains, rangeland and pasture. For endangered plants they range from 17,533 to 68,488. The toxicity endpoint used in these RQ calculations was the shoot weight from the vegetative vigor study. If root weight was used instead, the risk quotients would be much higher (**Appendix 5**). Therefore, the application of chlorsulfuron to small grains, rangeland and pasture exceeds LOCs for non-target and endangered/threatened terrestrial plants by several orders of magnitude. For this scenario (which assumes no runoff), the risk quotients for aerial applications are approximately 5 times higher than for ground applications. Exposure from the sod/ golf course and nursery uses were not estimated due to low overall usage; however, because the maximum application rates for those uses are higher than for the uses modeled, the LOCs would be exceeded for these uses as well. Direct exposure scenarios were also not calculated, but RQs for plants and endangered plants would be higher than those estimated from exposure via spray drift or runoff.

Table 13. Chlorsulfuron Risk Quotients (RQs) for Non-Target and Endangered Terrestrial Plants Resulting From Drift Exposure Alone (No Runoff) Using a EC_{25} of 4.0 x 10^{-6} lbs ai/acre for Non-Target Plants and a EC_{05} of 4.5625 x 10^{-8} lbs ai/acre for Endangered Plants (Using Vegetative Vigor, Onion Shoot Weight).

Crop	Appl. rate (lbs ai/A)	EEC for ground appl.[1] (lbs ai/A)	EEC for aerial appl.[2] (lbs ai/A)	RQs for ground application		RQs for aerial application	
	Single application			Non-target plants [3]	Endangered plants [4]	Non-target plants [5]	Endangered plants [6]
Barley (post emergent)	0.016	1.6 x 10^{-4}	8.0 x 10^{-4}	40	3507	200	17533
Oats (pre-emergent)	0.023	2.3 x 10^{-4}	1.15 x10^{-3}	58	5040	290	25202
Oats (post-emergent)	0.016	1.6 x 10^{-4}	8.0 x 10^{-4}	40	3507	200	17533
Wheat (pre-emergent	0.023	2.3 x 10^{-4}	1.15 x 10^{-3}	58	5040	290	25202
Wheat (post-emergent	0.016	1.6 x 10^{-4}	8.0 x 10^{-4}	40	3507	200	17533
Pastures and rangeland	0.0625	6.25 x 10^{-4}	3.13 x 10^{-3}	156	13698	800	68488
Fallow	0.016	1.6 x 10^{-4}	8.0 x 10^{-4}	40	3507	200	17533
Unimproved turf	0.012	1.2 x 10^{-4}	N/A	30	2630	N/A	N/A
Unimproved industrial turf	0.023	2.3 x 10^{-4}	N/A	58	5040	N/A	N/A
Non crop sites	0.047	4.7 x 10^{-4}	N/A	118	10300	N/A	N/A
Non-crop (industrial sites)	0.14	1.4 x 10^{-3}	N/A	350	30683	N/A	N/A
Non-crop land restoration	0.031	3.1 x 10^{-4}	N/A	78	6794	N/A	N/A

1/ EEC for ground applications = drift = total load
Drift = application rate (lbs ai/acre) x 0.01 (drift)
2/ EEC for aerial applications = drift = total load
Drift = application rate (lbs ai/acre) x 0.05 (drift)
3/ RQ = EEC for ground application / EC25
4/ RQ = EEC for ground application / EC05
5/ RQ = EEC for aerial application / EC25
6/ RQ = EEC for aerial application / EC05

3.5.3 Terrestrial Plant Assessment for Contaminated Irrigation Water

Risk quotients were also calculated to evaluate whether there is a potential for adverse impacts to plants if exposed to irrigation water inadvertently containing chlorsulfuron. Modeled estimates suggest that irrigation water from groundwater and surface water sources may contain high enough levels of chlorsulfuron to damage non-target plants and sensitive crops within irrigated fields.

Table 14 provides risk quotients for non-target plants resulting from exposure to irrigation water containing 1.6 ppb of chlorsulfuron in groundwater, derived from SCIGROW (**Table 6**) or 6.0 ppb of chlorsulfuron in surface water, generated using PRZM/EXAMS. The 6.0 ppb estimate roughly covers North Dakota, Texas, and Pennsylvania scenarios, although Florida could be as high as 9.5 ppb (**Table 4**).

Toxicity endpoints from the vegetative vigor study were used in the RQ calculations because it was assumed that non-target plants are exposed to chlorsulfuron directly from irrigation water. This screening-level assessment indicates that irrigation water may inadvertently contain high enough levels of chlorsulfuron to adversely impact sensitive agricultural crops such as soybeans, sugarbeets, onions, *etc*. if they are grown in fields that are irrigated with water containing chlorsulfuron. Risk quotients for sensitive crops within irrigated fields range from 91 for irrigation using groundwater to 341 for using surface water to irrigate fields. Since the LOC for plants is 1.0, the risk quotients exceed the LOC by over two orders of magnitude. Therefore, in regions where chlorsulfuron has been used historically, agricultural crops grown in fields irrigated with groundwater or surface water containing chlorsulfuron may be adversely effected. For this assessment it was assumed that there are no endangered plants that occur within irrigated fields.

Table 14. Risk Quotients for Non-target Plants Resulting From Exposure to Irrigation Water Containing 1.6 ppb Chlorsulfuron in Groundwater or 6.0 ppb in Surface Water (using the vegetative vigor EC_{25} of 4.0×10^{-6} for non-endangered plants).

Location	EEC: chlorsulfuron in irrigation groundwater and surface water (lbs ai/acre)[1]	Risk Quotients for groundwater (GW) and surface water (SW) irrigation Non-Endangered plants[2] (EEC/EC_{25})
Within the irrigated field[1]	Groundwater: 3.634×10^{-4} Surface water: 1.363×10^{-3}	GW: 91 SW: 341

[1/] Estimated Environmental Concentration assuming 1 inch of irrigation water is applied to the target field.
[2/] It is assumed that there are no endangered plants within agricultural fields that are irrigated.

3.6 Toxicity Studies (from Public Literature)

A number of published reports suggest that chlorsulfuron, and other herbicides with the same mode of action, may result in delayed effects on crop yield and plant reproduction at levels lower than those noted to cause short-term visible effects (for a review see Ferenc 2001).

3.6.1 Fletcher *et al.* 1995

The influence of chlorsulfuron on the reproduction of green pea *(Pisum sativum)* was examined by exposing plants at three different stages of development to three different exposure levels (46, 92, and 180 mg ha^{-1}), corresponding to 2 $x10^{-3}$, 4 x 10^{-3}, and 8 x 10^{-3} of the recommended field application rates for small grain crops. The most susceptible stage of development was when plants possessed six expanded leaves and one visible flower bud. At that stage an application rate of 180 mg ha^{-1} (0.8% of the recommended field rate) reduced yield of treated plants by 99% of that of control plants without severely altering height or appearance of mature plants.

When corresponding low application rates of atrazine, glyphosate, and 2,4-D were administered at this same development stage there were no effects on either growth or reproduction. Thus chlorsulfuron had an influence on plant reproduction that was not produced by other herbicides at low levels. The researchers concluded that small amounts of drifting sulfonylureas are potentially more damaging to the yield of non-target plants than that of other commonly used herbicides.

3.6.2 Coyner *et al.* 2000

The effect of chlorsulfuron on the non-target freshwater macrophyte, *Potamogeton pectinatus* (sago pondweed) was evaluated using environmental growth chambers. This ecologically important submerged plant is a food source for many species of wildlife such as ducks, geese and swans, as well as marsh and shorebirds (Hurly, 1994). *P. pectinatus* also provides habitat and nursery area for many fish and other aquatic life. It grows in regions where chlorsulfuron is used.

In this study *P. pectinatius* was exposed to chlorsulfuron at 0.25, 0.50. 1.0 or 2.0 ppb for 4 weeks. Plants exposed to 0.25 ppb chlorsulfuron showed a 76% reduction in length and a 50% reduction of stems and leaves compared to control plants. Increased mortality was observed at 1.0 ppb or greater. Correll and Wu (1982) found that *P. pectinatus* exposed to 650 ppb atrazine for 4 week period did not have a mortality rate higher than the control plants.

Comparing the test results from this study to those from the guideline aquatic plant studies (**Table 9**) suggest that vascular plants such as duckweed (*Lemna gibba*), may be more susceptible to chlorsulfuron than non-vascular plants such as the freshwater diatom *Navicula pelliculosa.* Results of risk quotient calculations using the results from Coyner *et al.* (2000) are presented in Section 2.6.1.

3.7 Field Studies, Greenhouse Studies, and Incident Reports

Results from a number of field studies, greenhouse studies, laboratory studies and incident reports support the conclusion that chlorsulfuron applied at labeled rates may result in high risk to non-target plants grown in the vicinity of application sites. Several of the fields studies below were conducted by researchers from the EPA laboratory in Corvalis, Oregon and one of the non-target plant incidents (at Horse Heaven Hills) was investigated by a researcher from the same EPA laboratory.

Several researchers have concluded that these studies indicate that small quantities of the chemical, such as might be found in airborne particles traveling long distances, may change plant reproduction without altering vegetative growth. If the effect of chlorsulfuron on cherry trees is characteristic of other plant species, drifting sulfonylureas may severely reduce both the crop yields and fruit development on native plants, an important component of the habitat and food web for wildlife.

Plant reproductive processes may be more sensitive to chlorsulfuron than growth effects. Low levels of chlorsulfuron appear to adversely influence plant reproduction, which is not characteristic of many common herbicides. If such events are occurring in agriculture, not only will it be difficult to recognize them but it will be virtually impossible to prove that chlorsulfuron was responsible for the episode, because the amounts of chlorsulfuron inducing yield reduction are often below the detection level of conventional chemical analysis.

3.7.1 Field Studies

Fletcher et al. 1993

Researchers at the Oregon State University Lewis-Brown Horticulture Farm near Corvallis, Oregon investigated the influence of chlorsulfuron on cherry trees during the fall of 1991 and the spring of 1992, by comparing the weight of fruit collected from treated and control branches. Single applications of chlorsulfuron were administered until wetness with a dual nozzle spray wand at five concentrations representing 0, 1/1000th, 1/500th, 1/100th, and 1/10th of the recommended tank mixture rate of chlorsulfuron for use on small grain crops in Washington, Oregon, and California. Three multiple applications experiments were also conducted at 1-week intervals.

Results indicate that exposure of the developing buds to low levels of chlorsulfuron in September caused the next spring's yield to be reduced to 15% of the controls. Spring treatment resulted in yields of treated branches of 40% that of controls. Study authors determined that the low dose herbicides are approximately 100 times more toxic than herbicides used prior to 1982. Significant adverse effects on yields (up to 85% yield loss) was measured following treatment at, during, or shortly after bloom. These effects on the full grown, woody perennial cherry tree occurred from the use of 1/500th the maximum label rate for chlorsulfuron herbicide (1/500th of 1/3 oz. ai/acre).

The researches concluded that "the results from this series of experiments showed that at low levels of chlorsulfuron (4.6 x 10^{-7} M), reproduction of cherry trees was reduced without visible disruption of vegetative organs. The high sensitivity cherry trees displayed toward chlorsulfuron indicates that small quantities of the chemical, such as might be found in airborne particles traveling long distances, may change plant reproduction without altering vegetative growth. If the effect of chlorsulfuron on cherry trees is characteristic of other plants species, drifting sulfonylureas may severely reduce both the crop yields and fruit development on native plants, an important component of the habitat and food web for wildlife".

Bhatti et al. 1995

Field experiments were conducted at the Irrigated Agricultural Research and Extension Center, Prosser, Washington in 1992 and 1993 to study the effects of simulated chlorsulfuron drift by treating branches of three cherry (*Prunus avium*) cultivars at different growth stages. In single exposure experiments, the yield and quality of fruit decreased significantly with the increase of chlorsulfuron concentrations. The concentrations correspond to 1/900th, 1/300th, 1/100th and 1/10th the field application rates (23.34 g/ha) recommended for wheat. In multiple exposure experiments, fruit yield, fruit size, and color was significantly reduced with increasing chlorsulfuron concentrations and numbers of exposures. The data suggest that multiple exposures of a susceptible cherry cultivar to low levels of chlorsulfuron at full bloom and post bloom stages can reduce yield and delay maturity of cherries while increasing firmness.

The researchers concluded that these results concur with the observations by Fletcher *et al.* (1993), in that the toxicity of chlorsulfuron to cherries was correlated with concentration and reproductive growth stage at the time of exposure. However, if visible symptoms were not present, there were no yield reductions. Reproduction in cherry trees can be adversely affected by exposure to concentrations of chlorsulfuron substantially lower than field application rates.

3.7.2 Greenhouse Studies

The influence of low application rates of chlorsulfuron on the growth and reproduction of four taxonomically diverse plant species (canola, smart weed, soybean, and sunflower) were examined (Fletcher *et al*. 1996). Exposure ranged from 1 x10^{-3} to 8 x 10^{-3} of the recommended field rates for cereal crops. Each species received a single application at one of the three different stages of reproduction development. The comparative effects of four different herbicides (atrazine, chlorsulfuron, glyphosate, and 2,4-D) were determined in the same manner.

Chlorsulfuron reduced the yields of all plants tested, with the amount of reduction depending on the time and rate of application. For canola and soybean, applications of 9.2 x 10^{-5} and 1.8 x 10^{-4} kg/ha, respectively, reduced seed yields by 92 and 99% as compared to controls without causing significant changes in vegetative growth. These low application rates are within the range of reported herbicide drift levels and suggest that chlorsulfuron may cause severe reductions in the yields of some non-target crops if they are subject to exposure at critical stages of development. Application of other herbicides at comparable rates and stages of plant development had no influence on either canola or soybean.

Researchers concluded that chlorsulfuron and perhaps other sulfonylurea herbicides appear to have influences on plant reproduction which are not characteristic of many common herbicides. Low application rates of chlorsulfuron influenced the reproduction of four taxonomically diverse species in a manner similar to that shown previously for cherries and green pea (see above). In this study, canola and soybean were the most sensitive species to chlorsulfuron. Smart weed, a food source for waterfowl, was moderately sensitive and sunflower was insensitive except at the highest application rate and only one stage in development.

Analysis of spray drift data collected under field conditions have been reported by Bird (1992) to range, depending on meteorological conditions, from 0.02 to 2% of application at a distance as great as¼ mile from the application zone. Since the application rates of chlorsulfuron used in this investigation fall withing this range, it follows that there may be occasions where chlorsulfuron may drift onto non-target vegetation and severely curtail yield without causing noticeable effects on the vegetative growth or foliar appearance of the non-target plants. If such events are occurring in agriculture, not only will it be difficult to recognize them but it will be virtually impossible to prove that chlorsulfuron was responsible for the episode, because the amounts of chlorsulfuron inducing yield reduction of soybean in this study are below the detection level of conventional chemical analysis (Zahnow, 1982). The yield reduction that chlorsulfuron may cause in crops such as canola and soybean would not be expected for the other herbicides examined in this investigation.

Chlorsulfuron and other sulfonylurea herbicides are 100 times more toxic to the vegetative growth of plants than older, commonly used herbicides such as atrazine and 2,4-D (Beyer, *et al.* 1988). Results of this greenhouse study suggest that sulfonylurea herbicides are even more toxic to plant reproduction. If certain crops such as soybean are exposed to chlorsulfuron concentrations of 1.8 x 10^{-4} kg/ha or higher at critical stages during reproductive development, chlorsulfuron may be as much as 10,000 times more toxic to yield than other conventional herbicides such as atrazine and 2,4-D.

3.7.3 Non-target Plant Incident Reports

There are three non-target plant incidents attributed to off-site drift of chlorsulfuron (Glean®) in the EPA's EIIS incident database. One incident occurred in the spring of 1990, near Benton City Washington (Fletcher, 1991). Orchard growers alleged that herbicides applied to wheat fields in Horse Heaven drifted onto orchards in Badger Canyon and damaged cherry, apple, plum, and apricot crops. On numerous occasions between May 2 and June 5, 1990 investigators employed by the state of Washington investigated allegations of herbicide-drift damage in Badger Canyon.

A report from the Washington State Dept. of Agriculture (Fletcher, 1991) indicated that sulfonylureas, Express® and Glean® (chlorsulfuron) were applied within a 5- to 15-mile arc south and west of Badger Canyon on dates ranging from March 26 to April 14, a time span which coincides with flowering and fruit set for cherry trees in Badger Canyon. The report also indicated that the wind direction and velocity favored drift of Glean herbicide from Horse Heaven Hills toward Badger canyon. Growers contended that sulfonylurea herbicides were most likely to be responsible for the damage because damage of this magnitude never occurred prior to the use of sulfonylurea herbicides on Horse Heaven Hills.

Examinations of two cherry and one apricot orchard clearly showed that the crop was exceptionally light in 1990 with some trees having virtually no fruit. There appeared to be less fruit on the west side of the orchards, the side facing Horse Heaven Hills. One orchard had numerous young apple trees with leader stems showed growth abnormalities typical of herbicide damage. Fletcher concluded that some of the damage observed in the orchards, such as viral infected leaves, was not due to herbicide drift. Fruit loss may have been due to herbicide drift. However, there is no conclusive evidence, such as analytical data showing the presence of a sulfonylurea compound at the site of reported plant damage, in Badger Canyon.

According to another incident report (#I000230-001) in Benton WA, there was off-target drift of aerially applied chlorsulfuron from a plateau devoted to wheat farming. The off-target movement approximated a front equivalent to one land section. The drift allegedly resulted in extensive crop damage to an orchard. Peach trees were severely damaged, cherries and prunes suffered some damage. Young and old plantings were damaged alike. Peaches were not affected.

Consulting agrologists were called in to identify the source of the damage. They were able to duplicate the incident with the original resulting damage to peaches, cherries and prunes without damage to pears. This was achieved through the use of various herbicides and simulated drift. They were able to narrow the herbicide to one, to pinpoint the location of the treated wheat crop, and duplicate the drift pattern. The date of this event was not recorded. The certainty index in the EIIS report indicates that it is highly probable that this incident was caused by chlorsulfuron.

A third incident that was attributed to chlorsulfuron (Telar®) and/or 2,4-D occurred in Kentucky during April- May, 1994 (#I001473-001). The report indicates that the state highway department applied two herbicides to a roadway. Subsequently, a farmer alleged injury to tobacco seedlings in a nearby greenhouse. The injury was described as turning yellow and stopping growth; a condition referred to as lance-shaped leaves. The EIIS report indicates that 0.016 ppm of chlorsulfuron was found in samples taken during the incident. The certainty index indicates that this incident was possibly caused by chlorsulfuron and/or 2,4-D.

It is often difficult to determine the cause of plant damage because many symptoms of toxicity in plants appear similar to disease and nutrient deficiencies. Furthermore, chlorsulfuron adversely effects plant growth and reproduction at such low levels that detecting residues in plant tissues or in soil samples may be extremely difficult or impossible using conventional analytical methods.

3.8 Risk Characterization for Terrestrial and Aquatic Plants

Chlorsulfuron Estimated Environmental Concentrations (EECs) resulting from labeled use rates and application methods greatly exceed LOCs for non-target and endangered plants. Chlorsulfuron is very highly toxic to non-target plants, as measured by an EC_{25} of 4.0×10^{-6} lbs a.i./acre and an EC_{05} of 4.6×10^{-8} lbs a.i. per acre (vegetative vigor). Based on available data, it appears that the dose response curve for chlorsulfuron is shallow. Therefore, test concentrations were not low enough in the seedling emergence and vegetative vigor studies to determine the NOAEC for several plant species. More detailed summaries are provided in **Appendices 4 and 5.**

The representativeness of plants used in phytotoxicity testing of non-target naturally occurring plants is uncertain. The range of plants used in testing is limited to annuals despite the fact that woody plants and other perennials are commonly found in agricultural areas. Moreover, homogenous crop test plant seed lots lack the variation that occurs in natural populations, so the test plants are likely to have less variation in response than would be expected from wild populations.

In some instances, specific test species may be indicative of an effect to another naturally occurring non-target species. Native plants sharing species, genus or family affinity with the tested crop plant may show similar levels of sensitivity to a pesticide. For instance wild onions may show similar sensitivity to commercially grown onions to a particular herbicide. However, given the intensive breeding and selection that is used to develop commercial strains of a species, it is possible that natural and commercial plants of the same species may show very different responses.

A single aerial application of chlorsulfuron, assuming 5% of the applied drifts into non-target areas, results in EECs as high as 0.003 lbs ai/acre. Therefore, RQs for cereal, pasture/rangeland, and fallow use sites based on maximum application rates range up to 1,042 for non-target plants and up to 68,488 for endangered plants. The toxicity endpoint used in these RQ calculations was the shoot weight from the vegetative vigor study. If root weight was used instead, the risk quotients would be much higher **(Appendix 5).**

Several of the non-agricultural uses have multiple applications and several chlorsulfuron product labels do not specify important information on maximum application rates, numbers of applications, and methods of application. The risk quotients in Tables 10 - 14 were calculated assuming only one application of chlorsulfuron. If multiple applications are assumed, the risk quotients would be higher.

Most of the plant risk quotients are based on toxicity values derived from the seedling emergence and vegetative vigor study (MRID 4258720-01). However, the test concentrations in this study were not low enough to determine the NOAEC for some endpoints and the EC_{25} was calculated to be lower than the lowest test concentration. Therefore, the EC_{05} was used in risk quotients for endangered species and the accuracy of this measurement is uncertain.

The amount of time that the LOC is exceeded was estimated using first order degradation. The results indicate that based on maximum application rates and a soil dissipation half-life for chlorsulfuron of 60 days and using the seedling emergence endpoint, the LOC for non-target plants is exceeded for approximately 300 days following a single application of 0.016 lbs ai/acre to small grains and for well over a year for plants living in wetlands (**Appendix 7**).

While EFED guideline laboratory plant toxicity tests required by the EPA do not include reproduction endpoints, results of field studies and green house studies conducted by researchers from the EPA laboratory in Corvalis, Oregon (Fletcher *et al.* 1993 and Fletcher *et al.*1996) indicate that chlorsulfuron adversely effects plant reproduction at concentrations likely to be found in the environment.

Additionally, the Dupont Vegetation Management Report of 2002 indicates that Telar DF® (chlorsulfuron) herbicide inhibits seed formation and the production of viable seed. This aspect is characteristic of Telar DF® herbicide when applied at the rosette-bloom stages of growth. The viability of weed seed is greatly reduced or eliminated following the application of Telar DF® herbicides when applied prior to maturation of the seed embryo. The report also indicates that while grasses are very tolerant to Telar DF® at early or late stages of growth, it should not be used on grasses grown for seed. Field research and practical use experience have demonstrated that numerous desirable tree and shrub species (established plantings) have a high degree of tolerance to Telar DF® from incidental soil residual contact when used according to the label. However, tolerances to this product varies from species to species and site considerations.

Another source of uncertainty is the fact that current product labels recommend that chlorsulfuron be tank mixed with other common herbicides to ensure that resistant weeds are killed, which may result in synergistic effects to non-target plants. Toxicity data on combinations of herbicides are lacking. However, current label precautions appear to suggest that synergistic effects may occur if chlorsulfuron is applied to fields to which certain other insecticides have been applied. For example, the label for Finesse® states that "Finesse should not be used within 60 days of crop emergence if an organophosphate insecticide (such as "Di Syston®") was used as an in-furrow treatment, or crop injury may result." Presumably, neither of these two pesticides if used alone will cause crop injury to wheat or barley. However, the label for Finesse® indicates that they apparently do cause crop injury when used together. The label restricts the use of Finesse® plus Malathion® and the use of Finesse® plus Lorsban® in the Northwest, as crop injury may result. This suggests that there may be synergistic effects to plants when chlorsulfuron is applied to fields along with organophosphate insecticides. The Finesse Label also indicates that "Tank-mix applications of Finesse plus Assert may cause temporary crop discoloration/stunting or injury when heavy rainfall occurs shortly after application".

Furthermore, the extent to which indirect effects of chlorsulfuron occur in relation to endangered terrestrial and aquatic animals is uncertain. Several field studies have documented adverse effects of chlorsulfuron to cherry trees and other non-target plant species. If these impacts are characteristic of native plant species, drifting chlorsulfuron may severely reduce growth and reproductive development of native plants, an important component of the habitat and food web for endangered wildlife.

3.8.1 Plants Exposed to Chlorsulfuron Drift

Non-target plants in areas where chlorsulfuron is applied may be exposed to short range drift (1 m to 1 km) and/or longer range drift (greater than 1 km). Drift may result from fine droplets which blow off-target before settling (spray drift) or potentially from treated soil blowing off-target (secondary drift). Although plants growing in proximity to application sites are expected to be at greatest risk of experiencing relatively high exposures to chlorsulfuron, longer range drift has been alleged to occur and cause visible effects to terrestrial plants (Felsot *et al*. 1996). Symptoms of chlorsulfuron exposure to non-target plants in areas away from application sites were documented during the same time period as spray applications, suggesting that drift in these instances was mostly due to the movement of spray droplets.

However, chlorsulfuron labels (*e.g.* Finesse) include the following precaution: “To reduce the potential for movement of treated soil due to wind erosion, do not apply to powdery, dry, or light sandy soil until they have been stabilized by rainfall, trashy mulch, reduced tillage or other cultural practices. Injury to adjacent crops may result when treated soil is blown onto land used to produce crops other than cereal grains." Chlorsulfuron is persistent on soil at most pH’s and the majority of it is applied to winter wheat (pre-or post-plant), which is commonly grown in dry regions. Therefore, the potential for treated soil to be blown off-target and result in exposure to non-target plants, should not be discounted.

While for some pesticides, application of fine sprays is important for control of target pests, chlorsulfuron's solubility, persistence, relatively low soil binding, and mobility within plants (Weed Science Society 1989) suggests that covering weeds evenly with fine droplets is not necessary to control them. Because chlorsulfuron can move with soil water and be taken up by plant roots or absorbed through plant foliage and be transported systemically throughout the weed, relatively large droplets of chlorsulfuron contacting weeds or surrounding soil are expected to be effective in killing weeds. Coarse sprays minimize drift and are not expected to reduce efficacy. Chlorsulfuron product labels (*e.g.* Finesse®) provide the following statement: "The most effective way to reduce drift potential is to apply large droplets (>150 - 200 microns). The best drift management strategy is to apply the largest droplets that provide sufficient coverage and control." The language which is standard on most DuPont pesticide product labels provides suggestions of particular droplets sizes that reduce drift but do no require the applicator to use a specific droplet size spectrum. Although a *range of droplet diameters* is mentioned, chlorsulfuron labels do not describe a *droplet size distribution* (such as the American Society of Agricultural Engineers standard definitions for droplet size) which is more appropriate for describing spray quality in regard to spray drift. When the product is applied according to the label directions, many fine, driftable droplets may be produced that do not result in improved weed control and result in off target movement and potentially in non-target plant damage.

The distance that fine spray droplets may travel is largely dependent on their size, release height, and meteorological conditions like wind speed. Larger droplets tend to deposit in the application area or nearby while smaller droplets may be blown farther downwind. Droplet settling velocity, the speed at which droplets settle in air without turbulence, can be useful for conveying the importance of droplet size on off-target movement. While a droplet with a diameter of 1000 μm (1 mm) takes 1.3 seconds to fall 10 feet and would travel 13.7-feet downwind, in a 10 mph wind, a 100 μm droplet takes 14 seconds to reach the ground and will travel 185 feet, and a 10 μm droplet will take 18 minutes to reach the ground and travel 2.7-miles downwind. These calculations are simplified in that they don't take into account vertical mixing in the atmosphere, the range of droplet sizes produced by a nozzle, or, for aerial applications, the wake of aerial application equipment. It is possible to use spray drift models better account for these aspects of off-target drift.

3.8.2 Plants in Semi-Aquatic Areas (Wetlands)

The EC_{25} for non-target plants is 3.1×10^{-5} lbs ai/acre and the NOAEC for endangered species is 6.8×10^{-6} lbs ai/acre based on the sugarbeet seedling emergence tests (**Table 11**). For a single ground application of chlorsulfuron the EECs ranged from 0.0082 lbs ai/acre for small grains (wheat, barley and oats) to 0.032 lbs ai/acre for pastures and rangeland. These EECs are calculated assuming 1.0 % off-site drift and 5.0% runoff (ten acres to one acre).

The RQs for non-target plants range from 267 to 383 for small grains up to 1,042 for pasture and rangeland and for endangered plants RQs range from 1,200 to 1,725 for small grains up to 4,688 for pasture and rangeland. Therefore, ground application of chlorsulfuron to small grains, pastures and rangeland greatly exceed LOCs for non-target and endangered plants inhabiting wetlands located near application sites. Based on PRZM/EXAMS modeling, estimated environmental concentrations remain constant; therefore, the LOC is exceeded for well over a year **(Appendix 7)**. To calculate the EEC for aerial applications, 5.0% drift and 5.0% runoff (10 acres to one acre) are assumed. This results in RQs for aerial applications that are approximately 9% higher than for ground applications.

In the RQ calculations it is assumed that 1.0 % of the ground applied chlorsulfuron drifts to offsite areas and for aerial applications 5.0 % drifts offsite. However, field studies submitted by the Spray Drift Task Force (Hewitt et al. 2002) and others reviewed by EPA (Bird *et al.* 1996) suggest that downwind deposition from spray drift can be higher or lower than these values depending largely on droplet size applied, release height, and wind speed. RQs would be higher if it was assumed that a larger percent of applied chlorsulfuron drifts offsite. Spray drift data and models show droplets can travel more than a thousand feet downwind (Teske et al. 2002). Given the high toxicity of chlorsulfuron to plants, and the distances that spray drift can travel, the potentially affected area around a treated field may be very large.

3.8.3 Terrestrial Plants (Seedling Emergence)

To calculate the RQs for terrestrial plants the EC_{25} for non-target plants (3.1×10^{-5} lbs ai/acre) and the NOAEC for endangered species (6.8×10^{-6} lbs ai/acre) were used (**Table 12**). For a single ground application of chlorsulfuron the EECs ranged from 9.6×10^{-4} lbs ai/acre for small grains (wheat, barley and oats) to 0.0038 lbs ai/acre for pastures and rangeland. These EECs are calculated assuming 1.0 % off-site drift and 5.0% runoff (one acre to one acre). The RQs for non-target plants range from 31 to 45 for small grains up to 123 for pasture and rangeland. For endangered plants RQs range from 141 to 203 for small grains up to 551 for pasture and rangeland. Therefore, ground application of chlorsulfuron to small grains, pastures, and rangeland greatly exceed risk LOCs for non-target and endangered plants inhabiting areas near application sites.

The RQs for a single aerial application **(Table 12**) are approximately 60% higher than for a ground application. To calculate EECs for an aerial application of chlorsulfuron, 5.0% drift and 5.0% runoff (one acre to one acre) are assumed. The RQs for non-target plants range from 52 to 75 for small grains up to 204 for pasture and rangeland. For endangered plants RQs range from 235 to 338 for small grains up to 919 for pasture and rangeland. Therefore, aerial application of chlorsulfuron to small grains, pastures and rangeland greatly exceeds risk LOCs for non-target and endangered plants inhabiting areas near application sites. The LOC is exceeded for well over a year following chlorsulfuron application.

3.8.4 Terrestrial Plants (Vegetative Vigor)

The vegetative vigor EC_{25} for non-target plants (4.0×10^{-6} lbs ai/acre) and the EC_{05} for endangered species (4.6×10^{-8} lbs ai/acre) were used to calculate the RQs for terrestrial plants (**Table 13**). For a single ground application of chlorsulfuron the EECs ranged from 1.6×10^{-4} lbs ai/acre for small grains (wheat, barley and oats) to 6.3×10^{-4} lbs ai/acre for pastures and rangeland. These EECs are calculated assuming 1.0 % off-site drift and no runoff. The risk quotients for non-target plants range from 40 to 58 for small grains up to 156 for pasture and rangeland. For endangered plants RQs range from 3,507 to 5,040 for a small grains up to 13,698 for pasture and rangeland. Therefore, ground application of chlorsulfuron to small grains, pastures and rangeland exceeds LOCs for non-target and endangered plants inhabiting areas near application sites.

The RQs for a single aerial application (**Table 13**) are five times higher than for a ground application. To calculate the EEC for an aerial application, 5.0% drift and no runoff was assumed. The risk quotients for non-target plants range from 200 to 290 for small grains up to 800 for pasture and rangeland. For endangered plants RQs range from 17,533 to 25,202 for a small grains up to 68,488 for pasture and rangeland. Therefore, aerial application of chlorsulfuron to small grains, pastures and rangeland greatly exceeds LOCs for non-target and endangered plants inhabiting areas near application sites.

Field studies conducted by researchers from the EPA laboratory in Corvalis Oregon have determined that chlorsulfuron adversely effects plant reproduction at concentrations likely to be found in the environment (Fletcher *et al.* 1993 and Bahatti *et al.* 1995). However, laboratory plant toxicity tests required by the EPA do not include reproduction endpoints and available data evaluating this effect are very limited.

Greenhouse studies provide further evidence of potential adverse effects to non-target plants. Fletcher *et al.* (1996) demonstrated that chlorsulfuron applications of 9.2×10^{-5} and 1.8×10^{-4} kg/ha, respectively, reduced seed yields of canola and soybean by 92 and 99%, respectively, as compared to controls without causing significant changes in vegetative growth. These low application rates are within the range of reported herbicide drift levels and suggest that chlorsulfuron may cause severe reductions in the yields of some non-target crops if they are subject to exposure at critical stages of development. Application of other herbicides at comparable rates and stages of plant development had no influence on either canola or soybean.

Additionally, as discussed in Section 3.7.3, a non-target plant incident report from the Washington State Dept. of Agriculture (Fletcher, 1991) indicates that growers contended that sulfonylurea herbicides, Express and Glean (chlorsulfuron) were most likely responsible for damage to cherry trees in Badger Canyon because damage of this magnitude never occurred prior to the use of sulfonylurea herbicides on Horse Heaven Hills.

3.8.5 Plants Exposed to Irrigation Water Containing Chlorsulfuron

Results of ground and surface water modeling indicate that in regions where chlorsulfuron is historically used, irrigation water from groundwater or surface water sources may contain levels of chlorsulfuron high enough to adversely effect non-target plants. We are aware of only one ground-water monitoring study included chlorsulfuron as an analyte. Chlorsulfuron was only detected in one sample at the limit of detection; however, the extent to which the monitoring occurred in the highest chlorsulfuron use area was not determined.

Risk quotients were also calculated for sensitive crops within irrigated fields. It was assumed that there are no endangered plants within the irrigated field. The RQs for crops range from 91 for irrigation using groundwater to 341 for using surface water to irrigate fields. Therefore, in regions where chlorsulfuron has been used historically, groundwater and surface water irrigation may result in damage to agricultural crops that are sensitive to chlorsulfuron. Irrigation using surface water increases the risk by over a factor of 3.

The above risk quotients were calculated assuming a one time exposure to irrigation water containing chlorsulfuron. If multiple irrigation events are assumed, the risk quotients would be higher. There may be a need for additional plant toxicity tests to determine how toxicity resulting from relatively low concentrations (i.e 1.6 ppb) of chlorsulfuron in an inch of simulated irrigation water compares to the toxicity levels demonstrated in the vegetative vigor and seedling emergence studies that have already been conducted.

3.8.6 Aquatic Plants

Several chlorsulfuron product labels do not specify important information on maximum application rates, numbers of applications, and methods of application. The risk quotients calculated in the assessment were based on a single application of chlorsulfuron to various agricultural crops. If multiple applications are assumed, risk quotients would be higher.

The peak EECs (PRZM/EXAMS) based on a single chlorsulfuron application range from 4.2 μg/L for wheat to 9.5 μg/L for turf (**Table 4**). The assumptions used in this modeling are provided in section 2.2. The EC_{50} for *Lemna gibba* is 0.35 μg/L the NOAEC is 0.24 μg/L (**Table 9**). The RQs for non-target aquatic plants range from 12 to 21 and for endangered aquatic plants the RQs range from 18 to 40 (**Table 10**). Therefore, RQs for non-target and endangered aquatic plants found in water bodies adjacent to application sites exceed the LOCs.

Additionally, results of Coyner *et al.* (2000) indicate that *P. pectinatius,* exposed to chlorsulfuron at 0.25 ppb for 4 weeks showed a 76% reduction in length and a 50% reduction of stems and leaves compared to control plants. Calculations using these toxicity values and the above EECs result in risk quotients ranging from 17 to 30 for non-target aquatic vascular plants.

3.8.7 Refined Assessment of Spray drift on non-target Terrestrial Plants

The following assessment is focused primarily on chlorsulfuron use on crops and is intended to accurately reflect the most important application conditions actually used in applying chlorsulfuron to assess spray drift risks to non-target plants. Application parameters used by aerial applicators in Washington and Oregon were used to estimate a range of spray drift levels in this assessment. Reports of set ups for ground boom applications were not available and thus ground boom configurations were assumed to include the range of values available in the AgDRIFT model.

Laboratory toxicity data used in this analysis were limited to effects occurring in a relatively short amount of time after a single exposure. A number of published reports suggest that chlorsulfuron, and other herbicides with the same mode of action, may result in delayed effects on crop yield and plant reproduction at levels lower than those noted to cause short-term visible effects (for a review see Ferenc 2001). If reproductive effects occur at similar or lower levels than laboratory phytotoxicity data used in this analysis, delayed effects may occur at distances substantially greater than 1000 feet from applications.

This assessment focuses on the effects of spray drift on non-target terrestrial plants. Exposure from chlorsulfuron runoff can also cause phytotoxicity to non-target plants. Chlorsulfuron's mobility and persistence in soil suggests that runoff may be an important route of exposure to non-target plants down slope of application areas. Plants in up-slope areas are not affected by runoff but may be damaged by spray drift.

Use Pattern Evaluated

This refined assessment focused on chlorsulfuron use on grain crops, such as wheat. According to the USGS and USDA, this use accounts for more than 98% of agricultural chlorsulfuron usage. The maximum application rate for wheat on the Glean product label is 0.023 lbs ai/acre. Product label rates for wheat are 0.0078 to 0.016 lbs ai /acre with application per crop season (Finesse product label). Up to 0.0625 lbs ai/acre may be used on pasture/rangeland and higher application rates are allowed for industrial areas. Use information is summarized in Table 1.

Chlorsulfuron is applied as a liquid spray and, for most uses, may be applied by ground or air. Directions for ground applications to wheat (Glean label) suggest that spray volume should be at least 3 gallons/acre for flat fan nozzles or 20 gallons/acre for Raindrop or flood jet nozzles. The lower volume is presumably allowed for the flat fan nozzle because this commonly used nozzle can produce a fine enough spray to cover the field with the low volume of 3 gallons/acre. With a volume of 3 gallons/acre, a relatively coarse spray would result in too few drops per unit area to adequately distribute the herbicide and control weeds in that area. Raindrop and flood jet nozzles are two models of nozzle that can be used to produce coarser sprays. With coarser sprays, higher volumes are generally necessary to result in adequate coverage of treated fields and weeds for control. (For information on the design of flat fan and flood jet nozzles and their relative drift levels see http://www.hardi-international.com/Agronomy/Education_Material/pdf/04a.pdf or http://lancaster.unl.edu/ag/factsheets/289.htm).

DuPont conducted a small survey of aerial applicators as an indication of typical aerial application parameters (see Appendix 9a). The DuPont survey included 15 aircraft set ups for chlorsulfuron applications in Washington and Oregon. Reported in the survey is the application volume (gallons per acre), boom length (relative to wingspan), nozzle type, nozzle angle, aircraft speed, spray pressure, and variables that were assumed in order to calculate spray droplet size. The droplets size spectra estimated from the equipment variables ranged from ASAE medium to ASAE coarse.

Toxicity

Toxicity tables for the successive plant life stages (seedling emergence and vegetative vigor) are in **Appendix 4 and 5.** The most sensitive species tested were sugarbeet (seedling emergence, EC_{25} 3.8 x 10^{-5} lbs ai/acre) and onion (vegetative vigor, EC_{25} 4.4x10^{-6} lbs/ai acre). The most sensitive effects measured in these tests were reductions in shoot weight and plant height. The phytotoxicity data was limited in that the confidence in the estimated EC_{05} and NOAEL was low.

Non-target plants exposed to herbicides may be killed outright or weakened, reducing their fitness. Non-lethal effects could cause plants to become more susceptible to plant pathogens, become less effective in competing with sympatric species, or reduce reproductive success. In instances where herbicide exposure effects fertilization or seed production, reproduction of plants in the wild would be expected to be reduced and population level changes could occur.

The representativeness of plants used in phytotoxicity testing of non-target naturally occurring plants is uncertain. The range of plants used in testing is limited to annuals despite the fact that woody plants and other perennials are commonly found in agricultural areas. Moreover, homogenous crop test plant seed lots lack the variation that occurs in natural populations, so the test plants are likely to have less variation in response than would be expected from wild populations.

In some instances, specific test species may be indicative of an effect to another naturally occurring non-target species. Native plants sharing species, genus or family affinity with the tested crop plant may show similar levels of sensitivity to a pesticide. For instance wild onions may show similar sensitivity to commercially grown onions to a particular herbicide. However, given the intensive breeding and selection that is used to develop commercial strains of a species, it is possible that natural and commercial plants of the same species may show very different responses.

Phytotoxicity Tests and Spray Drift

Spray drift exposure to plants away from field edges is expected to result in relatively few concentrated droplets depositing on and around plants. In contrast, laboratory vegetative vigor and seedling emergence phytotoxicity tests, use relatively high volumes of spray to better cover the test plant or the soil surface. In instances where an herbicide's movement in plants or soil is limited, the test conditions of the phytotoxicity studies may result in higher measured toxicity than would result from spray drift away from the field's edge. In the instance of herbicides that are mobile within plants and soil, such as chlorsulfuron which is mobile in soil and can be transported throughout exposed plants, the volume of spray used for the exposure may not alter the magnitude of the toxic effect.

Exposure

Current Label Directions relevant to Spray Drift

Chlorsulfuron product labels have very few restrictions on how and under what conditions the product may be applied. For instance there are no droplet size, wind speed, or boom height restrictions. The absence of bounds makes it more difficult to determine what conditions should be used for risk assessment. The absence of basic mandatory label language also allows applicators to make unnecessarily high drift applications. Applicator common sense would prevent worst case applications but may not result in optimal applications. For instance it is unlikely that an applicator would make a ground boom application with a high boom and a fine spray because drifting spray would be visible and it would be apparent that the efficiency of the application was low. However, without proper guidance an applicator may use a low boom but a finer spray than necessary to achieve control. Under this scenario drifting spray would be less visible but still unnecessarily high. Specifying basic spray drift control measures provides applicators with the necessary information to perform an effective and low-drift application and risk assessors with the necessary information to model drift.

AgDRIFT Background

AgDRIFT is a computer model that can be used to estimate downwind deposition of spray drift from aerial, ground boom, and orchard and vineyard airblast applications. The model contains three tiers of increasing complexity. In Tier 1, the user can assess downwind deposition from a single application from all three application methods under default conditions. The current version of AgDRIFT only allows Tier 1 level analyses for ground and airblast application methods. In higher tiers more options are available for aerial applications. The aerial portion of the model is based on a mechanistic US Forest Service model (AGDISP. Bilanin et al 1989). The ground boom and orchard airblast portions are empirical models based on data collected by the Spray Drift Task Force (SDTF). The SDTF field data were used to validate the aerial portion of AgDRIFT (Bird et al 1996a and 1996b). AgDRIFT was developed under a cooperative research and development agreement between EPA, USDA, and the SDTF.

Aerial AgDRIFT: The most important factors affecting drift from aerial applications are spray quality (droplet size), release height, and wind speed. The aerial part of the model predicts mean values based on the inputs provided. The Tier 1 aerial results are generated using the specified droplet size spectra, 10 foot release height, and a 10 mph wind speed. When wind speed and/or release height is lower than the modeled values the spray drift levels would be expected to be lower. Conversely, in instances where applications may be made in higher wind speeds or at a higher release height these inputs may not be adequately conservative and higher tier modeling may be necessary.

Ground boom sprayers in AgDRIFT: The most important factors affecting drift from ground boom applications are spray quality, release height, and wind speed. The ground boom part of AgDRIFT is based on field trial data from bare ground applications. The results of the model reflect the quality and conditions of the data on which it is based. The data from the field trials were grouped into categories by spray quality (droplet size) and release height. Results from field trials conducted with different wind speeds were averaged. The average wind speed over all the trials was approximately 10 mph. AgDRIFT outputs for ground boom applications estimate the 50^{th} and 90^{th} percentile of data collected from field trials. For this analysis the 50^{th} percentile data was used. The field trial data were not corrected for incomplete analytical recoveries, suggesting the true mean deposition values would be approximately 20% higher than the model's deposition results.

Phytotoxicity and Downwind Distance

Using the AgDRIFT model (version 2.01) and registrant submitted phytotoxicity data (MRID 42587201, McKelvey and Kuratle 1992) it is possible to estimate distances downwind from application areas at which a particular toxic effect level would be experienced by a particular tested plant species. To make Figures 2 through 7 below, EC_{25} values (for vegetative vigor shoot weight) of the tested species were used with the toxicity slope[1] from each species to calculate EC_{10}, EC_{20}, EC_{30}, to EC_{90} effect levels[2]. These EC_x values were entered into an Excel spreadsheet with Tier 1 AgDRIFT (version 2.01) deposition distance results and the maximum chlorsulfuron application rate for pasture/rangeland (0.0625 lbs ai/acre). Excel then calculated estimated downwind deposition levels for chlorsulfuron use on pasture/rangeland and compared the deposition values to the EC_x values to identify the downwind distance at which the EC_x values would be reached. Excel arranged the distances into three dimensional bar charts showing the downwind distance at which a particular toxicity level for each species is expected to occur under the Tier 1 AgDRIFT conditions with the specified application rate.

The barcharts shown in Figures 2 through 7 are specific to the maximum application rate for pasture/rangeland (0.0625 lbs ai/acre). **Appendix 9b** contains phytotoxicity barcharts for a middle of the range application rate from the Finesse product label for preemergent spraying to wheat (0.012 lbs ai/acre).

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[1] Toxicity slopes are calculated from dose-response relationship of chlorsulfuron on of the test plant species. Species with high (steep) slopes show large increases in toxicity from small increases in exposure. Species with low (shallow) slopes show small increases in toxicity from relatively large increases in exposure.

[2] A log normal toxicity distribution is assumed. The following equation is used to calculate the various EC_x levels: $[EC_{25} / 10^{-0.67/slope}] \times 10^{-a/slope} = EC_x$ where a = 1.28, 0.84, 0.54, 0.25, 0, -0.25, -0.54, -0.84, and -1.28 for EC_{10}, EC_{20}, EC_{30}, EC_{40}, EC_{50}, EC_{60}, EC_{70}, EC_{80}, EC_{90}, respectively.

Figure 2. Predicted phytotoxicity levels and associated downwind distances from an **aerial** application conducted with a **coarse** spray in a 10 mph wind with a 10 foot release height at an application rate of 0.0625 lbs chlorsulfuron per acre. The plant species listed on the bottom right axis are test species for which the registrant submitted phytotoxicity data (the toxicity slope for cucumber was unavailable so cucumber results are not shown).

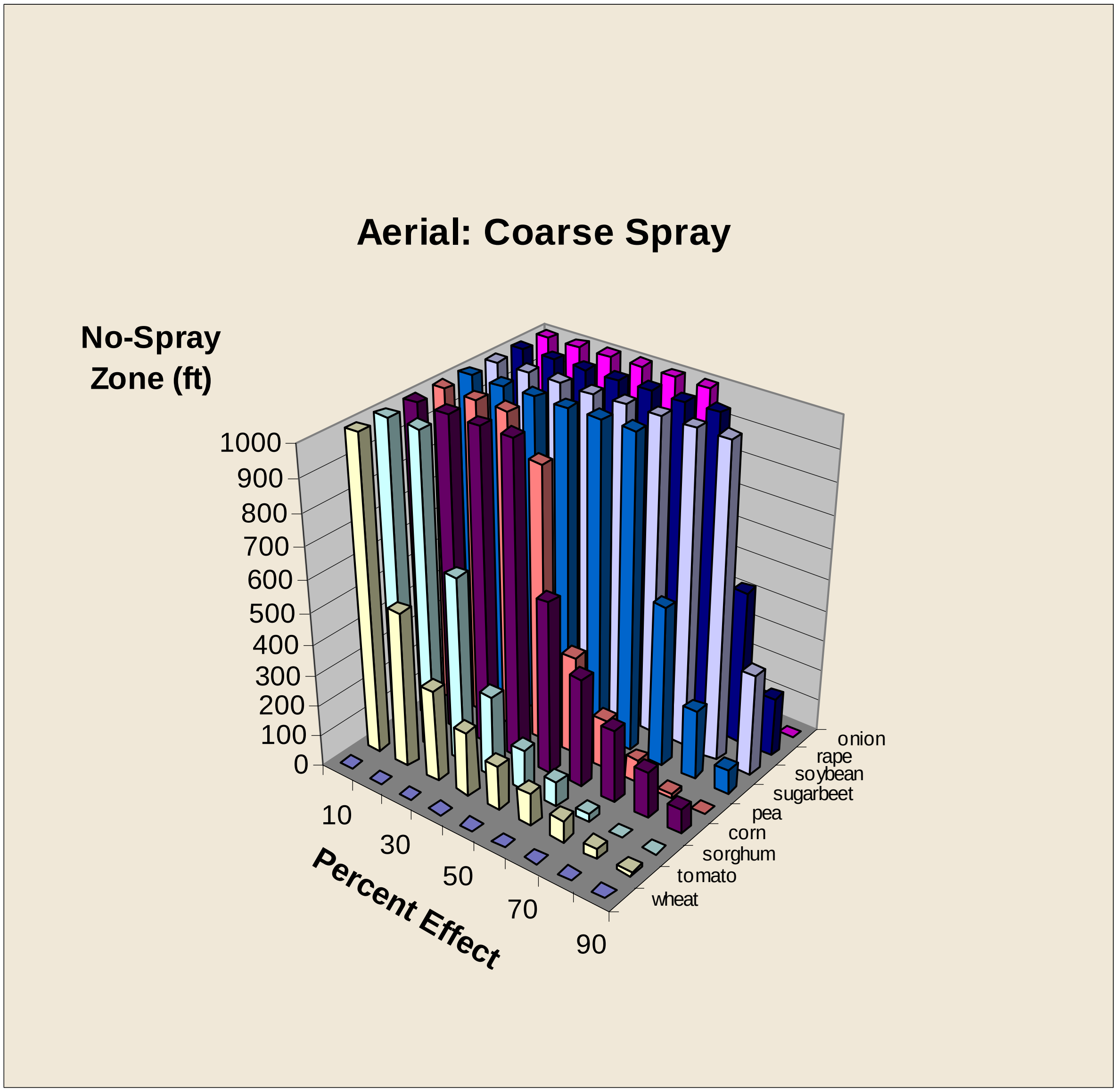


Figure 3. Predicted phytotoxicity levels and associated downwind distances from an **aerial** application conducted with a **medium** spray in a 10 mph wind with a 10 foot release height at an application rate of 0.0625 lbs chlorsulfuron per acre. The toxicity slope for cucumber was unavailable.

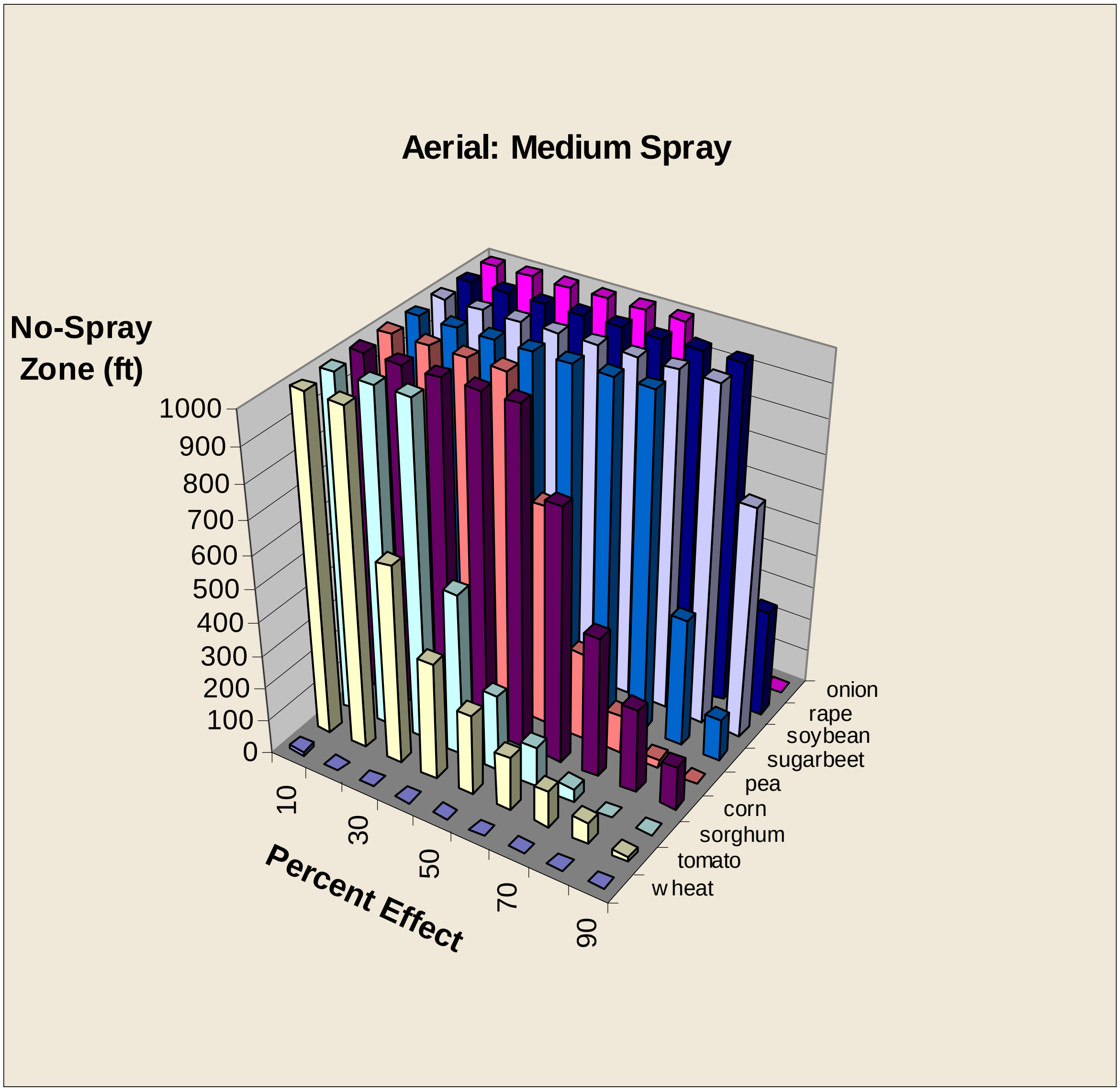


Figure 4. Predicted phytotoxicity levels and associated downwind distances from a **ground boom** application conducted with a **medium/coarse** spray in an approximate 10 mph wind with a **2 foot release height** at an application rate of 0.0625 lbs chlorsulfuron per acre. The toxicity slope for cucumber was unavailable.

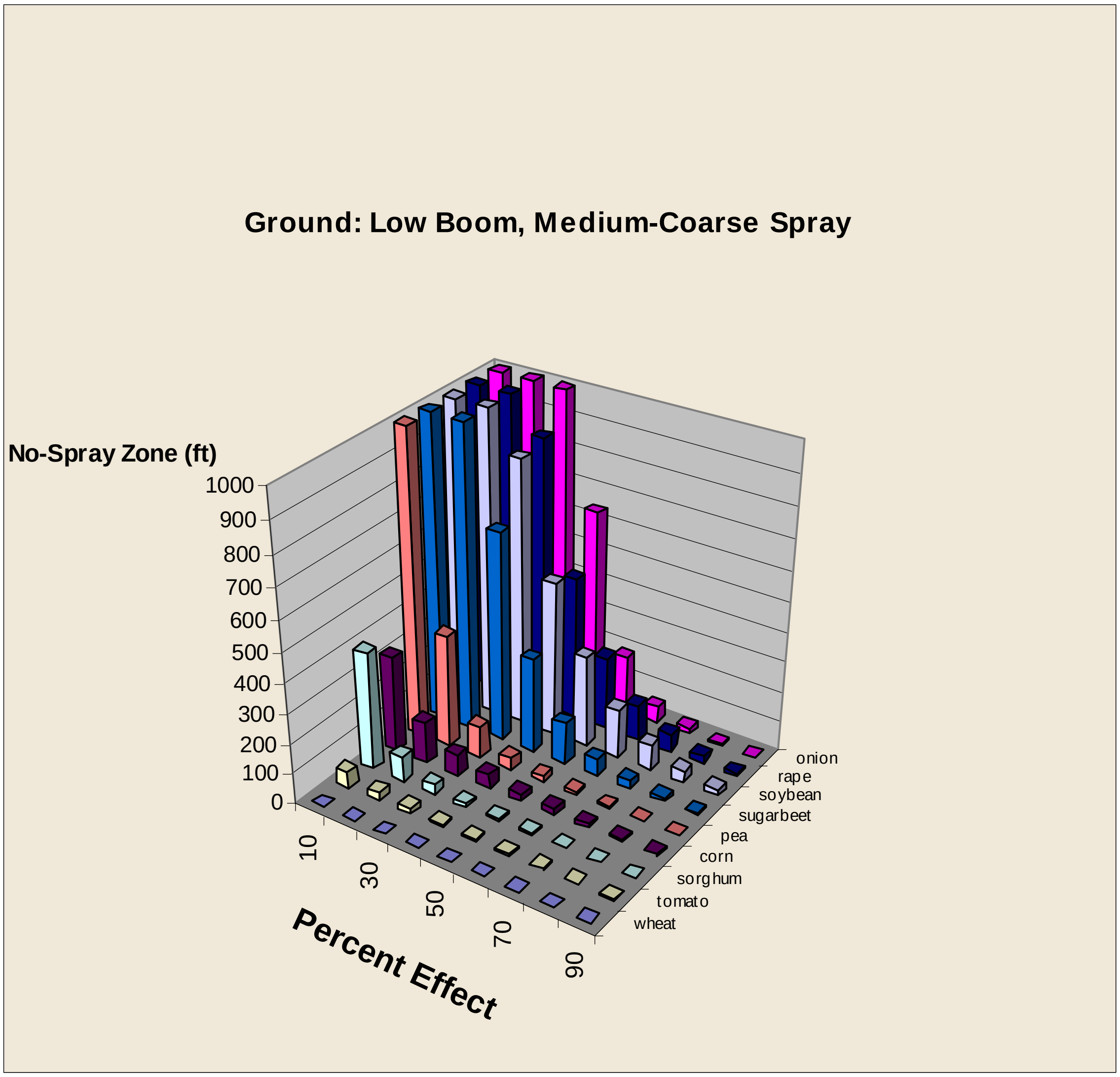


Figure 5. Predicted phytotoxicity levels and associated downwind distances from a **ground boom** application conducted with a **medium/coarse** spray in an approximate 10 mph wind with a **4 foot release height** at an application rate of 0.0625 lbs chlorsulfuron per acre. The toxicity slope for cucumber was unavailable.

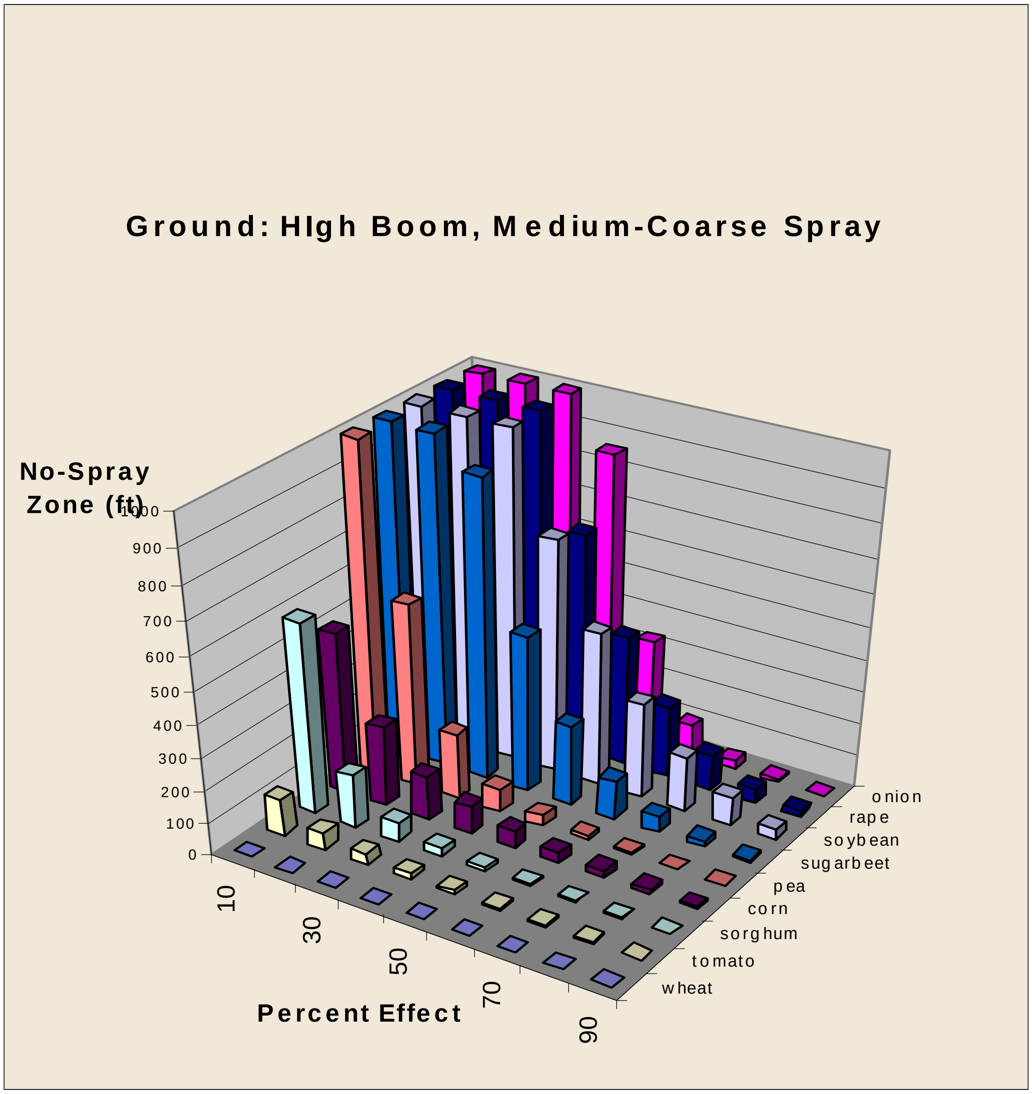


Figure 6. Predicted phytotoxicity levels and associated downwind distances from a **ground boom** application conducted with a **medium** spray in an approximate 10 mph wind with a **2 foot release height** at an application rate of 0.0625 lbs chlorsulfuron per acre. The toxicity slope for cucumber was unavailable.

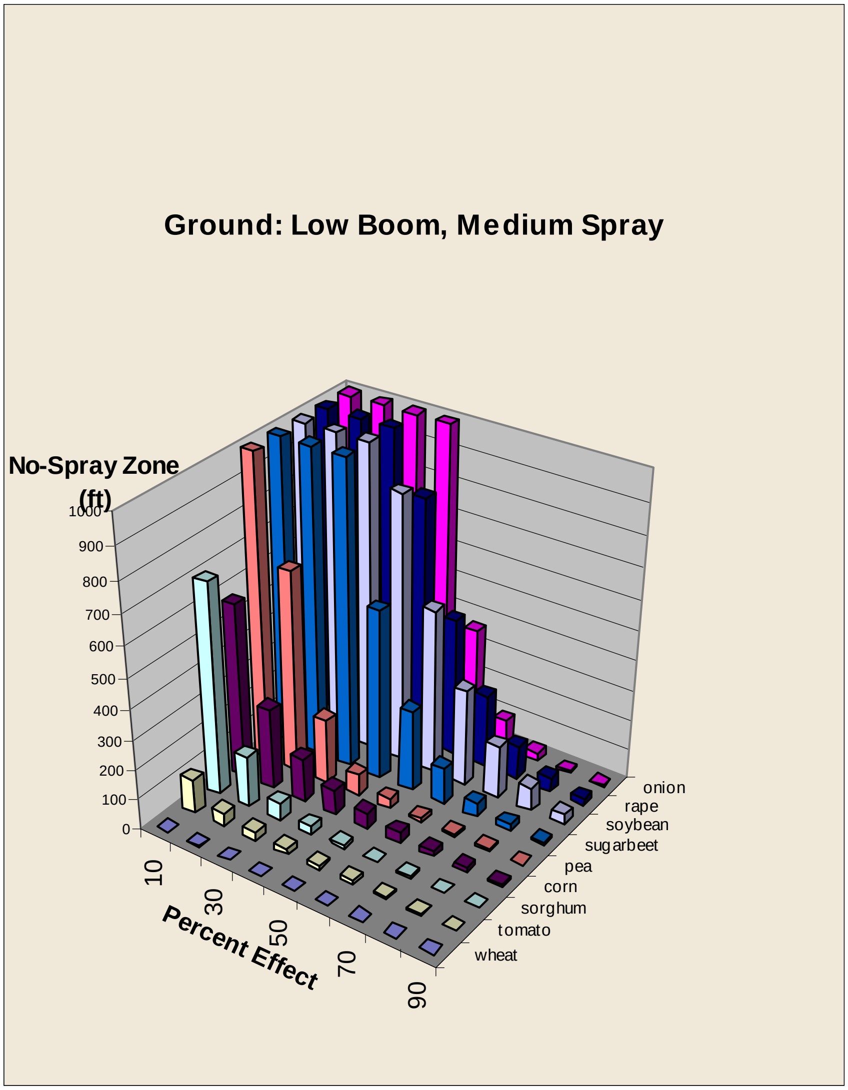
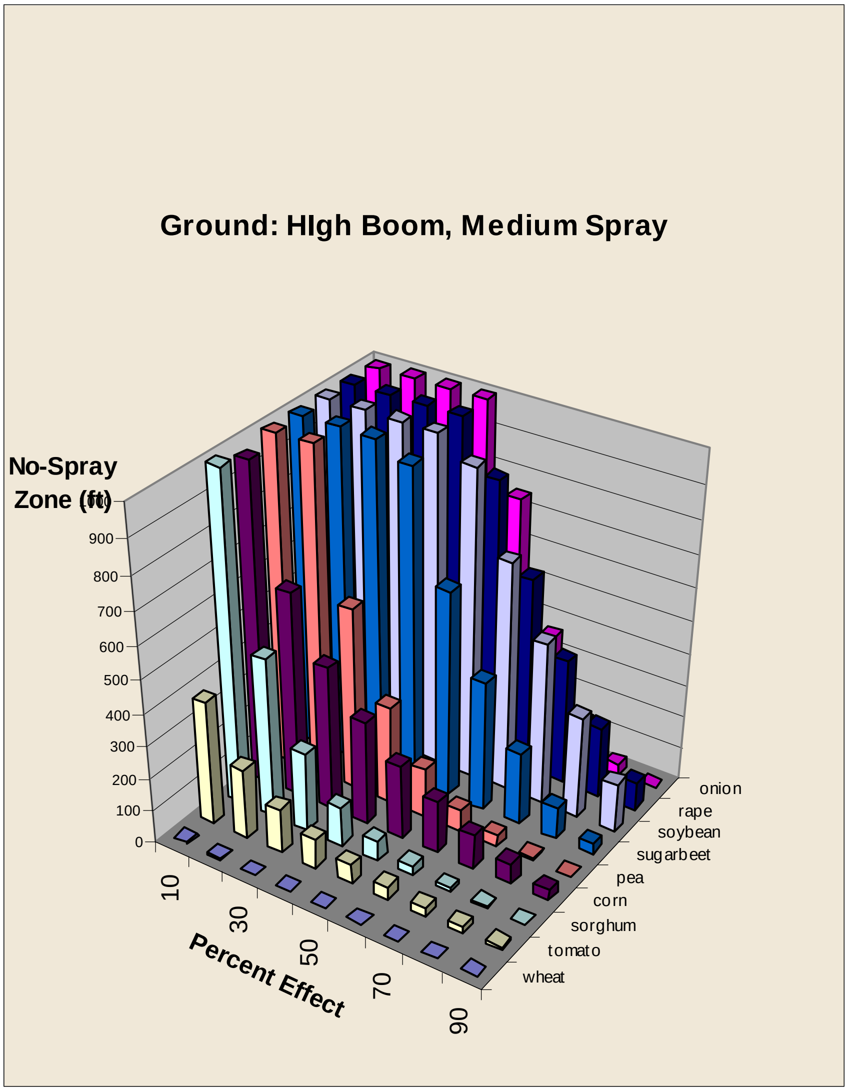


Figure 7. Predicted phytotoxicity levels and associated downwind distances from a **ground boom** application conducted with a **medium** spray in an approximate 10 mph wind with a **4 foot release height** at an application rate of 0.0625 lbs chlorsulfuron per acre. The toxicity slope for cucumber was unavailable.



Conclusions

Based on the phytotoxicity study results for wheat and chlorsulfuron use sites such as pasture/range land, certain grass species appear to be tolerant to acute chlorsulfuron effects. Some tolerant species apparently are susceptible to reproductive effects from single exposures based on product claims of inhibiting seed head formation described on some product labels. Because of lack of data, reproductive effects cannot be evaluated at this time. Available data suggest that it is unlikely that field edges and areas downwind comprised of grass would be greatly affect by acute effects of chlorsulfuron.

Figures 2 through 7 above show the phytotoxicity downwind of chlorsulfuron applications is expected to vary based on a number of parameter including application method (ground boom versus aerial), the droplet size spectrum, and the release height.

Figures 2 through 7 show effects (EC_x effect levels) by distance, but do not show at what distance plants are likely to be killed outright. When plants are tested by pesticide companies for efficacy generally a 70% effect level is considered to be a threshold for lethal effects to a healthy weed (Pallett 2003). Thus the EC_{70} effect level can serve as estimate of when non-target plants are expected to have a high likelihood of rapid death similar to the desired effect for weed species.

Aerial Applications

For aerial applications, medium and coarse sprays are apparently the most commonly used sprays by aerial applicators in Washington and Oregon - see **Appendix 9b**. Medium spray is expected to produce higher drift levels than coarse sprays resulting in greater phytotoxicity at greater downwind distances. Using the EC_{70} as an estimate for an exposure that would lead to rapid death, Figure 3 shows that 3 of the 9 tested species downwind of an application with a medium spray would be expected to be killed soon after application in an area stretching from the edge of the treated field to a distance exceeding 1000 feet downwind from the treatment area. Using a coarse spray, Figure 2 shows that 2 of the 9 tested species would be expected to be killed from the edge of the field to a distance exceeding 1000 feet downwind from the treatment area. Aerial applications with a medium spray are expected to affect at least 8 of the 9 species tested at the EC_{20} level or above for shoot weight greater than 1000 feet downwind of applications. In other words, a 20% or more reduction in shoot weight would be expected for at least 8 of 9 tested species for over 1000 feet downwind of applications under the assumed conditions. With a coarse spray, under the same conditions, at least 8 of the 9 tested species are expected to be affected at the EC_{10} level 1000 feet or more downwind (i.e. a 10% reduction in shoot weight in an areas stretching for more than 1000 feet downwind).

Ground boom Applications

In all instances the ground boom applications modeled resulted in lower drift deposition levels and downwind phytotoxicity than modeled aerial applications. Ground boom deposition values were affected by both droplet size and release height. Spray drift and predicted off-target effects can be reduced by lowering the release height and/or increasing spray droplet size.

Under the lowest ground boom drift conditions allowed by AgDRIFT 2.01 (2 foot boom height and medium/coarse spray), 5 of 9 tested species would be expected to be rapidly killed from 10 to 85 feet downwind the treated area (Fig. 4). Under the same conditions, 5 of the 9 tested species would be affected at the EC_{10} level in the area stretching for the edge of the field to beyond 1000 feet downwind.

Under the highest ground boom drift conditions (4 foot boom and medium spray), plant species would be expected to be killed in the area that stretches from 0 to 10 feet (for 8 of 9 tested plants) and 0 to 500 feet (for the most sensitive tested plant) downwind of the treated field (Fig. 7). Under the same conditions, 6-7 of the 10 tested species are expected to be affected at the EC_{10} level at distances from 0 to beyond 1000 feet downwind. Tested species are expected to be affected at the 90% effect level at 10 feet (5 of 9 species) to 150 feet (1 of 9 species) downwind.

Risk Characterization

Chlorsulfuron is a selective herbicide. Some species, such as certain grasses, are relatively tolerant to chlorsulfuron while other species are sensitive to acute effects and reproductive effects. If certain plants in a plant community consisting of many species are consistently selected against through inhibiting growth, reducing reproductive success, or being killed, the sensitive plant species are likely to be removed from the community. Plants under selective pressure are not able to compete as successfully with other plants for resources such as light and water. Thus with pressure on a particular group of species other species would be likely displace the sensitive species and become more common. Changes in the species composition in the boundaries of herbicide-treated fields have been noted in the literature (Kleijn and Snoeijing 1997, Jobin *et al* 1997). Given the selectivity of chlorsulfuron and the drift potential associated with spray application methods, it is expected that chlorsulfuron is applying selective pressure against certain species downwind of application areas. The magnitude of the selective pressure is expected to depend on the level of drift as well as the sensitivity of exposed species.

The results of this analysis suggest that placing restrictions on droplet size for aerial applications and droplet size and boom height for ground boom application may reduce risks associated with chlorsulfuron applications. Typical values for both wind speed and release height are likely to vary geographically . Aerial applicators balance low release heights with flight safety. Aerial applicators will generally use higher release heights in hilly areas or fields with tall windbreaks at their boundaries. For ground boom applications, high release heights are used to avoid having the ends of the spray boom hitting the ground in uneven fields or when relatively high sprayer speed is desired. Ground boom release height can vary from less than 2 feet to more than 6 feet above the ground or crop canopy. Average wind speed for chlorsulfuron use areas vary with location with higher wind speed occurring in plains states. Table 15 shows wind speeds ranges for some representative areas.

Table 15. Wind speeds during the windiest month of the year for cities in high agricultural chlorsulfuron use areas.					
City, State	Approximate location in state	Month	Wind speed (mph)		
			75th Percentile	50th Percentile	25th Percentile
Yakima, WA	south central	April	10	6	4.5
Pendleton, OR	northwestern	April	10.5	6	4.5
North Platte, NE	central southwestern	April	14	11	7

More wind speed data for the above locations are in **Appendix 9c**.

Uncertainty and Potential Refinement of Risk Estimates

A number of uncertainties exist in this assessment of potential effects of chlorsulfuron spray drift to plants. With additional information it may be possible to further refine this assessment.

1) The representativeness of tested species for non-target plant species in chlorsulfuron use areas. In chlorsulfuron use areas woody and other perennial species are exposed to spray drift but their sensitivity to chlorsulfuron is uncertain. Toxicity data on a wider range of plants could be used to reduce uncertainty as to the potential effects of chlorsulfuron on perennial and woody species at field edges and farther downwind.

2) The duration of exposure. Laboratory data is based on single exposures to plants with observation continuing for two weeks after dosing. Non-target plants in chlorsulfuron use areas may be exposed to multiple pulses of chlorsulfuron. Data on the effect of repeat exposures at environmentally relevant levels could be used to determine the potential impacts to plants that are exposed to drift from multiple applications.

3) The toxic endpoint measured. Some chlorsulfuron product labels and research on non-target plants show chlorsulfuron negatively affects plant reproduction. Data defining what exposure levels at various developmental stages result in impaired plant reproduction could be used for assessing potential impacts of spray drift on plant reproduction.

4) The adequacy of laboratory spraying treatments in representing spray drift far from field boundaries. Plants in laboratory studies are exposed to herbicide in volumes of carrier that are adequate to cover the test plants. Plants exposed to spray drift away from field boundaries would contact the same amounts of herbicides tested in the laboratory but in much lower volumes of carrier. Plants are exposed to spray drift away far away from the field edge in discrete spots where droplets impact the plant foliage opposed to the diffuse coating used in lab studies. The effect of small concentrated exposures relative to diffuse exposure is uncertain. Data on the effect of exposure volume on phytotoxicity could be used to refine effect level estimates.

4. ENDANGERED/THREATENED SPECIES

Available data indicate that chlorsulfuron does not exceed the LOC for endangered/threatened terrestrial or aquatic animals. However, the screening level risk assessment for endangered species indicates that chlorsulfuron does exceed the endangered species level of concern for endangered and threatened terrestrial and vascular aquatic plants. The endangered species assessment on all use sites will be refined using data submitted as a result of this RED. Further analysis regarding the overlap of individual species with each use site is required prior to determining the likelihood of potential impact to listed species. After the new data are reviewed, the risk assessment will be refined and exceedances of levels of concern for high risks to endangered species will be addressed.

Chlorsulfuron was included in the small grains cluster consultation with the Fish and Wildlife Service (FWS) in 1983. As chlorsulfuron's risks were determined to be a "no effect" determination with regard to aquatic and terrestrial animals, Reasonable and Prudent Alternatives and Reasonable and Prudent Measures were not provided for this pesticide. Risks to endangered plants were not considered in this Biological Opinion.

The current risk assessment does not evaluate risk from direct application to plants. However, given that endangered plant risk quotients for spray drift alone from aerial applications range from 17.5 thousand to 68 thousand, it is likely that nontarget plants receiving direct applications would be even more vulnerable to adverse effects.

The Office of Pesticide Programs recently published on its web site (http://www.epa.gov/espp/consultation/index.html), an overview of our ecological risk assessment process for threatened and endangered species. Because of the timing of that document and the fact that it still may undergo slight changes, the process described therein was not fully utilized for this screening-level endangered species risk assessment. The Agency will reassess the potential risk of chlorsulfuron use to endangered species using the new process at a later date and consult as appropriate with the U. S. Fish and Wildlife Service and National Marine Fisheries Service at that time.

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APPENDIX 1. PRZM and EXAMS input files

PRZM input for Florida Turf

```
FL 8/09/2001
Osceola County; Representation of the Lake Kissimmee/Indian River Region; MLRA 156A; Metfile:
W12834.dvf [Daytona Beach] (old: Met156A.met)
*** Record 3:
    0.78       0       0      25       1       3
*** Record 6 -- ERFLAG
       4
*** Record 7:
    0.04   0.303       1   172.8               4       2     600
*** Record 8
       1
*** Record 9
       1     0.1      10     100       3  74  74  74       0       5
*** Record 9a-d
       1      25
0101 1601 0102 1602 0103 1603 0104 1604 0105 1605 0106 1606 0107 1507 1607 0108
.023 .026 .030 .035 .042 .050 .056 .060 .063 .068 .074 .079 .082 .125 .148 .189
.023 .023 .023 .023 .023 .023 .023 .023 .023 .023 .023 .023 .023 .023 .023 .023
1608 0109 1609 0110 1610 0111 1611 0112 1612
.229 .265 .294 .314 .326 .017 .018 .019 .021
.023 .023 .023 .023 .023 .023 .023 .023 .023
*** Record 10 -- NCPDS, the number of cropping periods
      30
*** Record 11
  010261  150261  151261       1
  010262  150262  151262       1
  010263  150263  151263       1
  010264  150264  151264       1
  010265  150265  151265       1
  010266  150266  151266       1
  010267  150267  151267       1
  010268  150268  151268       1
  010269  150269  151269       1
  010270  150270  151270       1
  010271  150271  151271       1
  010272  150272  151272       1
  010273  150273  151273       1
  010274  150274  151274       1
  010275  150275  151275       1
  010276  150276  151276       1
  010277  150277  151277       1
  010278  150278  151278       1
  010279  150279  151279       1
  010280  150280  151280       1
  010281  150281  151281       1
  010282  150282  151282       1
  010283  150283  151283       1
  010284  150284  151284       1
  010285  150285  151285       1
  010286  150286  151286       1
  010287  150287  151287       1
  010288  150288  151288       1
  010289  150289  151289       1
  010290  150290  151290       1
*** Record 12 -- PTITLE
chlor - 1 applications @ 0.0625 kg/ha
*** Record 13
      30       1       0       0
*** Record 15 -- PSTNAM
chlor
*** Record 16
  010461  0 2  0.00.0625 0.95 0.16
  010462  0 2  0.00.0625 0.95 0.16
  010463  0 2  0.00.0625 0.95 0.16
  010464  0 2  0.00.0625 0.95 0.16
  010465  0 2  0.00.0625 0.95 0.16
```

```
  010466  0 2  0.00.0625 0.95 0.16
  010467  0 2  0.00.0625 0.95 0.16
  010468  0 2  0.00.0625 0.95 0.16
  010469  0 2  0.00.0625 0.95 0.16
  010470  0 2  0.00.0625 0.95 0.16
  010471  0 2  0.00.0625 0.95 0.16
  010472  0 2  0.00.0625 0.95 0.16
  010473  0 2  0.00.0625 0.95 0.16
  010474  0 2  0.00.0625 0.95 0.16
  010475  0 2  0.00.0625 0.95 0.16
  010476  0 2  0.00.0625 0.95 0.16
  010477  0 2  0.00.0625 0.95 0.16
  010478  0 2  0.00.0625 0.95 0.16
  010479  0 2  0.00.0625 0.95 0.16
  010480  0 2  0.00.0625 0.95 0.16
  010481  0 2  0.00.0625 0.95 0.16
  010482  0 2  0.00.0625 0.95 0.16
  010483  0 2  0.00.0625 0.95 0.16
  010484  0 2  0.00.0625 0.95 0.16
  010485  0 2  0.00.0625 0.95 0.16
  010486  0 2  0.00.0625 0.95 0.16
  010487  0 2  0.00.0625 0.95 0.16
  010488  0 2  0.00.0625 0.95 0.16
  010489  0 2  0.00.0625 0.95 0.16
  010490  0 2  0.00.0625 0.95 0.16
*** Record 17
       0       1       0
*** Record 18
       0       0     0.5
*** Record 19 -- STITLE
Adamsville Sand; Hydrologic Group C
*** Record 20
     102           0   0   1   0   0   0   0   0   0
*** Record 26
       0       0       0
*** Record 30
       4      36
*** Record 33
       4
       1       2    0.37    0.47       0       0       0
        0.0021660.002166       0
            0.1    0.47    0.27     7.5       0
       2      10    1.44   0.086       0       0       0
        0.0021660.002166       0
            0.1   0.086   0.036    0.58       0
       3      10    1.44   0.086       0       0       0
        0.0021660.002166       0
            0.1   0.086   0.036    0.58       0
       4      80    1.58    0.03       0       0       0
        0.0021660.002166       0
              5    0.03   0.023   0.116       0
***Record 40
       0
           YEAR      10            YEAR      10            YEAR      10   1
       1
       1  -----
       7    YEAR
    PRCP    TCUM   0   0
    RUNF    TCUM   0   0
    INFL    TCUM   1   1
    ESLS    TCUM   0   0  1.0E3
    RFLX    TCUM   0   0  1.0E5
    EFLX    TCUM   0   0  1.0E5
    RZFX    TCUM   0   0  1.0E5
```

PRZM input for Pennsylvania Turf

```
PA Turf; 9/28/01
"York Co, MLRA 148; Metfile: W14737.dvf (old: Met148.met),
*** Record 3:
```

```
    0.76     0.3       0    12.5       1       3
*** Record 6 -- ERFLAG
       4
*** Record 7:
    0.33   0.123       1   172.8               3      12     600
*** Record 8
       1
*** Record 9
       1     0.1      10     100       3  74  74  74       0       5
*** Record 9a-d
       1      26
0101 1601 0102 1602 0103 1503 1603 0104 1604 0105 1605 0106 1506 1606 0107 1607
.015 .015 .015 .015 .015 .017 .012 .006 .002 .007 .004 .002 .007 .005 .003 .001
.110 .110 .110 .110 .110 .110 .110 .110 .110 .110 .110 .110 .110 .110 .110 .110
0108 1608 0109 1609 0110 1610 0111 1611 0112 1612
.005 .003 .003 .005 .009 .013 .013 .014 .014 .015
.110 .110 .110 .110 .110 .110 .110 .110 .110 .110
*** Record 10 -- NCPDS, the number of cropping periods
      30
*** Record 11
  010461  150461  011161       1
  010462  150462  011162       1
  010463  150463  011163       1
  010464  150464  011164       1
  010465  150465  011165       1
  010466  150466  011166       1
  010467  150467  011167       1
  010468  150468  011168       1
  010469  150469  011169       1
  010470  150470  011170       1
  010471  150471  011171       1
  010472  150472  011172       1
  010473  150473  011173       1
  010474  150474  011174       1
  010475  150475  011175       1
  010476  150476  011176       1
  010477  150477  011177       1
  010478  150478  011178       1
  010479  150479  011179       1
  010480  150480  011180       1
  010481  150481  011181       1
  010482  150482  011182       1
  010483  150483  011183       1
  010484  150484  011184       1
  010485  150485  011185       1
  010486  150486  011186       1
  010487  150487  011187       1
  010488  150488  011188       1
  010489  150489  011189       1
  010490  150490  011190       1
*** Record 12 -- PTITLE
chlor - 1 applications @ 0.0625 kg/ha
*** Record 13
      30       1       0       0
*** Record 15 -- PSTNAM
chlor
*** Record 16
  010461  0 2  0.00.0625 0.95 0.16
  010462  0 2  0.00.0625 0.95 0.16
  010463  0 2  0.00.0625 0.95 0.16
  010464  0 2  0.00.0625 0.95 0.16
  010465  0 2  0.00.0625 0.95 0.16
  010466  0 2  0.00.0625 0.95 0.16
  010467  0 2  0.00.0625 0.95 0.16
  010468  0 2  0.00.0625 0.95 0.16
  010469  0 2  0.00.0625 0.95 0.16
  010470  0 2  0.00.0625 0.95 0.16
  010471  0 2  0.00.0625 0.95 0.16
  010472  0 2  0.00.0625 0.95 0.16
  010473  0 2  0.00.0625 0.95 0.16
  010474  0 2  0.00.0625 0.95 0.16
  010475  0 2  0.00.0625 0.95 0.16
```

```
  010476  0 2  0.00.0625 0.95 0.16
  010477  0 2  0.00.0625 0.95 0.16
  010478  0 2  0.00.0625 0.95 0.16
  010479  0 2  0.00.0625 0.95 0.16
  010480  0 2  0.00.0625 0.95 0.16
  010481  0 2  0.00.0625 0.95 0.16
  010482  0 2  0.00.0625 0.95 0.16
  010483  0 2  0.00.0625 0.95 0.16
  010484  0 2  0.00.0625 0.95 0.16
  010485  0 2  0.00.0625 0.95 0.16
  010486  0 2  0.00.0625 0.95 0.16
  010487  0 2  0.00.0625 0.95 0.16
  010488  0 2  0.00.0625 0.95 0.16
  010489  0 2  0.00.0625 0.95 0.16
  010490  0 2  0.00.0625 0.95 0.16
*** Record 17
       0       1       0
*** Record 18
       0       0     0.5
*** Record 19 -- STITLE
"Glenville, Silt Loam, HYDG: C"
*** Record 20
     102           0   0   1   0   0   0   0   0   0
*** Record 26
       0       0       0
*** Record 30
       4      36
*** Record 33
       4
       1       2    0.37    0.47       0       0       0
        0.0021660.002166       0
             0.1    0.47    0.27     7.5       0
       2      10     1.4   0.254       0       0       0
        0.0021660.002166       0
             0.1   0.254   0.094    1.74       0
       3      12     1.4   0.254       0       0       0
        0.0021660.002166       0
               2   0.254   0.094    1.74       0
       4      78     1.8   0.201       0       0       0
        0.0021660.002166       0
               2   0.201   0.121   0.174       0
***Record 40
       0
            YEAR      10            YEAR      10            YEAR      10   1
       1
       1  -----
       7    YEAR
    PRCP    TCUM   0   0
    RUNF    TCUM   0   0
    INFL    TCUM   1   1
    ESLS    TCUM   0   0  1.0E3
    RFLX    TCUM   0   0  1.0E5
    EFLX    TCUM   0   0  1.0E5
    RZFX    TCUM   0   0  1.0E5
```

PRZM input for North Dakota Wheat

```
North Dakota Spring Wheat MLRA F56 Cass County Bearden silty clay loam
"Red River Valley of the North MLRA 56 MN, ND, SD 1948-1983; Metfile: W14914.dvf (old: Met56.met),
*** Record 3:
    0.75     0.5       0      12       1       1
*** Record 6 -- ERFLAG
       4
*** Record 7:
    0.28    0.17       1   172.8               3     1.5     600
*** Record 8
       1
*** Record 9
       1     0.1      22     100       1  91  85  87       0     100
*** Record 9a-d
       1      28
0101 1601 0102 1602 0103 1603 0104 1604 2004 0105 0505 1605 0106 1606 0107 1607
.583 .581 .579 .577 .574 .574 .575 .575 .611 .617 .610 .562 .468 .268 .092 .064
.014 .014 .014 .014 .014 .014 .014 .014 .014 .014 .014 .014 .014 .014 .014 .014
0108 0508 1008 1608 0109 1609 0110 1610 0111 1611 0112 1612
.065 .036 .098 .110 .126 .139 .152 .162 .168 .170 .171 .171
.014 .014 .014 .014 .014 .014 .014 .014 .014 .014 .014 .014
*** Record 10 -- NCPDS, the number of cropping periods
      30
*** Record 11
  150561  250761  050861       1
  150562  250762  050862       1
  150563  250763  050863       1
  150564  250764  050864       1
  150565  250765  050865       1
  150566  250766  050866       1
  150567  250767  050867       1
  150568  250768  050868       1
  150569  250769  050869       1
  150570  250770  050870       1
  150571  250771  050871       1
  150572  250772  050872       1
  150573  250773  050873       1
  150574  250774  050874       1
  150575  250775  050875       1
  150576  250776  050876       1
  150577  250777  050877       1
  150578  250778  050878       1
  150579  250779  050879       1
  150580  250780  050880       1
  150581  250781  050881       1
  150582  250782  050882       1
  150583  250783  050883       1
  150584  250784  050884       1
  150585  250785  050885       1
  150586  250786  050886       1
  150587  250787  050887       1
  150588  250788  050888       1
  150589  250789  050889       1
  150590  250790  050890       1
*** Record 12 -- PTITLE
chlor - 1 applications @ 0.023 kg/ha
*** Record 13
      30       1       0       0
*** Record 15 -- PSTNAM
chlor
*** Record 16
  050161  0 2  0.0 0.023 0.95 0.16
  050162  0 2  0.0 0.023 0.95 0.16
  050163  0 2  0.0 0.023 0.95 0.16
  050164  0 2  0.0 0.023 0.95 0.16
  050165  0 2  0.0 0.023 0.95 0.16
  050166  0 2  0.0 0.023 0.95 0.16
  050167  0 2  0.0 0.023 0.95 0.16
  050168  0 2  0.0 0.023 0.95 0.16
  050169  0 2  0.0 0.023 0.95 0.16
  050170  0 2  0.0 0.023 0.95 0.16
```

```
  050171  0 2  0.0 0.023 0.95 0.16
  050172  0 2  0.0 0.023 0.95 0.16
  050173  0 2  0.0 0.023 0.95 0.16
  050174  0 2  0.0 0.023 0.95 0.16
  050175  0 2  0.0 0.023 0.95 0.16
  050176  0 2  0.0 0.023 0.95 0.16
  050177  0 2  0.0 0.023 0.95 0.16
  050178  0 2  0.0 0.023 0.95 0.16
  050179  0 2  0.0 0.023 0.95 0.16
  050180  0 2  0.0 0.023 0.95 0.16
  050181  0 2  0.0 0.023 0.95 0.16
  050182  0 2  0.0 0.023 0.95 0.16
  050183  0 2  0.0 0.023 0.95 0.16
  050184  0 2  0.0 0.023 0.95 0.16
  050185  0 2  0.0 0.023 0.95 0.16
  050186  0 2  0.0 0.023 0.95 0.16
  050187  0 2  0.0 0.023 0.95 0.16
  050188  0 2  0.0 0.023 0.95 0.16
  050189  0 2  0.0 0.023 0.95 0.16
  050190  0 2  0.0 0.023 0.95 0.16
*** Record 17
       0       1       0
*** Record 18
       0       0     0.5
*** Record 19 -- STITLE
Bearden silty clay loam; HTDG: C
*** Record 20
     100           0   0   1   0   0   0   0   0   0
*** Record 26
       0       0       0
*** Record 30
       4      36
*** Record 33
       3
       1      10     1.4   0.377       0       0       0
        0.0021660.002166       0
            0.1   0.377   0.207    1.74       0
       2      52     1.5   0.292       0       0       0
        0.0021660.002166       0
              1   0.292   0.132   0.116       0
       3      38     1.8   0.285       0       0       0
        0.0021660.002166       0
              2   0.285   0.125   0.058       0
***Record 40
       0
           YEAR      10            YEAR      10            YEAR      10   1
       1
       1  -----
       7    YEAR
    PRCP    TCUM   0   0
    RUNF    TCUM   0   0
    INFL    TCUM   1   1
    ESLS    TCUM   0   0  1.0E3
    RFLX    TCUM   0   0  1.0E5
    EFLX    TCUM   0   0  1.0E5
    RZFX    TCUM   0   0  1.0E5
```

PRZM input for Texas Wheat

```
TX wheat; 8/13/2001
"Winter wheat in Blacklands prairie section of Texas grown on benchmark Crockett soil. HGRP: D; MLRA
87; Metfile: W13958.dvf (old: Met87.met), Waco met station "
*** Record 3:
    0.71     0.5       0      10       1       3
*** Record 6 -- ERFLAG
       4
*** Record 7:
    0.43   0.103       1   172.8               1       3     600
*** Record 8
       1
*** Record 9
       1     0.1     110      99       3  94  87  88       0      90
*** Record 9a-d
       1      28
0101 1601 0102 1602 0103 1603 0104 1604 0105 1605 0106 1606 2006 0107 1607 0108
.125 .111 .101 .094 .074 .043 .044 .046 .080 .083 .086 .087 .026 .027 .029 .031
.014 .014 .014 .014 .014 .014 .014 .014 .014 .014 .014 .014 .014 .014 .014 .014
1608 0109 1009 1609 2009 2509 0110 1610 0111 1611 0112 1612
.033 .035 .110 .119 .266 .318 .318 .293 .218 .187 .163 .136
.014 .014 .014 .014 .014 .014 .014 .014 .014 .014 .014 .014
*** Record 10 -- NCPDS, the number of cropping periods
      30
*** Record 11
  101061  300461  170661       1
  101062  300462  170662       1
  101063  300463  170663       1
  101064  300464  170664       1
  101065  300465  170665       1
  101066  300466  170666       1
  101067  300467  170667       1
  101068  300468  170668       1
  101069  300469  170669       1
  101070  300470  170670       1
  101071  300471  170671       1
  101072  300472  170672       1
  101073  300473  170673       1
  101074  300474  170674       1
  101075  300475  170675       1
  101076  300476  170676       1
  101077  300477  170677       1
  101078  300478  170678       1
  101079  300479  170679       1
  101080  300480  170680       1
  101081  300481  170681       1
  101082  300482  170682       1
  101083  300483  170683       1
  101084  300484  170684       1
  101085  300485  170685       1
  101086  300486  170686       1
  101087  300487  170687       1
  101088  300488  170688       1
  101089  300489  170689       1
  101090  300490  170690       1
*** Record 12 -- PTITLE
chlor - 1 applications @ 0.023 kg/ha
*** Record 13
      30       1       0       0
*** Record 15 -- PSTNAM
chlor
*** Record 16
  150961  0 2  0.0 0.023 0.95 0.16
  150962  0 2  0.0 0.023 0.95 0.16
  150963  0 2  0.0 0.023 0.95 0.16
  150964  0 2  0.0 0.023 0.95 0.16
  150965  0 2  0.0 0.023 0.95 0.16
  150966  0 2  0.0 0.023 0.95 0.16
  150967  0 2  0.0 0.023 0.95 0.16
  150968  0 2  0.0 0.023 0.95 0.16
  150969  0 2  0.0 0.023 0.95 0.16
```

```
  150970  0 2  0.0 0.023 0.95 0.16
  150971  0 2  0.0 0.023 0.95 0.16
  150972  0 2  0.0 0.023 0.95 0.16
  150973  0 2  0.0 0.023 0.95 0.16
  150974  0 2  0.0 0.023 0.95 0.16
  150975  0 2  0.0 0.023 0.95 0.16
  150976  0 2  0.0 0.023 0.95 0.16
  150977  0 2  0.0 0.023 0.95 0.16
  150978  0 2  0.0 0.023 0.95 0.16
  150979  0 2  0.0 0.023 0.95 0.16
  150980  0 2  0.0 0.023 0.95 0.16
  150981  0 2  0.0 0.023 0.95 0.16
  150982  0 2  0.0 0.023 0.95 0.16
  150983  0 2  0.0 0.023 0.95 0.16
  150984  0 2  0.0 0.023 0.95 0.16
  150985  0 2  0.0 0.023 0.95 0.16
  150986  0 2  0.0 0.023 0.95 0.16
  150987  0 2  0.0 0.023 0.95 0.16
  150988  0 2  0.0 0.023 0.95 0.16
  150989  0 2  0.0 0.023 0.95 0.16
  150990  0 2  0.0 0.023 0.95 0.16
*** Record 17
       0       1       0
*** Record 18
       0       0     0.5
*** Record 19 -- STITLE
"Crockett fine sandy loam - Fine, smectic, thermic Udertic Paleustalf  "
*** Record 20
     110           0   0   1   0   0   0   0   0   0
*** Record 26
       0       0       0
*** Record 30
       4      36
*** Record 33
       3
       1      10     1.6    0.17       0       0       0
        0.0021660.002166       0
             0.1    0.17    0.06    1.16       0
       2      10     1.6    0.17       0       0       0
        0.0021660.002166       0
              10    0.17    0.06    1.16       0
       3      90     1.7   0.247       0       0       0
        0.0021660.002166       0
              10   0.247   0.127    0.29       0
***Record 40
       0
            YEAR      10            YEAR      10            YEAR      10   1
       1
       1  -----
       7    YEAR
    PRCP    TCUM   0   0
    RUNF    TCUM   0   0
    INFL    TCUM   1   1
    ESLS    TCUM   0   0  1.0E3
    RFLX    TCUM   0   0  1.0E5
    EFLX    TCUM   0   0  1.0E5
    RZFX    TCUM   0   0  1.0E5
```

Typical EXAMS input file (index reservoir shown here, farm pond differs only by setting STFLO to zero)

```
set mode = 3
set outfil(4) to Y
set outfil(2) to N
READ ENV C:\models\INPUTS\EXAMSenv\ir298.exv
READ MET C:\models\INPUTS\Metfiles\w12834.dvf
SET YEAR1 = 1961
recall chem 1
chemical name is chlor
set MWT(1) = 357.8
set VAPR(1) = 4.6e-6
set SOL(1,1) = 31800
set KOC(1) = 36
set QTBAS(*,1,1) = 2
set QTBAW(*,1,1) = 2
READ PRZM P2E-C1.D61
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
RUN
READ PRZM P2E-C1.D62
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D63
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D64
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D65
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D66
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D67
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D68
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
```

```
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D69
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D70
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D71
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D72
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D73
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D74
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D75
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D76
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D77
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D78
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
```

```
READ PRZM P2E-C1.D79
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D80
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D81
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D82
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D83
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D84
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D85
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D86
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D87
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D88
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D89
SET STFLO(1,*) = 22.2104590672629
```

```
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
READ PRZM P2E-C1.D90
SET STFLO(1,*) = 22.2104590672629
set EVAP(*,*) = 0.0
set NPSFL(*,*)=0.0
set NPSED(*,*)=0.0
set RAIN(*) = 0.0
CONTINUE
QUIT
```

APPENDIX 2. SUMMARY OF CHLORSULFURON TOXICITY TESTS FOR TERRESTRIAL AND AQUATIC ANIMALS.

Study Type (%Active Ingredient)	Species	Toxicity Value (ai)	Toxicity Category	MRID/Acc.# Author (Year)	Study Classification
Dietary LC_{50}	Mallard duck *(Anus platyrhynchos)*	LC_{50}>5,000 ppm	Practically nontoxic	099462 (1979)	Core
Dietary LC_{50}	Northern bobwhite *(Colinus virginianus)*	LC_{50} >5,000 ppm	Practically nontoxic	099462 (1979)	Invalid [1]
Acute Oral LD_{50}	Northern bobwhite *(Colinus virginianus)*	LD_{50}>5,000 mg/kg	Practically nontoxic	099462 (1980)	Core
Acute Oral LD_{50}	Mallard duck *(Anus platyrhynchos)*	LD_{50}>5,000 mg/kg	Practically nontoxic	099462 (1980)	Core
Avian Reproduction	Mallard duck *(Anus platyrhynchos)*	NOAEL > 961 ppm LOAEL >961 ppm	N/A	42634002 Beavers, J.B. *et al.* (1992)	Core
Avian Reproduction	Northern bobwhite *(Colinus virginianus)*	NOAEL = 174 ppm LOAEL = 961 ppm	N/A	42634001 Beavers, J.B. *et al.* (1992)	Core
Rat two generation reproduction	Laboratory rat	NOAEL = 35 mg/kg/day	N/A	40089316	N/A
Rat acute oral	Laboratory rat	LD_{50} = 5.5 g/kg	N/A	00031406	N/A
Acute LC_{50}	Blue gill sunfish	LC_{50} >300 ppm	practically nontoxic	099462	Core
Acute LC_{50}	Channel catfish	LC_{50} > 50 ppm	Practically nontoxic	099462	Core
Acute LC_{50}	Fathead minnow	LC_{50} >300 ppm	Practically nontoxic	099462	Core
Acute LC_{50}	Rainbow trout	LC_{50} >250 ppm	Practically nontoxic	099462	Core
Acute LC_{50}	*Daphnia magna*	LC_{50} >370 ppm	Practically nontoxic	099462	Core
Early life-stage	Rainbow trout	NOAEC = 32 mg/l	N/A	419764 Pierson, K.B. (1991)	Core
Life-cycle	*Daphnia magna*	NOAEC = 20 mg/l	N/A	419764-08 Hutton, D.G. (1989)	Supplemental [3]
Acute LC_{50}	Mysid *(Mysidopsis b*	LC_{50} = 89 mg/l	slightly	419764-02	Core
Acute LC_{50}	Sheepshead minnow *(Cyprinodon*	LC_{50} >980 mg/l	practically nontoxic	419764-01 Ward, T.J. and R.L.	Core
Embryo-larvae	Eastern Oyster	EC_{50} = 376 mg/l	practically	419764-03	Supplemental [4]
Embryo-larvae	Eastern Oyster *(Crassostrea virginica*	EC_{50} = 384 ppm	Practically nontoxic	423286-01 Ward, T.J. and R.L. Boeri (1991)	Core
Acute contact	Honey bees	LD_{50} > 25 ug/bee	Practically	421299-02	Core

1/ Due to mortality in the controls, this study is invalid and does not fulfil test guideline requirements.
2/ Although the reproduction study is unacceptable, a NOAEL was determined for the effect of concern (still births) and the LOAEL was 356 mg/kg/day. Reproductive toxicity was observed in both generations/both litters, as evidenced by decreased fertility of the dams. No parental toxicity was observed.

3/ This study does not fulfill test guidelines requirements. It is repairable if additional information on the solvent control and dilution water is submitted.

4/ This study does not fulfill test guideline requirements because mortality data were not provided in the report.

APPENDIX 3. ESTIMATED ENVIRONMENTAL CONCENTRATIONS ON AVIAN AND MAMMALIAN FOOD ITEMS (ppm) FOLLOWING A SINGLE APPLICATION AT 1 LB a.i./A

Food Items	**EEC (ppm) Predicted Maximum Residue[1]**	**EEC (ppm) Predicted Mean Residue[1]**
Short grass	240	85
Tall grass	110	36
Broadleaf/forage plants and small insects	135	45
Fruits, pods, seeds, and large insects	15	7

[1] Predicted maximum and mean residues are for a 1 lb ai/a application rate and are based on Hoerger and Kenaga (1972) as modified by Fletcher *et al.* (1994).

APPENDIX 4. NON-TARGET TERRESTRIAL PLANT SEEDLING EMERGENCE TOXICITY (TIER II) FOR 98.2% CHLORSULFURON WITH BUFFER AND VALENT X-77 SURFACTANT IN SOME SOLUTIONS.

Species	% ai	Endpoints	NOAEL / EC_{25} (lbs ai/A)	MRID No. Author/Year	Study Classification
Cucumber	98.2	Plant height Emergence	0.000035 / 0.00025 >0.00439 / ND	42587201 McKelvey, R.A., and Kuratle, H. 1992	Supplemental
Pea		Plant height Emergence	0.000035 / 0.000113 0.000176 / 0.000281		
Rape		Plant height Emergence	0.000035 / 0.000113 >0.00439 / ND		
Soybean		Plant height Emergence	0.000875 / 0.0015 >0.00439 / ND		
Sugarbeet *		Plant height Emergence	0.0000068 / 0.000038 0.000176 / 0.000281		
Tomato		Plant height Emergence	0.0000351 / 0.000169 >0.02194 / ND		
Corn		Plant height Emergence	<0.00035 / 0.0003 0.00439 / 0.05		
Onion		Plant height Emergence	0.000035 / 0.000163 0.000035 / 0.000413		
Sorgum		Plant height Emergence	0.000163 / 0.00138 >0.0219 / ND		

* Used in RQ calculations

APPENDIX 5. NON-TARGET TERRESTRIAL PLANT VEGETATIVE VIGOR TOXICITY (TIER II) FOR 98.2% CHLORSULFURON WITH BUFFER AND VALENT X-77 SURFACTANT IN SOME SOLUTIONS.

Species	% ai	Endpoints	NOAEL / EC_{25} (lbs ai/A)	MRID No. Author/Year	Study Classification
Cucumber	98.2	Plant height Shoot weight	0.000225 / 0.001875 0.001125 / 0.006125	42587201 McKelvey, R.A., and Kuratle, H. 1992	Supplemental
Pea		Plant height Shoot weight	00.00045 / 0.00025 0.000045 / 0.000181		
Rape		Plant height Shoot weight	0.000045 / 0.0001 0.0000087 / 0.0002		
Soybean		Plant height Shoot weight	0.000045 / 0.0000443 0.0000087 / 0.0000193		
Sugarbeet		Plant height Shoot weight	0.0000087 / 0.0002062 0.0000087 / 0.0000268		
Tomato		Plant height Shoot weight	0.000045 / 0.002 0.000045 / 0.0005562		
Corn		Plant height Shoot weight	0.000225 / 0.000625 0.000225 / 0.0001937		
Onion		Plant height Shoot weight *	0.0000087 / 0.0000368 0.0000087 / 0.0000044		
Sorgum		Plant height Shoot weight	0.000225 / 0.002625 <0.000720 / 0.0001562		
Wheat		Plant height Shoot weight	0.001125 / 0.05563 0.02813 / 0.005813		

* The most sensitive parameter in the vegetative vigor toxicity study was the sugarbeet root weight (EC_{05} = 1.94 x 10^{-8} lbs ai/acre). However, the EC_{05} for onion shoot weight (4.56 x 10^{-8} lbs ai/acre) was used in the risk assessment for endangered species.

APPENDIX 6. RQ CALCULATIONS FOR SURFACE AND GROUNDWATER IRRIGATION

To calculate risk quotients for plants when groundwater contaminated by chlorsulfuron is applied to crops, the following method was used.

If a one acre field is irrigated with one inch of water containing 1.6 ppb chlorsulfuron, the effective mass of chlorsulfuron applied to the field is 0.00036 lbs chlorsulfuron/acre, calculated as follows:

$$\frac{1.6\ \mu g\ \text{chlorsulfuron}}{\text{Liter}} \times \frac{1\ kg}{10^9\ \mu g} \times \frac{1\ \#}{0.4536\ kg} \times 1\ \text{Acre} \times \frac{4.356 \times 10^4\ ft^2}{\text{Acre}} \times \frac{1}{12}\ ft \times \frac{28.32\ \text{Liter}}{ft^3}$$

Therefore, the **risk quotients for sensitive crops within the field** that is irrigated with groundwater containing 1.6 ppb chlorsulfuron and surface water containing 6.0 ppb are calculated as follows:

Ground water: EEC/EC_{25} for vegetative vigor $= \frac{0.00036\ \text{lbs ai/acre}}{0.000004\ \text{lbs ai/acre}} = 91$

Surface water: EEC/EC_{25} for vegetative vigor $= \frac{0.00136\ \text{lbs ai/acre}}{0.000004\ \text{lbs ai/acre}} = 341$

APPENDIX 7. FIRST ORDER DEGRADATION FOR CHLORSULFURON

Simulation 1.

Initial test concentration: 0.00096 (Based on a single 0.16 lbs ai/acre ground application for small grains, 5% drift and one acre to one acre runoff)

Soil dissipation Half-life: 60 days

Length of simulation: 365 days

Day 0 = 0.00096
Day 100 = 3.02E-04
Day 200 = 9.52E-05
Day 298 = 3.11E-05
Day 300 =3.0E-05
Day 365 = 1.42E-05
Maximum residue = 9.6E-04
Average residue = 2.25E-04

Day 298 EEC = 0.000031 and the EC_{25} = 0.0000306 (seedling emergence)
Day 298 RQ = 1.0

Therefore, the LOC is exceeded for 298 days.

Simulation 2.

Initial test concentration: 0.00816 (Based on a single 0.16 lbs ai/acre application for small grains, 5% drift and ten acre to one acre runoff to wetlands)

Soil dissipation Half-life: 60 days; Length of simulation: 365 days

Day 0 = 8.16E-03
Day 100 = 2.57E-03
Day 200 = 8.10E-04
Day 300 = 2.55E-04
Day 365 = 1.20E-04
Maximum residue = 8.16E-03
Average residue = 1.91E-04

Day 365 EEC = 0.00012 and the EC_{25} = 0.0000306 (seedling emergence)
Day 365 RQ = 3.9 Therefore, the LOC is exceeded for well over 365 days.

APPENDIX 8. TIER 1 DRINKING WATER ASSESSMENT MEMORANDUM

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

OFFICE OF
PREVENTION, PESTICIDES,
AND TOXIC SUBSTANCES

PC Code: 118601
DP Barcode: D266073

MEMORANDUM

June 25, 2002

SUBJECT: Drinking Water Assessment to Support TRED for Chlorsulfuron

FROM: Lucy Shanaman, Chemist
Environmental Risk Branch IV
Environmental Fate and Effects Division

THROUGH: R. David Jones, Senior Agronomist
Environmental Risk Branch IV
Environmental Fate and Effects Division

Betsy Behl, Chief
Environmental Risk Branch IV
Environmental Fate and Effects Division

TO: Jim Tompkins,
Product Manager 25
Herbicide Branch, Registration Division

This memo presents the Tier I Drinking Water Assessment for the parent compound, chlorsulfuron, calculated using FIRST (surface water; version 1.0, 8/1/01) and SCIGROW (groundwater; version 1.0, 11/12/97) for use in the human health risk assessment. *This assessment does not encompass degradation products of chlorsulfuron*. For drinking water derived from **surface water** sources, the ***acute (peak) value*** is ***46.8 μg/L (ppb)***, and the ***chronic (average annual) value*** is ***16.4 μg/L (ppb)***, for non-crop, non-residential turf. The **groundwater** screening concentrations for ***both acute and chronic exposure*** values are ***3.5 μg/L (ppb)*** for non-crop, non-residential turf. These concentrations were predicted from maximum label use information. The reported values represent upper-bound estimates of the concentrations that might be found in locations vulnerable to pesticide contamination, for either surface water used for drinking water, or in groundwater, due to the use of chlorsulfuron on non-residential turf. Modeling was also done using label information for application to wheat crops. Should the results of this assessment indicate a need for further refinement, or if any degradation products become of toxicological concern, please contact us as soon as possible so that we may schedule a Tier II assessment. A more conservative estimate which included the degradation products, assuming both stability and mobility equal to the parent compound, was also made.

Table 1. Modeling Results Based on Low Pressure Ground Spray Application of Chlorsulfuron

Model	Concentration From Use on Wheat	**Concentration From Use on Non-Residential Turf**
FIRST Surface Water Peak Day (Acute)	1.6 ppb	**46.8 ppb**
FIRST Surface Water Annual Average (Chronic)	0.55 ppb	**16.4 ppb**
SCIGROW Ground Water (Acute and Chronic) Value	0.16 ppb	**3.5 ppb**

Monitoring Data:

Chlorsulfuron was not an analyte in the USGS, NAWQA monitoring program. *Pesticides in Groundwater Database, A Compilation Of Monitoring Studies: 1971-1991 National Summary*, US EPA September 1992, entries indicate that of eight wells tested, there were no recorded detections of chlorsulfuron. An article from the open literature examining streams, reservoir outflows, and wells in the Midwestern United States[3] indicates that chlorsulfuron was detected in 5 %, or fewer, of the 71 streams tested, only detected in one of the outflow samples from the five reservoirs, and was not detected in groundwater samples collected from 25 wells. Maximum concentrations, measured using high performance liquid chromatography in tandem with mass spectroscopy (HPLC-MS), were less than one μg/L (ppb). The estimated reporting limit (MRL) was 0.010 μg/L.

Environmental Fate:

Chlorsulforon is expected to be very mobile in the environment. Laboratory data (soil thin layer chromatography) indicates that the degradation product sulfonamide is less mobile than chlorsulfuron, and that triazine amine is less mobile than both the parent compound, chlorsulfuron, and the degradation product, sulfonamide. However, a precise estimate of the specific degree of mobility which can be attributed to either of these degradation products is undetermined. Laboratory studies indicate that chlorsulfuron is not expected to be highly persistent in the environment. With some exceptions, reported concentrations of degradation products peaked at study termination. Triazine amine concentrations were reported to peak relatively early in aerobic soil metabolism studies, transforming into hydroxy triazine amine with concentrations increasing steadily throughout the study.

Drinking Water Treatment Effects:

Primary water treatment is not expected to remove chlorsulfuron from drinking water. The predicted high mobility of chlorsulfuron means that it is not expected to sorb appreciably to soil and/or sediment, indicating that it would not be expected to be removed from drinking water by either sedimentation or flocculation. Additionally, water treatment processes are more likely to raise the pH during treatment, therefore, hydrolysis is not expected to be a primary degradation pathway.

[3] *Concentration of Selected Sulfonylurea, Sulfonamide, and Imidazolinone Herbicides, Other Pesticides, and Nutrients in 71 Streams, 5 Reservoir Outflows, and 25 Wells in the Midwestern United States, 1998*; Battaglin WA, Furlong ET, Burkhardt MR; U.S. Department of the Interior, U.S. Geological Survey, Water-Resources Investigations Report 00-4225, Denver, Colorado; 2001.

Background Information on FIRST:

FIRST[4] is a screening model designed by the Office of Pesticide Programs to estimate the concentrations found in drinking water from surface water sources for use in human health risk assessment. As such, it provides upper bound values on the concentrations that might be found in drinking water due to the use of a pesticide. It was designed to be simple to use and to only require data which is typically available early in the pesticide registration process. FIRST is a single event model (one runoff event), but can account for spray drift from multiple applications. FIRST is hardwired to represent the Index Reservoir, a standard water body used by the Office of Pesticide Programs to assess drinking water exposure (Hetrick *et al, 1998*). It is based on a real reservoir in Illinois that is known to vulnerable to pesticide contamination. The single runoff event moves a maximum of 8% of the applied pesticide into the pond. This amount can be reduced due to degradation on the field and the effects of binding to soil in the field.

Background Information on SCIGROW:

SCIGROW[5] (version 1.0, November 12, 1997) provides a Tier 1, groundwater screening exposure value to be used in determining the potential risk to human health from drinking water contaminated with the pesticide. SCIGROW estimates likely groundwater concentrations if the pesticide is used at the maximum allowable rate in areas where groundwater is vulnerable to contamination. In most cases, a large majority of the use area will have groundwater that is less vulnerable to contamination than the areas used to drive the SCIGROW estimate.

Modeling Inputs and Results:

A conservative estimate of surface water EEC's and drinking water concentrations were made which would included any possible degradation products. While laboratory data did indicate that some of the degradation products were less mobile than the parent, the results were unquantified. A conservative estimate of degradate mobility equal to that of the parent compound, chlorsulfuron, was made. In the absence of any quantified biotic or abiotic degradation date for the transformation products, which generally reached the reported maximum at study termination, complete stability was assumed for both parent and the degradates. This assumption assured that both the parent compound and the degradation products would be included in the estimated surface water concentrations. The modeling results from FIRST, using these assumed parameters, estimates pre-treatment surface water concentrations of ***total chlorsulfuron residues (both parent and degradation products)***, resulting from two applications, at 60 day intervals, of the maximum use rate of LESCO TFC Dispersible Granule Turf Herbicide®, at an acute (peak) value of 59.7 μg/L (ppb), and a chronic (average annual) value of 41.3 μg/L (ppb). Please note that these values for parent, and any possible degradation products, are more conservative, and replace the values which were included in the FQPA memo. The values reported at the beginning of this memo are for parent only, as Health Effects Division has indicated that only the parent compound is of toxicological concern.

Table 2 and Table 3 summarize the general input values used in the model runs for FIRST and SCIGROW for chlorsulfuron, applied two times by low pressure ground spray and incorporated to a depth of 3 to 4 inches for wheat crops, at a rate of 0.0156 pounds of active ingredient per acre for wheat crops and 0.333 pounds of active ingredient per acre for non-crop, non-residential turf. Labeled non-crop, non-residential turf uses include industrial turf grass areas such as: airports, military installations, fence rows, roadsides, right-of-ways, lumberyards, tank farms, pipeline and utility right-of-ways, pumping installations, railroads, storage areas, plant sites, and other similar areas. Input parameter values were selected in accordance with US EPA OPP EFED water model parameter selection guidelines, *Guidance for Selecting Input*

[4] http://www.epa.gov/oppefed1/models/water/index.htm

[5] http://www.epa.gov/oppefed1/models/water/index.htm

Parameters in Modeling the Environmental Fate and Transport of Pesticides, Version II, February 28, 2002[6]. In the absence of anaerobic metabolism data, that value was multiplied by two, as outlined in the guidelines, to generate an anaerobic metabolism half-life of 160 days. Application rates were obtained from submitted labels.

FIRST predicted surface water acute peak concentrations of 1.6 ppb for wheat and 46.8 ppb for non-residential turf. Chronic (average annual) concentrations were 0.55 ppb for wheat and 16.4 ppb for non-residential turf. SCIGROW predicted groundwater concentration s of 0.16 ppb for wheat and 3.5 ppb for non-residential turf. Modeling results appear in Table 2 and Table 3. FIRST and SCIGROW output files have been appended to this document.

Table 2. Input Parameters for FIRST

Parameter	Wheat Crops	Non-Residential Turf
Chemical	chlorsulfuron	chlorsulfuron
Water Solubility (pH 7; 25 °C)	31,800 mg/L	31,800 mg/L
Hydrolysis Half-Life (pH7)	stable	stable
Aerobic Soil Metabolism Half-Life	80 days	80 days
Aerobic Aquatic Metabolism Half-Life	160 days (2 x aerobic soil half-life)	160 days (2 x aerobic soil half-life)
Photolysis Half-Life	stable	stable
Organic Carbon Adsorption Coefficient (K_{oc})	21 L/kg	21 L/kg
Application Method	ground spray, incorporate 3 inches	low pressure ground spray
Application Rate	0.0156 lbs. a.i./acre	0.33 lbs. a.i./acre
Application Frequency	2 per year	2 per year
Interval Between Applications	30 days	60 days

Table 3. Input Parameters for SCIGROW

Parameter	Wheat Crops	Non-Residential Turf
Chemical	chlorsulfuron	chlorsulfuron
Organic Carbon Adsorption Coefficient (K_{oc})	21 L/kg	21 L/kg
Aerobic Soil Metabolism Half-Life	80 days	80 days

[6] http://www.epa.gov/oppefed1/models/water/index.htm

Application Rate	0.0156 lbs. a.i./acre	0.333 lbs. a.i./acre
Application Frequency	2 per year	2 per year

APPENDIX I

FIRST SURFACE WATER MODELING RESULTS FOR CHLORSULFURON

OUTPUT TABLES FOR CHLORSULFURON ON WHEAT

```
RUN No.   1 FOR CHLORSULFURON    ON   WHEAT        * INPUT VALUES *
   --------------------------------------------------------------------
    RATE (#/AC)   No.APPS &   SOIL  SOLUBIL  APPL TYPE  %CROPPED INCORP
     ONE(MULT)    INTERVAL    Koc   (PPM )   (%DRIFT)     AREA    (IN)
   --------------------------------------------------------------------
   .016(   .028)   2  30      21.031800.0   GROUND( 6.4)  56.0    .0

   FIELD AND RESERVOIR HALFLIFE VALUES (DAYS)
   --------------------------------------------------------------------
   METABOLIC  DAYS UNTIL  HYDROLYSIS   PHOTOLYSIS   METABOLIC  COMBINED
    (FIELD)  RAIN/RUNOFF  (RESERVOIR)  (RES.-EFF)   (RESER.)   (RESER.)
   --------------------------------------------------------------------
     80.00        2          N/A       .00-     .00   160.00    160.00

   UNTREATED WATER CONC (MICROGRAMS/LITER (PPB))    Ver 1.0 AUG 1, 2001
   --------------------------------------------------------------------
        PEAK DAY  (ACUTE)      ANNUAL AVERAGE (CHRONIC)
          CONCENTRATION             CONCENTRATION
   --------------------------------------------------------------------
             1.566                          .550
```

FIRST SURFACE WATER MODELING RESULTS FOR CHLORSULFURON

OUTPUT TABLES FOR CHLORSULFURON ON NON-RESIDENTIAL TURF

```
RUN No.   2 FOR CHLORSULFURON    ON   NON_RESIDE    * INPUT VALUES *
--------------------------------------------------------------------
 RATE (#/AC)   No.APPS &   SOIL  SOLUBIL  APPL TYPE  %CROPPED INCORP
  ONE(MULT)    INTERVAL    Koc   (PPM )   (%DRIFT)     AREA    (IN)
--------------------------------------------------------------------
.333(   .531)   2  60      21.031800.0   GROUND( 6.4)  87.0    .0

FIELD AND RESERVOIR HALFLIFE VALUES (DAYS)
--------------------------------------------------------------------
METABOLIC  DAYS UNTIL  HYDROLYSIS   PHOTOLYSIS   METABOLIC  COMBINED
 (FIELD)  RAIN/RUNOFF  (RESERVOIR)  (RES.-EFF)   (RESER.)   (RESER.)
--------------------------------------------------------------------
  80.00        2          N/A       .00-     .00   160.00    160.00

UNTREATED WATER CONC (MICROGRAMS/LITER (PPB))    Ver 1.0 AUG 1, 2001
--------------------------------------------------------------------
     PEAK DAY  (ACUTE)      ANNUAL AVERAGE (CHRONIC)
       CONCENTRATION             CONCENTRATION
--------------------------------------------------------------------
          46.811                      16.446
```

FIRST SURFACE WATER MODELING RESULTS FOR CHLORSULFURON AND DEGRADATION PRODUCTS

OUTPUT TABLES FOR BOTH CHLORSULFURON AND DEGRADATE RESIDUES ON NON-RESIDENTIAL TURF

```
RUN No.   1 FOR chlorsulfuron and degradates  ON   industrial turf      * INPUT
VALUES *
   -------------------------------------------------------------------
    RATE (#/AC)   No.APPS &   SOIL  SOLUBIL  APPL TYPE  %CROPPED INCORP
     ONE(MULT)    INTERVAL    Koc   (PPM )   (%DRIFT)     AREA    (IN)
   -------------------------------------------------------------------
   .333(   .666)   2  60      21.030000.0   GROUND( 6.4)  87.0    .0

   FIELD AND RESERVOIR HALFLIFE VALUES (DAYS)
   -------------------------------------------------------------------
   METABOLIC  DAYS UNTIL  HYDROLYSIS   PHOTOLYSIS   METABOLIC  COMBINED
    (FIELD)  RAIN/RUNOFF  (RESERVOIR)  (RES.-EFF)   (RESER.)   (RESER.)
   -------------------------------------------------------------------
       .00        2          N/A        .00-     .00      .00       .00

   UNTREATED WATER CONC (MICROGRAMS/LITER (PPB))    Ver 1.0 AUG 1, 2001
   -------------------------------------------------------------------
        PEAK DAY  (ACUTE)      ANNUAL AVERAGE (CHRONIC)
          CONCENTRATION             CONCENTRATION
   -------------------------------------------------------------------
             59.566                      41.344
```

APPENDIX II

SCIGROW GROUND WATER MODELING RESULTS FOR CHLORSULFURON

OUTPUT TABLES FOR CHLORSULFURON ON NON-RESIDENTIAL TURF

```
 RUN No.   1 FOR chlorsulfuron       INPUT VALUES
 --------------------------------------------------------------------
  APPL (#/AC)  APPL.  URATE    SOIL    SOIL  AEROBIC
  RATE          NO. (#/AC/YR)  KOC   METABOLISM (DAYS)
 --------------------------------------------------------------------
     .016      2        .031       21.0       80.0

 GROUND-WATER SCREENING CONCENTRATIONS IN PPB
 --------------------------------------------------------
                   .162135
 --------------------------------------------------------
A=    75.000  B=    26.000  C=     1.875  D=     1.415  RILP=     4.847
F=      .716  G=     5.197  URATE=      .031  GWSC=         .162135
```

SCIGROW GROUND WATER MODELING RESULTS FOR CHLORSULFURON

OUTPUT TABLES FOR CHLORSULFURON ON NON-RESIDENTIAL TURF

```
 RUN No.   2 FOR chlorsulfuron       INPUT VALUES
 --------------------------------------------------------------------
  APPL (#/AC)  APPL.  URATE    SOIL    SOIL  AEROBIC
  RATE          NO. (#/AC/YR)  KOC   METABOLISM (DAYS)
 --------------------------------------------------------------------
     .333      2        .666       21.0       80.0

 GROUND-WATER SCREENING CONCENTRATIONS IN PPB
 --------------------------------------------------------
                  3.460952
 --------------------------------------------------------
A=    75.000  B=    26.000  C=     1.875  D=     1.415  RILP=     4.847

F=      .716  G=     5.197  URATE=      .666  GWSC=        3.460952
```

APPENDIX 9a SURVEY OF AERIAL APPLICATORS TO DETERMINE TYPICAL AIRCRAFT SETUPS

Non-Confidential Version of Attachment A to
DuPont Letter to USEPA Dated May 2, 2003

In previous correspondence with EPA regarding the droplet size spectrum expected for typical aerial applications of chlorsulfuron products, we proposed a small, informal survey of aerial applicators to determine typical aircraft setups. To that end, we have obtained descriptions of the spray setups used on fifteen aircraft from fourteen applicators in Washington and Oregon.

To minimize drift, the Glean FC and Finesse labels specify the use of solid stream nozzles oriented straight back when the product is applied by air in the vicinity of sensitive crops. As shown in the attached table, most of the aircraft were fitted with solid stream nozzles with a nozzle angle of 0, as recommended on the label.

The drop size distribution was determined by the USDA –ARS model implemented in AgDRIFT® version 2.04. The model provides a drop size spectrum for a spray solution of water containing 0.25% Triton X-100. In general, we expect the drop size distribution from the model to be shifted toward the fine size distribution as compared to the size distribution for typical agricultural products. The inputs to the model - nozzle type, orientation angle, air speed, and pressure - were supplied by the applicators or representative values were selected as indicated in the attached table.

The drop size distributions were evenly split between ASAE medium, medium to coarse, and coarse. The intent of the label recommendations is to produce a drop size spectrum that will minimize drift, and we anticipated that most of the solid stream nozzles and spray settings would produce a coarse size distribution. We attribute the difference between our expectations and the model results primarily to the higher than expected air speed used for applications. We expected that air speeds would be in the range of 100-110 mph, as it was for aircraft 14 and 15 in the attached table. In contrast, 10 of the 15 applicators fly at a speed of 120 mph or higher. The droplet size distribution shifts toward the fine distribution at higher speeds. For example, aircraft 4 flown at 135 mph produces a medium to coarse size distribution, while at 100 mph would produce a very coarse to extremely coarse size distribution, according to the USDA model.

Since the USDA model simulates drop size distributions for a spray solution with low surface tension, those distributions are likely to show a greater volume of fine droplets than would be expected for typical products. Our experience in the Pacific Northwest suggests that the label recommendations have been successful in reducing drift, as compared to the potential indicated by the drop size distributions predicted by the USDA model.

Aircraft Setups for Application of Chlorsulfuron Products in Washington and Oregon

Aircraft Setup	GPA	Boom-length	Nozzle type	Angle	Speed	Aircraft	Pressure	Assumed Variables	Droplet spectrum (ASAE)
1	7	65%	CP 30 deg plate	0	90-110	188 Cessna	15 psi	all orifices, 20-40psi, 90-110 mph	Medium
2	5	75%	CP 30 deg plate	0	110-120	Airtractor AT 400 & 502		all orifices, 20-40psi, 110-120 mph	Medium
3	5	75%	D-8	0	115	Thrush S2R-6		DC46 core, 40 psi	Coarse
4	3	68%	Lund multi-tip 8	0	135	Turbine Thrush	40 psi		Medium to coarse
5	3	70%	CP 0 deg	0	125-130	Super Doer Thrush		all orifices, 40 psi	Medium to coarse
6	3	68%	Lund multi-tip -8	0	130	502 & 802 Air Tractor	40 psi		Medium to coarse
7	5	68%	D-8	0,10	100-110	Agcat G164 Super B		40 psi	Coarse
8	3	68%	CP Straight Stream	0	135	Super Doer 1200 Wright 1820		40 psi	Medium to coarse
9	3	68%	Spray Systems D-7 no core	0	120-125	Cessna Husky	20 psi		Medium
10	3 to 5	68%	D8, 10, or 12	35	120	Airtractor AT502 - turbine		DC46 core, 40 psi	Medium
11	5	67%	CP .171 15deg plate	15	120	Agcat	25 psi	used 5 ° plate, 15 not in model	Medium
12	5	67%	D10/46	0	120	Airtractor AT502 - turbine	30 psi		Medium to coarse
13	5	67%	D10	0	120	Airtractor AT502 - turbine		DC46 core, 40 psi	Coarse
14	3	68%	CP solid stream, no plate	0	115	Air tractor	40 psi		Coarse

15	7.5	60%	CP solid stream, no plate	0	105-115	Turbo Agcat	22 psi		Coarse

APPENDIX 9b PHYTOTOXICITY RESULTING FROM SPRAY DRIFT DURING A MEDIUM APPLICATION RATE

Finesse product applications to preemergent wheat. The application ranges from 0.0078 to 0.016 lbs ai/acre. The mean of the high and low values was used for these graphs.

Figure 8. Predicted phytotoxicity levels and associated downwind distances from an **aerial** application conducted with a **coarse** spray in a 10 mph wind with a 10 foot release height at an application rate of 0.012 lbs chlorsulfuron per acre. The plant species listed on the bottom right axis are test species for which the registrant submitted phytotoxicity data (the toxicity slope for cucumber was unavailable so cucumber results are not shown).

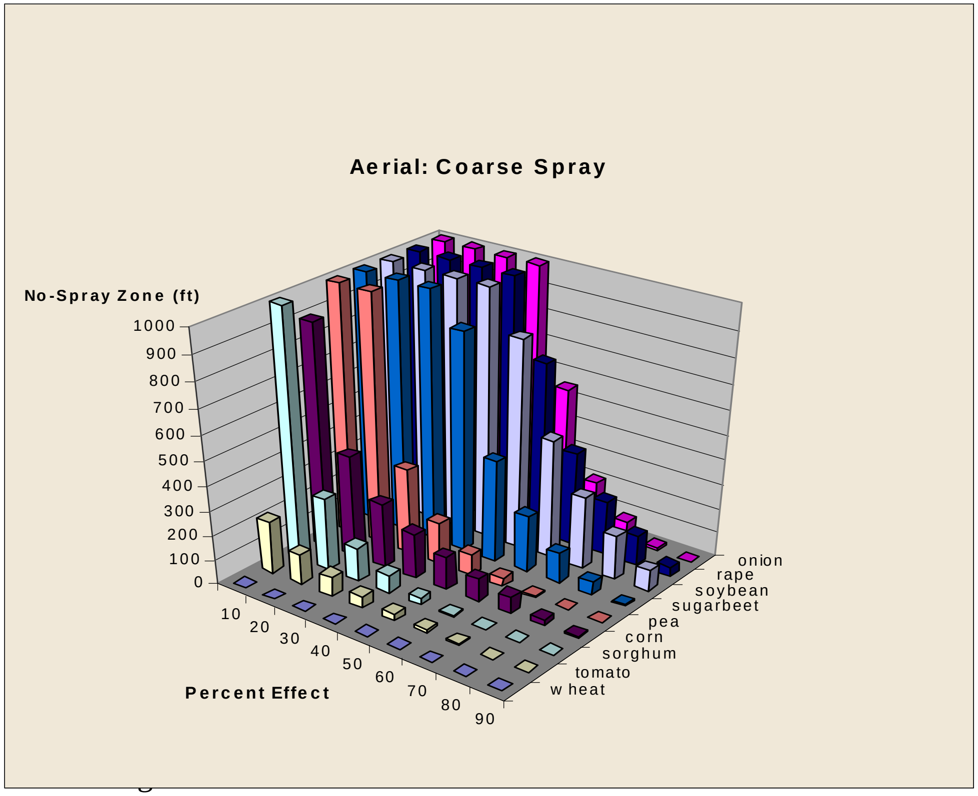


Figure 2. Predicted phytotoxicity levels and associated downwind distances from an **aerial** application conducted with a **medium** spray in a 10 mph wind with a 10 foot release height at an application rate of 0.012 lbs chlorsulfuron per acre. The toxicity slope for cucumber was unavailable.

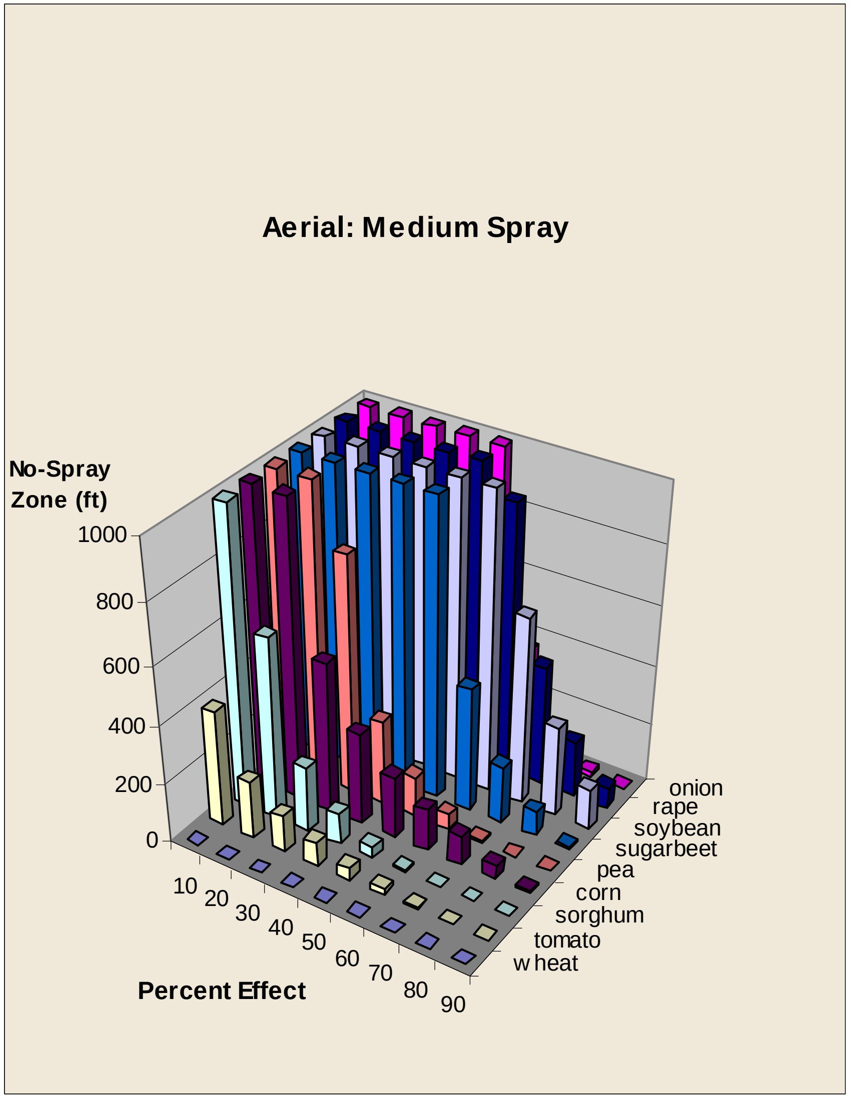


Figure 3. Predicted phytotoxicity levels and associated downwind distances from a **ground boom** application conducted with a **medium/coarse** spray in an approximate 10 mph wind with a **2 foot release height** at an application rate of 0.012 lbs chlorsulfuron per acre. The toxicity slope for cucumber was unavailable.

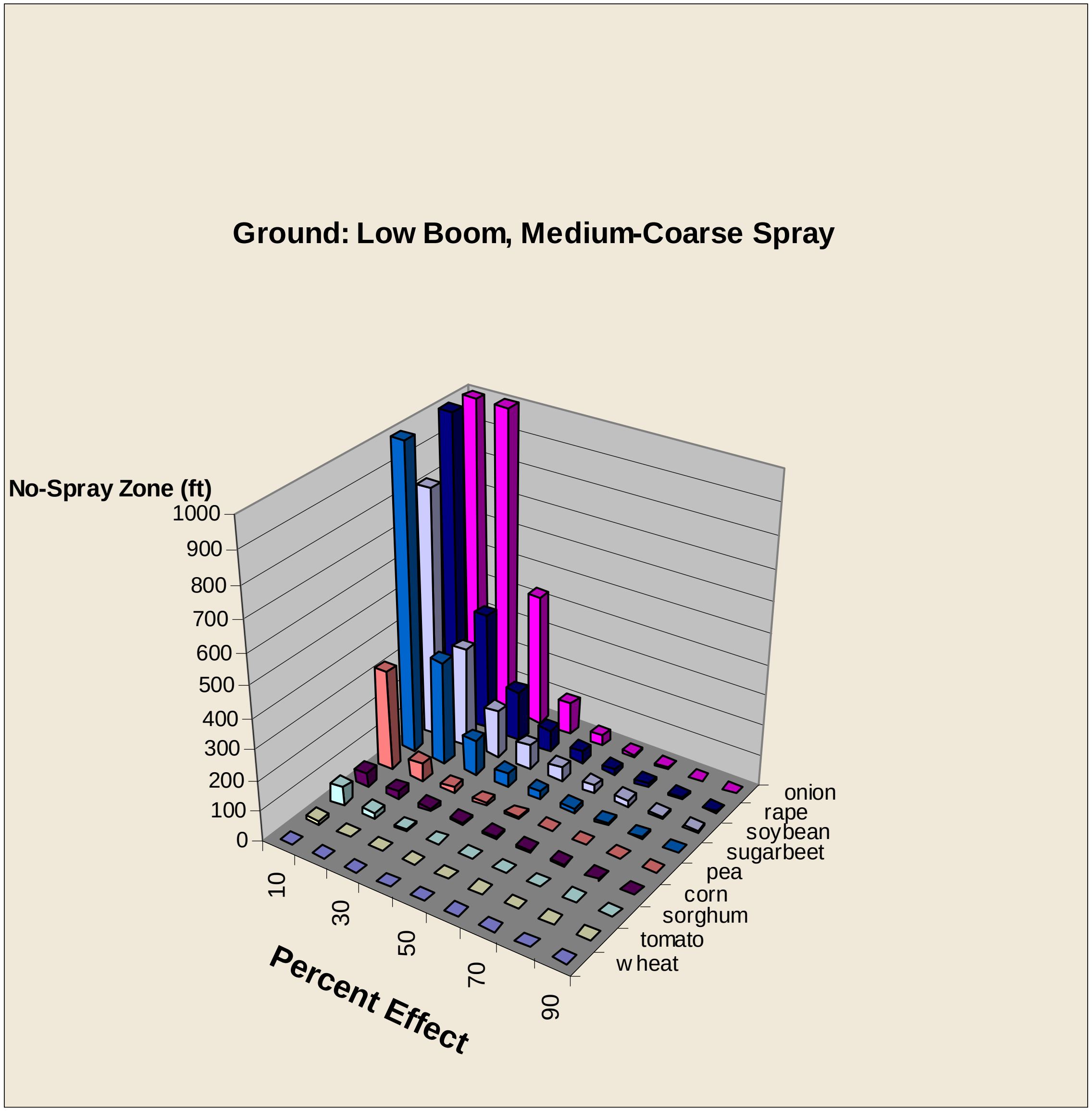


Figure 4. Predicted phytotoxicity levels and associated downwind distances from a **ground boom** application conducted with a **medium/coarse** spray in an approximate 10 mph wind with a **4 foot release height** at an application rate of 0.012 lbs chlorsulfuron per acre. The toxicity slope for cucumber was unavailable.

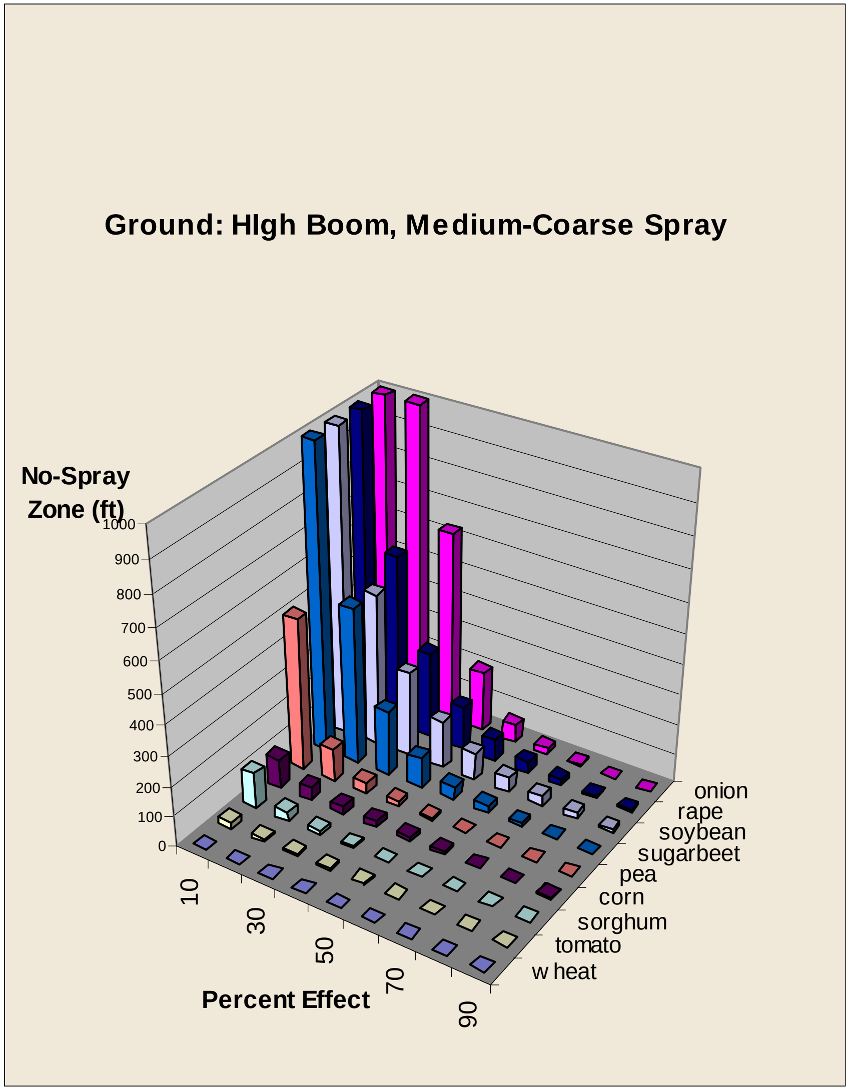


Figure 5. Predicted phytotoxicity levels and associated downwind distances from a **ground boom** application conducted with a **medium** spray in an approximate 10 mph wind with a **2 foot release height** at an application rate of 0.012 lbs chlorsulfuron per acre. The toxicity slope for cucumber was unavailable.

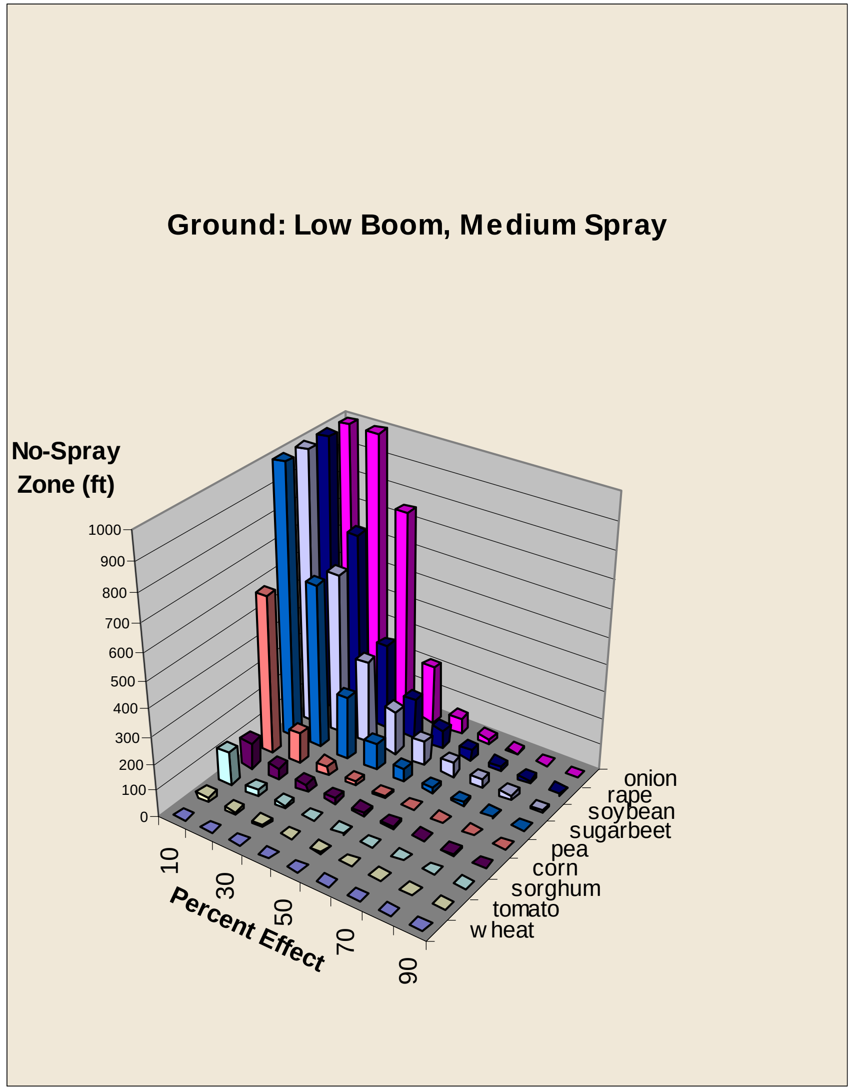
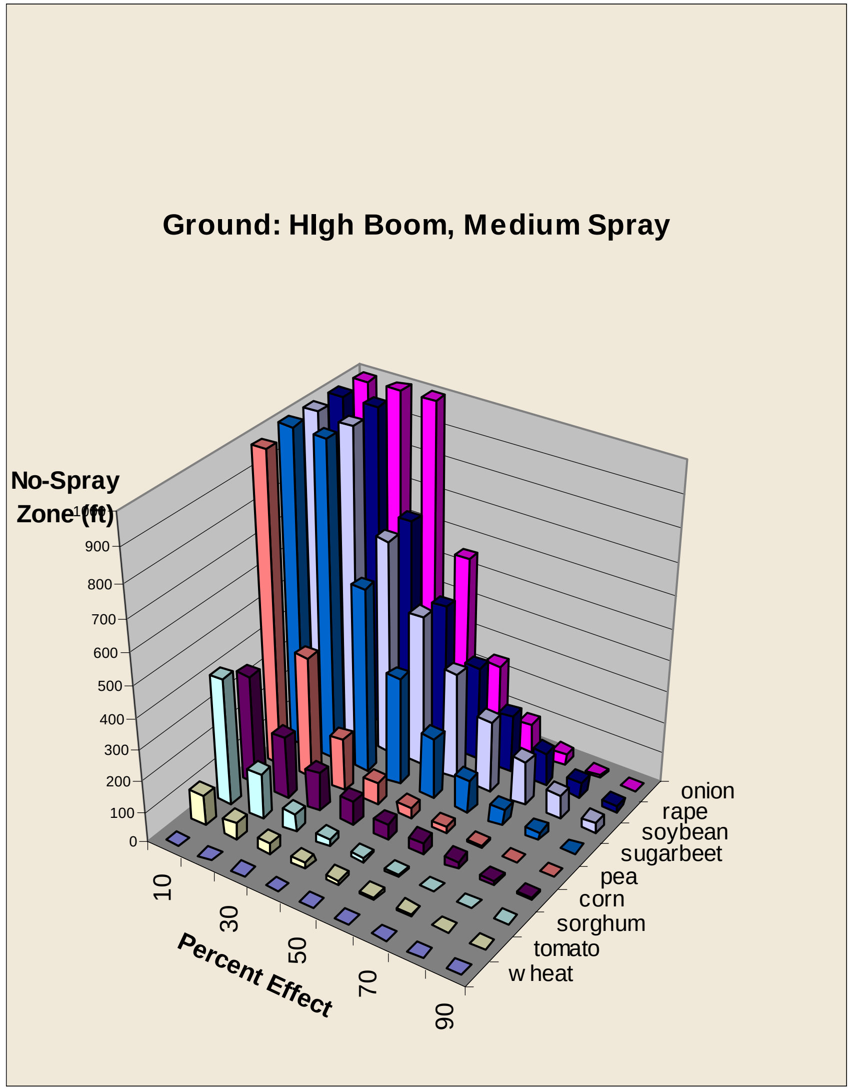
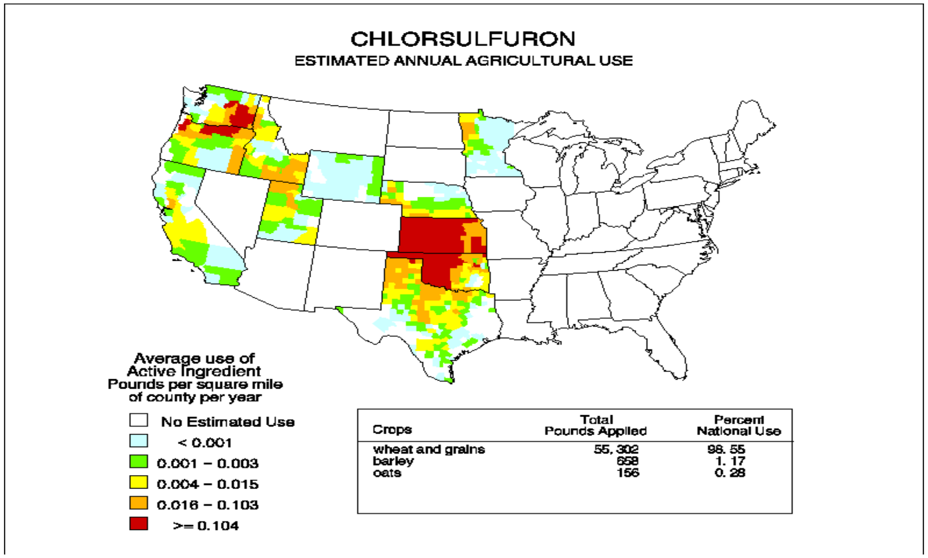


Figure 6. Predicted phytotoxicity levels and associated downwind distances from a **ground boom** application conducted with a **medium** spray in an approximate 10 mph wind with a **4 foot release height** at an application rate of 0.012 lbs chlorsulfuron per acre. The toxicity slope for cucumber was unavailable.



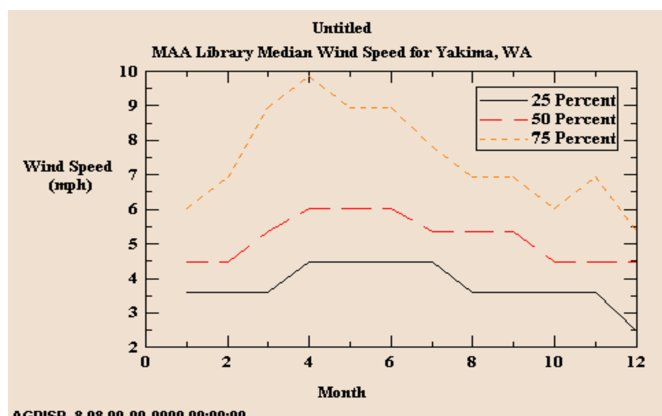
APPENDIX 9c PHYTOTOXICITY RESULTING FROM SPRAY DRIFT DURING A MEDIUM APPLICATION RATE

Estimated agricultural usage of chlorsulfuron from the US Geological Survey (http://ca.water.usgs.gov/pnsp/use92/chlrsulf.html):

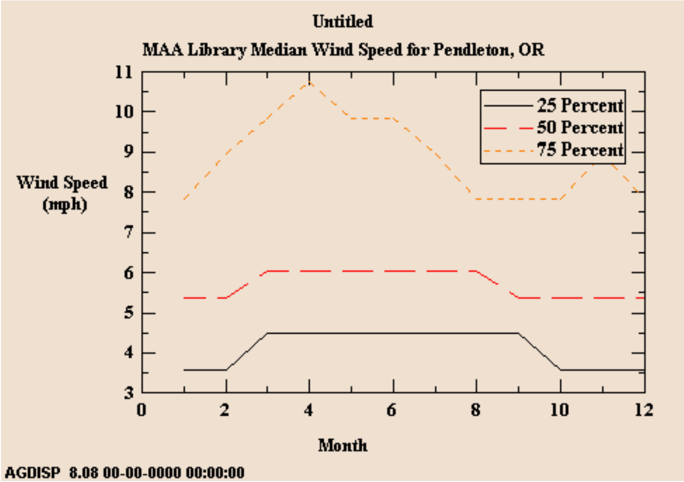


Wind speed data for three representative cities in areas where chlorsulfuron is used agriculturally. Graphs show 75th, 50th, and 25th percentile wind speeds for each month. Wind speed data is from SAMSON weather monitoring stations.

Yakima, south central Washington:



Pendleton, northwestern Oregon:



North Platte, central southwestern Nebraska: