

8-12-96

Chemical Code: 129081

Date Out: 8/2/96

DP Barcode: D223633

D220549

**ENVIRONMENTAL FATE AND GROUND WATER BRANCH**

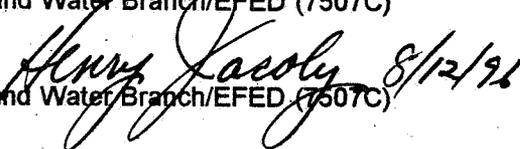
**Review Action**

To: Joanne Miller, PM #23  
Registration Division (7505C)

From: Elizabeth Behl, Section Head  
Ground Water Technology Section  
Environmental Fate & Ground Water Branch/EFED (7507C)



Thru: Henry Jacoby, Chief  
Environmental Fate & Ground Water Branch/EFED (7507C)



Attached, please find the EFGWB review of...

<b>DP Barcode:</b>	D223633; <u>D220549</u>		
<b>Common Name:</b>	Sulfentrazone; methanesulfonamide; F6285	<b>Trade name:</b>	not known
<b>Company Name:</b>	FMC Corp. Agricultural Chemicals Group		
<b>ID #:</b>	000279-GRUO sulfentrazone technical		
<b>Purpose:</b>	Final report for a small-scale prospective ground-water monitoring study at a single site.		

<b>Type Product:</b>	<b>Action Code:</b>	<b>Review Time:</b>
Herbicide	231	10 days

**STATUS OF STUDIES IN THIS PACKAGE:**

**STATUS OF DATA REQUIREMENTS:**

Guideline #	MRID	Status <sup>1</sup>	Guideline #	Status <sup>2</sup>
166-1	439268-14	C	166-1	P

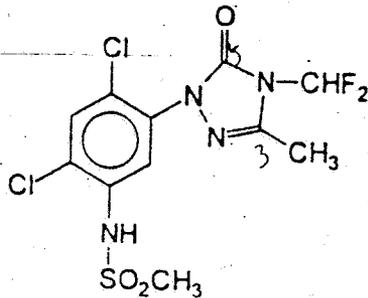
<sup>1</sup>Study Status Codes:

A=Acceptable U=Upgradeable C=Ancillary I=Invalid.

<sup>2</sup>Data Requirement Status Codes:

S=Satisfied P=Partially satisfied N=Not satisfied R=Reserved W=Waived.

1. **CHEMICAL:** Sulfentrazone (F6285 4F herbicide)



Sulfentrazone

2. **TEST MATERIAL:** formulated products.

3. **STUDY/ACTION TYPE:**

Small-scale prospective ground-water monitoring study.

4. **STUDY IDENTIFICATION:**

**Newly submitted:**

Chukwunenye, Callista. 1995. Response to 8/2/95 EFGWB review and FMC's response submission: Sulfentrazone herbicide. RA/TP application: Pesticide petition # 4F4407 EPA file symbol 279-GRUO, -GRUA, -GRUI. FMC Corp.: Philadelphia, PA. Report dated October 13, 1995.

Becker, John M. 1996. A combined soil dissipation and small-scale prospective groundwater monitoring study with F6285 4F herbicide. FMC Corp.: Philadelphia, PA. Report dated 1/26/96. EPA MRID no. 439268-14.

Becker, John M. 1995. Facsimile transmission to Michael Barrett dated 11/21/95. This is a request for approval for decommissioning the sulfentrazone ground-water monitoring study in NC.

**Previously submitted documents subject to additional review:**

Becker, John M. 1995. Letter to EPA (routed by the Agency through Joanne Miller, Product Manager 23) dated 3/17/95 requesting permission to terminate the small-scale prospective ground-water monitoring study for sulfentrazone in Edgecombe County, NC.

Becker, John M. 1995. A combined soil dissipation and small-scale prospective ground-water monitoring study with F6285 4F herbicide. Study submitted by FMC Corp., Agricultural Chemical Group. EPA MRID no. 43345434. Report dated 8/3/94.

**5. REVIEWED BY:**

Michael R. Barrett, Ph.D.      Signature: *Kim J. Costello for*  
 Chemist  
 OPP/EFED/EFGB/Ground-Water Section      Date: 8/8/96

**6. APPROVED BY:**

Elizabeth Behl      Signature: *Eliz Behl*  
 Acting Section Chief  
 OPP/EFED/EFGB/Ground-Water Section      Date: 8/8/96

**7. CONCLUSIONS:**

The irrigation accident which occurred 13 months after application of the herbicide precludes obtaining the full body of data normally required with these studies. Also, since many of the changes recommended by EFGB and GWTS (5/14/92 review, DP Barcode D174353) were not made, the utility of this study will be significantly limited. Nevertheless, significant insight into sulfentrazone leaching at a very vulnerable site is still possible with this study.

**The Ground-Water Impact of Sulfentrazone**

Under the conditions of this study, concentrations of parent plus acid reached up to 100 ppb in soil water at a three-foot depth (average of replicates; see Discussion section of this review for further details). Sulfentrazone residues persisted in the vadose zone; by the last sampling date analyzed before the irrigation accident brought an abrupt end to the sampling program (395 days after application), residues of parent + acid still averaged about 10 ppb in soil-pore water from all three depths (three, five, and seven feet). A similar pattern occurred in ground water with the peak concentrations (30 or 40 ppb) of sulfentrazone residues occurring about four to five months after application. Sulfentrazone residues clearly were both mobile and persistent at the study site and readily moved to ground water.

More general conclusions about sulfentrazone leaching to ground water that is less vulnerable than at the study site need to be made. This study, along with other laboratory and field studies, seem to indicate that

sulfentrazone is sufficiently mobile and persistent to leach to ground water at sites with less extreme ground-water vulnerability than was present at the study site being reviewed here. This study has been conducted at a site with very permeable soils, very shallow ground water (ca. 9-foot depth), under very wet conditions, with rapid recharge of the aquifer. The registrant contends that sulfentrazone will not leach to ground water at less vulnerable sites.

### Comparison of Sulfentrazone Leaching Potential with other Registered Soybean Herbicides

Ranking of Intrinsic Potential to Leach to Ground Water of Major Soybean Herbicides

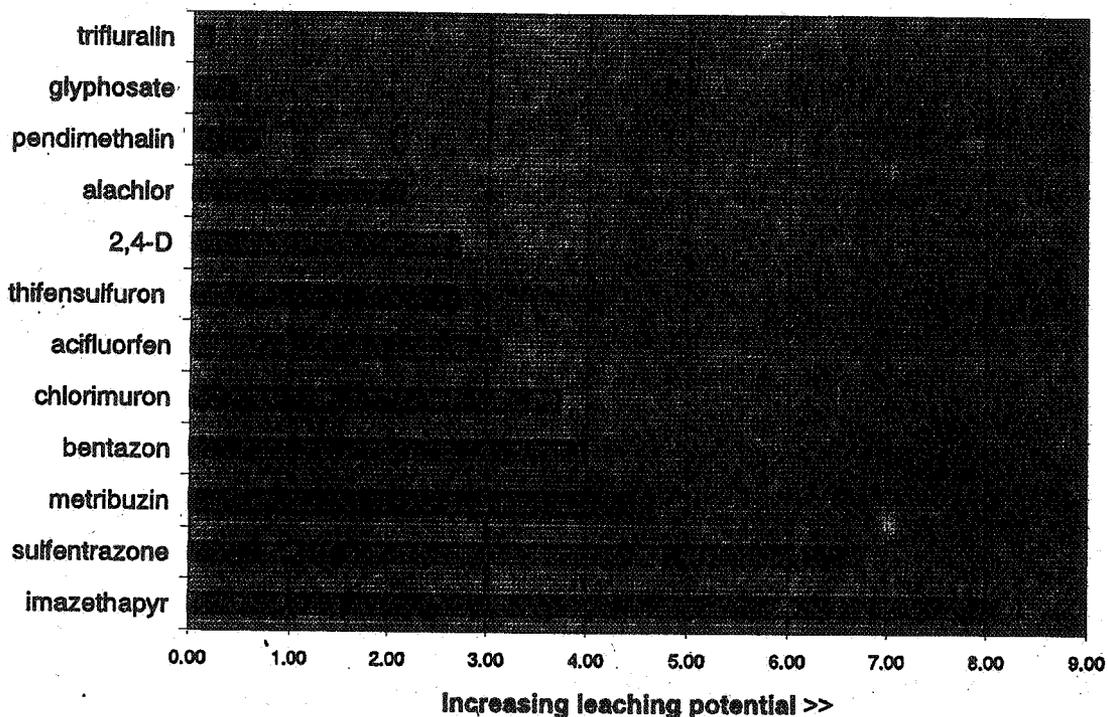


Figure 1.

Sulfentrazone leaching potential compared to other major soybean herbicides is shown in Figure 1. These comparisons are based upon average aerobic metabolism rates and soil organic carbon-adjusted sorption coefficients ( $K_{oc}$ ) for each pesticide, using the formula of Gustafson (Gustafson, D.I. 1989. Groundwater ubiquity score: A simple method for assessing pesticide leachability. *Environmental Toxicology and Chemistry* 4:339-357). The data used to make the calculations for Figure 1 are provided in the Appendix to this review. Sulfentrazone and its acid degradate clearly have more intrinsic leaching potential than the vast

majority of currently used soybean herbicides (and, for that matter, than the vast majority of all currently registered pesticides). The use rate of sulfentrazone (proposed maximum application rate of 0.375 lb ai/A), while less than the average rate for older generation herbicides, is higher than for most of the newer low-rate herbicides such as sulfonylureas. Therefore, ground water concentrations in the range of several ppb to tens of ppb are possible; this was confirmed for the study site with highly vulnerable ground water that was the subject of the study being reviewed here.

### **Potential Effects of Sulfentrazone on Nontarget Organisms**

Comparison of the ground-water concentrations at the test site (representing highly vulnerable conditions) shows that the most sensitive algae and crop species (e.g., tomatoes) might be affected by residue levels that might occur in ground water used for irrigation (See figure entitled "Dose causing adverse effects on nontarget organisms" in the Appendix). However, the Health Effects Division currently indicates there may be some developmental and other toxicological issues of concern; further analysis of the potential for nontarget effects will be needed.

## **8. RECOMMENDATIONS:**

1. The leaching potential of sulfentrazone appears to be greater than that of most currently registered pesticides, and the study reviewed here resulted in rapid leaching of sulfentrazone to ground water followed by sustained contamination. With time and market penetration, the likelihood of widespread contamination of sulfentrazone would be likely to increase. Therefore, registration of this chemical would require extra safeguards to ensure that widespread contamination of ground water would not occur, such as additional prospective ground-water monitoring studies, sampling of monitoring wells throughout the sulfentrazone use area, and the establishment of triggers for follow-up action.

If sulfentrazone were to be registered, with the necessary safeguards in place, RD should be aware of the following consequences:

- Past experience with the registration agreement of acetochlor, which includes requirements similar to those listed above, indicate that the registration of sulfentrazone would require a very large commitment of EPA resources. The negotiation and subsequent interpretation of the acetochlor agreement, as well as the review of the required data submissions resulting from the monitoring studies, have consumed substantial OPP resources;

- The States have made it clear to EPA that they believe it inappropriate to include new chemicals in the State Management Plan program. The development and execution of a

sulfentrazone state monitoring program similar to that underway for acetochlor would also require State input and expenditure of resources. In such a program, States would be consulted as to the design and location of monitoring wells, as well as in other aspects of the program.

2. In the future it would be most helpful for the registrant to submit a consolidated report rather than isolated, individual topical reports, which sometimes resulted in the reviewer having to search through the entire volume to find information about a particular aspect of the study.
3. If registration is to be granted pending the results of additional monitoring and other conditions, then label restrictions should be instituted which limit use of sulfentrazone in areas with that are vulnerable to ground-water contamination. The registrant should conduct a vulnerability assessment for the proposed use area, and restrict use in the areas/soils designated (e.g. sandy soils).

#### 9. BACKGROUND:

EFGWB previously reviewed a progress report for this study (6/27/95; DP Barcodes D215727, D211622, D211625, and D211627) and requested a limited amount of additional sampling and documentation of the study site with relationship to the effects of a major irrigation accident. FMC Corp. has now submitted a response to the previous review. This submission is intended to be reviewed by the Agency in conjunction with their previous study reports as a final small-scale prospective ground-water monitoring study report.

A protocol for this study was previously reviewed by the Ground Water Technology Section (GWTS) on 5/14/92 (DP Barcode D174353). The registrant applied bromide tracer on 5/14/92 and sulfentrazone at 0.5 lb ai/A (1x the maximum label rate at that time, but 1.33x the current maximum rate, according to the registrant's study progress report) on 5/15/92. All monitoring wells were located off-site (albeit close to the treated area), contrary to the specific requirement for this study by the Agency that ground-water monitoring wells be located inside the treated area. Historically the Agency has never recommended that a study be conducted without any wells inside the treated area. Four piezometers were placed around the perimeter of the test site and used to monitor ground-water flow, however, nested tensiometers were apparently not installed as recommended by the Agency. All samples were analyzed for both sulfentrazone parent and sulfentrazone 3-carboxylic acid, as requested by the Agency.

The study site selected was in Tarboro, Edgecombe County, North Carolina. This site was classified as Tarboro sand and loamy

sand, having about 84 to 90% sand and 6% clay whereas deeper soil was mostly sand and coarse sand with 92 to 96% sand. In four soil cores taken, the soil texture was generally a loamy sand near the surface, grading to a sand at lower depths (two cores were analyzed to a depth of about 11.5 feet and two others to a depth of 5 feet). Organic matter was about 1.2% in the upper six inches of soil and was close to zero at lower depths. Taxonomic information for the test soil was not provided.

On June 18, 1993 (about 13 months after the application of sulfentrazone) the traveling gun irrigation apparatus turned over while in operation and caused severe erosion in parts of the treated area. This accident was reported to GWTS in a telephone call; however, the registrant apparently did not follow-up on a request by GWTS to set up a meeting to discuss how to respond. Subsequent to the irrigation accident, most study monitoring activities were terminated. However, the registrant did analyze selected soil water and ground water samples at 14 months posttreatment (about 27 days after the irrigation accident) and at 39 months posttreatment.

## **10. DISCUSSION:**

### **Overview:**

In spite of some important deviations from the Agency-requested format and an irrigation accident which compromised the latter part of the study, this study does provide information on the leaching of sulfentrazone to shallow ground water overlain by highly permeable, sandy soils.

### **Study Design**

A total of four well clusters were installed along the outside edge of the treated area - no monitoring wells were located inside the treated area. Six suction lysimeter clusters were located inside the treated area however, data were reported from only five clusters. A large number of the scheduled soil pore water samples were not taken or analyzed.

### **Weather and Hydrology**

In this study, about 27 inches of rain and irrigation water reached the site in the first four months after application; 62 inches reached the site by 13 months after application. Supplemental irrigation was applied only in the months of June (1.5 inches) and July (3.12 inches) after the May 14, 1992 application of sulfentrazone (Becker, 1996; page 301). The dates of irrigation were not supplied. The total water applied was as follows:

Period	Site Water Added (irrigation + rain)	Historical Average Precipitation
May 15 to 31	1.67	2.14
June 1 to 30	6.52	4.14
July 1 to 31	6.41	4.57

From these data, it is not clear that the study conditions in the first few weeks after application would have been likely to result in an above normal amount of leaching. Interpretation would have been much easier with daily irrigation and precipitation data. It is significant to note that substantial leaching of sulfentrazone residues and bromide tracer was uniformly first observed at 3- 5- and 7-foot depths at the 2-month posttreatment sampling interval. Significant residues in ground water did not appear until 3- or 4-months after application even though the depth to ground water averaged nine feet or only about 2 feet below the lowest lysimeter in each cluster.

**Hydraulic conductivity:** Guelph permeameter tests were used to determine saturated hydraulic conductivity in the unsaturated zone. "Slug" tests were used to determine hydraulic conductivity in the surficial aquifer at the study site. The hydraulic conductivity was determined on the basis of the rate of rise of the water level in the well after a slug of water was removed (water was displaced from each well with a bailer to facilitate these measurements). Results were as follows:

Depth	Hydraulic conductivity, m/day
soil, 1 foot	0.68 to 0.89
soil, 3 feet	1.23 to 4.10
soil, 6 feet	5.24 to 26.01
soil, 8 feet	6.44 to 14.52
aquifer	56 to 70

Clearly, from these data very rapid movement to ground water of a mobile pesticide such as sulfentrazone can occur at a site such as this one. Ground-water flow velocity was calculated from the aquifer hydraulic conductivity measurements to be about 201 feet/day.

### Soil Monitoring Results

Sulfentrazone residues persisted in surface soil over the entire 13-month period for which sampling data were obtained prior to the irrigation accident which severely disturbed the integrity of the study. Sulfentrazone dissipation from the upper six inches of soil did not follow a first-order decline pattern. The first 50% disappearance time was 1 day, the second about 50 days, and then the dissipation slowed to near zero in the winter time.

Because of the persistence of residues in the vadose zone at all depths, it is clear that the overall degradation rate of sulfentrazone was much, much slower than the surface soil dissipation rate. These data are discussed further in the environmental fate Subdivision N Guideline study reviews. Residues of the 3-carboxylic acid were very low in soil samples, but, as discussed below, this degradate was a substantial component of the leached residues detected in soil pore water and in ground water.

### Soil Water and Ground Water Monitoring Results

Amounts of sulfentrazone leaching were substantial relative to the application rate. Residues of parent plus acid reached the following maximum concentrations in soil water (average of replicates):

Lysimeter depth, feet	Days after application	Total residues (parent + acid), ppb	Sulfentrazone concentration, ppb
3	124	100.8	19.7
5	186	30.7	15.1
7	214	25.3	12.3

By the last sampling date analyzed before the irrigation accident (395 days after application) residues of parent + acid averaged about 10 ppb in soil-pore water from all three depths. This was a 2-fold to 10-fold decline from peak concentrations (at the 3- and 7-foot depths, respectively) that had occurred several months earlier.

The mass of sulfentrazone leaching through the soil profile varied among the various soil clusters. Figures 2 and 3 present data on sulfentrazone acid residues for clusters no. 3 and 5 (the patterns for sulfentrazone parent were very similar). Figure 4 compares the combined parent + acid residues detected in soil water samples from the 3-foot depth for all five lysimeter

clusters for which data are available (refer to the Appendix to this review for details on separate parent and acid residue levels). The mass of sulfentrazone and sulfentrazone acid moving below 3 feet was nearly twice as much in Cluster 3 as it was in Cluster 2, and apparently 5 to 10 times as much as in Cluster 5 (data for clusters 3 and 5 are illustrated here). At seven feet, different relative results were obtained (not pictured, see data tables in the registrant's original report): the mass moving below seven feet was more than 20 times greater in Cluster 5 than in either Cluster 2 or Cluster 3 (no soil water was analyzed for cluster 3 however after about 100 days posttreatment).

### Acid Residues in Lysimeter Cluster Five

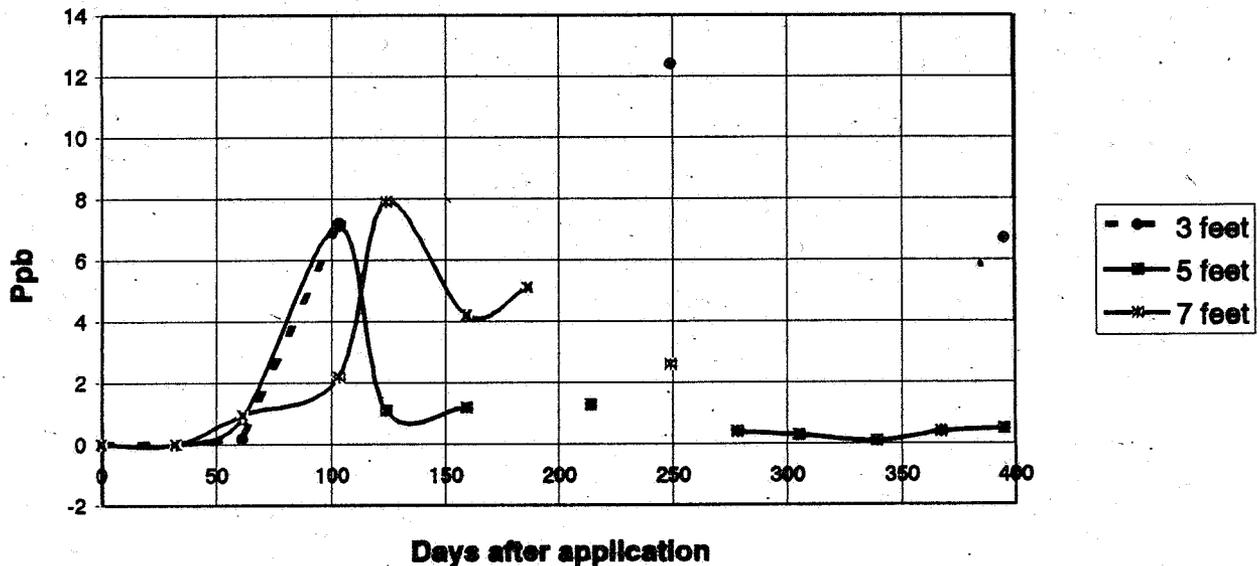


Figure 2.

### Acid Residues in Lysimeter Cluster Three

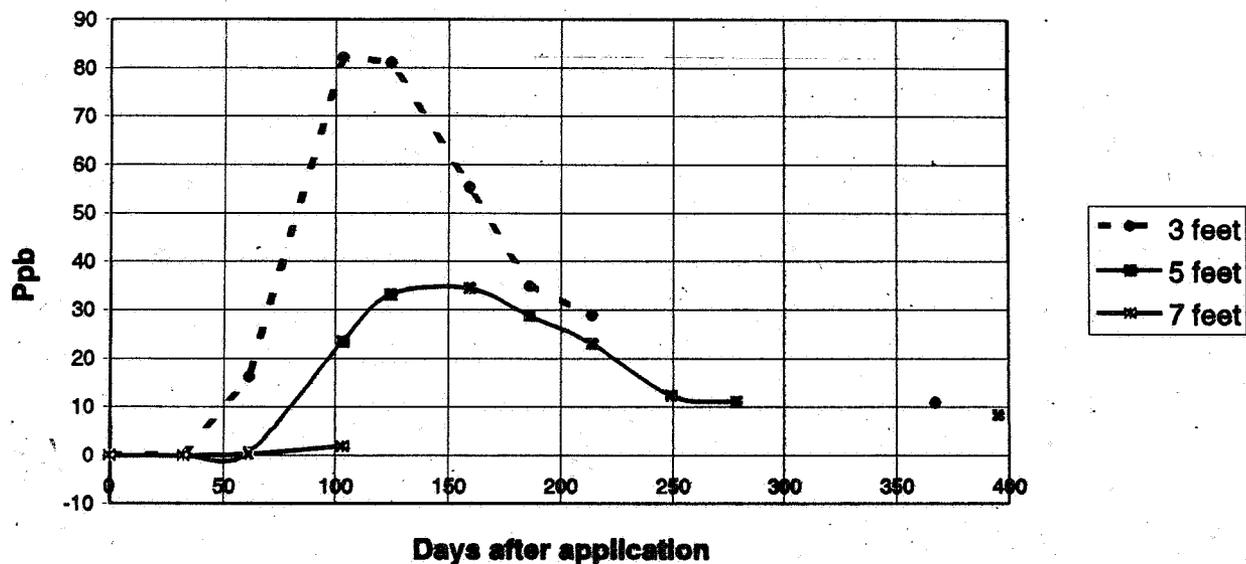


Figure 3.

A similar pattern occurred in ground water with the peak concentrations of sulfentrazone residues occurring about four to five months after application:

Well depth / timing	Days after application	Total residues (parent + acid), ppb	Sulfentrazone concentration, ppb
Shallow, max.	124	42.2	37.4
Shallow, final	395	13.3	7.2
Deep, maximum	160	30.6	19.2
Deep, final	395	9.3	5.1

Apparently, much of the applied sulfentrazone had moved through the soil profile within several months after application and the amount of residues leaching had declined by 13 months after application, when the last sample was taken. However, there were still significant amounts of sulfentrazone residues (parent and acid degradate) remaining in soil water at all depths sampled 13 months after treatment.

Because of the high persistence of sulfentrazone residues, their partition primarily into the soil pore water, and the relatively

rapid recharge of the aquifer that occurred, residues were detected in downgradient wells (which were located outside of the treated area). Unfortunately, among the Agency recommendations that were not followed for this study were those concerning the location of the monitoring wells. The registrant located 3 of their 5 well clusters entirely upgradient of the treated area, so in reality their design consisted of three control well clusters and two monitoring well clusters. Furthermore, only a small fraction of the treated area was upgradient of one of the two monitoring well clusters. As would be expected, tracer and herbicide residues in this cluster were substantially lower than in the single well cluster that was wholly downgradient from the treatment area. Since no wells were located on site, it cannot be determined what concentrations of sulfentrazone and its degradates were present at the point of entry of the leachate into the saturated zone. Figure 4 shows residues that were detected in the single well cluster that was entirely downgradient from the treated area. Even though this well was located just outside of the treated area, residues of sulfentrazone plus its acid degradate were within the 5 to 50 ppb range for the entire sampling period after the first detections three months posttreatment. Concentrations of parent were on average only slightly greater than sulfentrazone acid in ground water (approximately 55 % of the total residue was present as sulfentrazone parent) (see Appendix for details).

Sulfentrazone residues appeared to be quite persistent in ground water, as residues did not decline over the period of regular sampling. It is likely that most of the residues will dissipate in the aquifer before substantial degradation occurs.

#### Sulfentrazone Parent + Acid in Ground Water Samples from the Single Downgradient Well Cluster

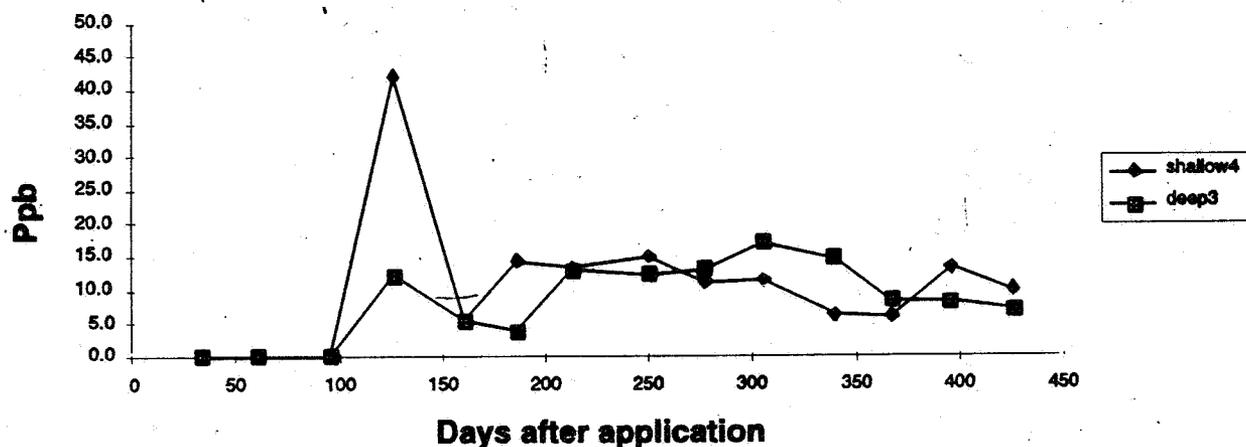


Figure 4.

Results of the final sampling event, two years after the irrigation accident: At the request of EPA, the registrant collected and analyzed a few samples from lysimeters and monitoring wells before decommissioning the site in 1995. The sampling date was approximately 1185 days after application. Soil water samples were analyzed from the 3- and 7-foot samples of lysimeter cluster two, which was not eroded away when the irrigation equipment overturned. Residues of parent + acid were 2.0 ppb (0.7 and 1.3 ppb parent and acid, respectively) in the 3-foot lysimeter (residues of parent plus acid generally averaged about 15 ppb from the same lysimeter two years earlier, before the irrigation accident). Residues were several times lower in the 7-foot sample estimated to be about 0.3 ppb parent plus acid, but considered to be a non-quantifiable detection below 0.5 ppb by then (residues were about 2 to 3 ppb two years earlier). From these limited data it appears that sulfentrazone gradually dissipated from the profile, with detectable, but substantially less concentrated residues remaining in the soil profile three years after application. It is not possible to determine how much of the dissipation over the approximately 2-year period between the irrigation accident and the final sampling event was by degradation as opposed to leaching; but earlier data imply that sulfentrazone residues persist for months or years in subsurface environments.

Damage to the test site from the irrigation accident:

The irrigation traveling gun apparatus toppled on the night of June 16, 1993 and resulted in severe erosion over 40% of the treatment area (on the eastern side). Soil loss was over six inches over perhaps about 15 to 20% of the treated area. Although the registrant did not continue to sample afterwards, they did take a few soil water and ground water samples two years later before closing down the study (the results are discussed above). Because of the extent of the damage, such results provide some information on sulfentrazone persistence, but not an accurate estimate of the extent of sulfentrazone leaching under normal agricultural practices.

Study results in the context of the entire soybean production area:

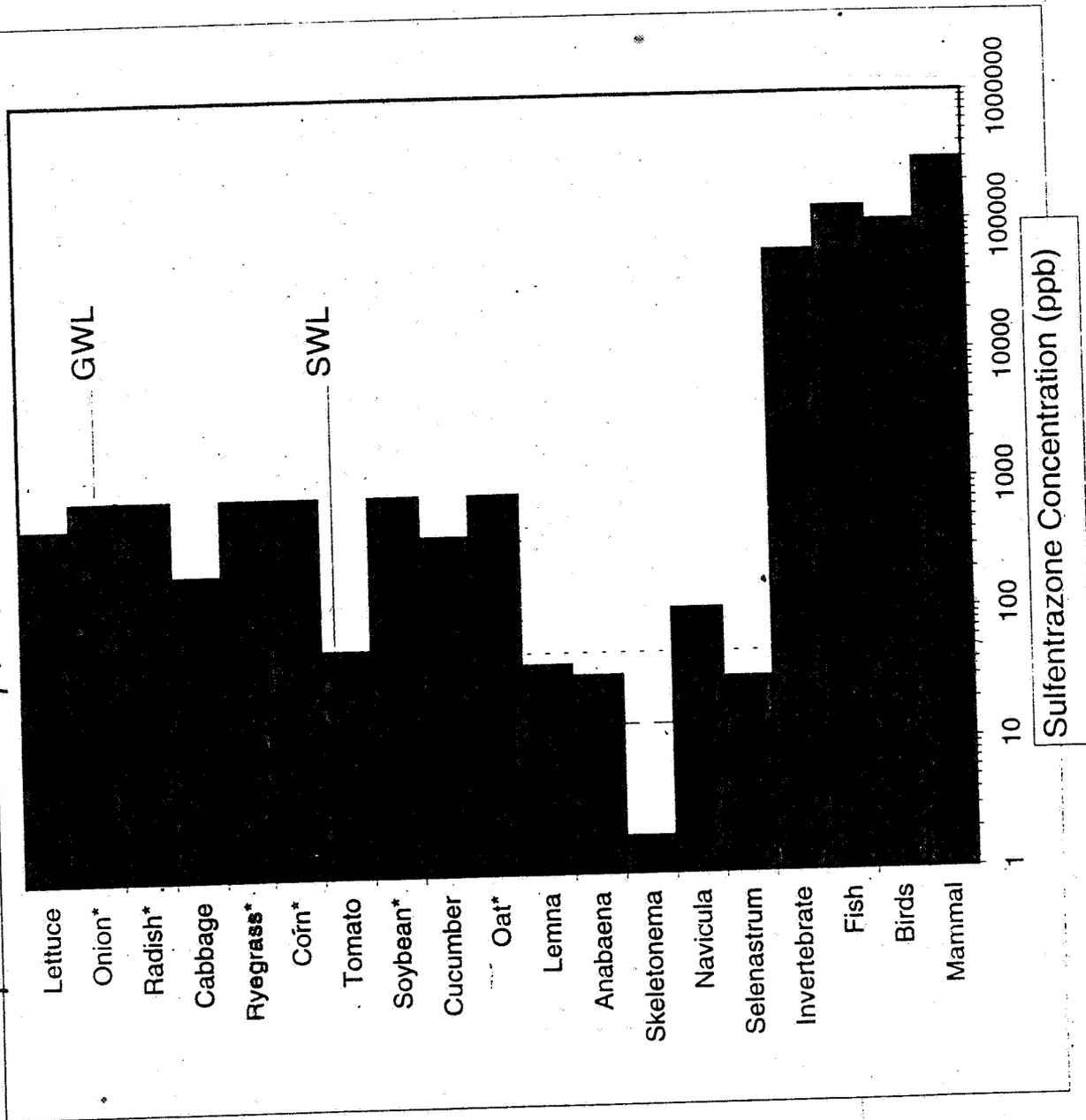
The registrant has provided supplemental data demonstrating that less than 1% of soybeans in the United States are grown on sandy soils similar to the test site. However, in major land resource area 133A (where the current study was conducted), 19% of potential soybean acres are sandy loam or sand (although presumably for some of this acreage there are finer-textured layers below the surface). The registrant does not believe that sulfentrazone will leach at less vulnerable sites.

Appendix

**Ranking of Leaching Potential of Sulfentrazone and Eleven Top Soybean  
Using the GUS index (Gustafson, 1989).**

<b>Compound</b>	<b>t1/2 log t1/2</b>		<b>Koc log Koc</b>		<b>GUS</b>	<b>ID</b>	<b>Soybeans % treated,</b>
imazethapyr	500	2.70	10	1.00	8.10	median	42
sulfentrazone	545	2.74	34	1.53	6.75	median	NA
metribuzin	40	1.60	16	1.20	4.48	median	10
bentazon	41	1.61	34	1.53	3.98	median	14
chlorimuron	80	1.90	110	2.04	3.73	median	15
acifluorfen	40	1.60	113	2.05	3.12	median	10
2,4-D	10	1.00	20	1.30	2.70	median	10
thifensulfuron	10	1.00	20	1.30	2.70	median	14
alachlor	17	1.23	180	2.26	2.15	median	7
pendimethalin	150	2.18	5000	3.70	0.66	median	25
glyphosate	25	1.40	5000	3.70	0.42	median	15
trifluralin	87	1.94	8000	3.90	0.19	median	24

Dose causing adverse effects on non target organisms, expressed as ppb in medium of exposure,



GUS Score Calculations for Soybean Pesticides

**Ranking of Leaching Potential of Sulfentrazone and Eleven Top Soybean Herbicides Using the GUS index (Gustafson, 1989).**

Compound	t1/2	log t1/2	Koc	log Koc	GUS	ID	Soybeans % treated, 1994
imazethapyr	500	2.70	10	1.00	8.10	median	42
sulfentrazone	545	2.74	34	1.53	6.75	median	NA
metribuzin	40	1.60	16	1.20	4.48	median	10
bentazon	41	1.61	34	1.53	3.98	median	14
chlorimuron	80	1.90	110	2.04	3.73	median	15
acifluorfen	40	1.60	113	2.05	3.12	median	10
2,4-D	10	1.00	20	1.30	2.70	median	10
thifensulfuron	10	1.00	20	1.30	2.70	median	14
alachlor	17	1.23	180	2.26	2.15	median	7
pendimethalin	150	2.18	5000	3.70	0.66	median	25
glyphosate	25	1.40	5000	3.70	0.42	median	15
trifluralin	87	1.94	8000	3.90	0.19	median	24

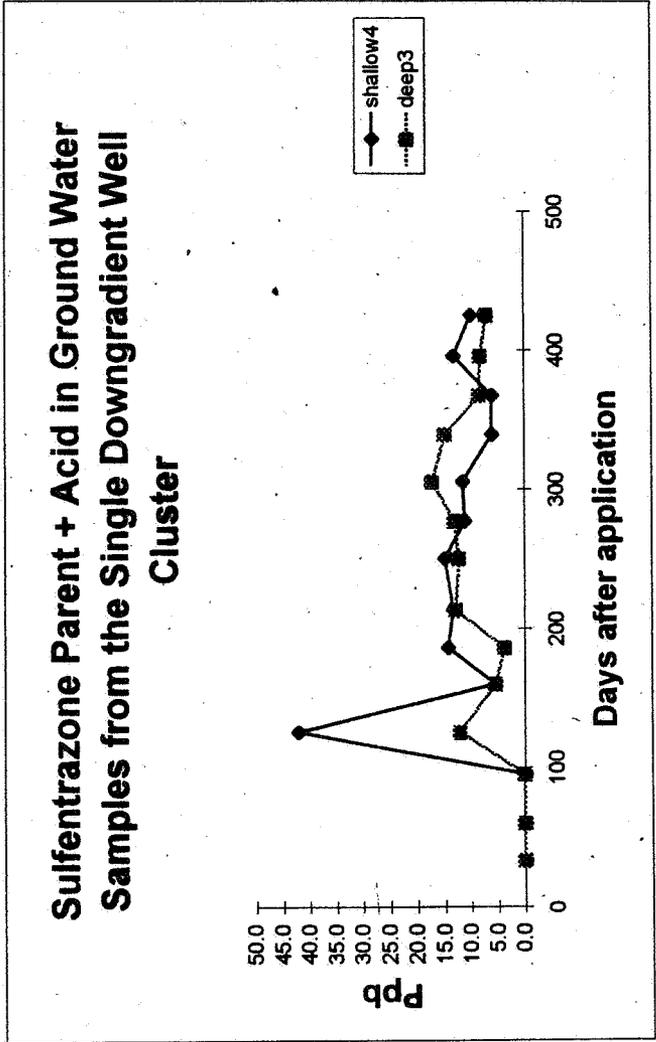
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Total in Wells 3 and 4

Total Residues of Sulfentrazone + Acid Degradate in Water from the Downgradient Well Cluster															Avg. for last	
Well id.	33	60	95	125	160	186	213	250	277	305	339	367	395	425	(days)	10 samples
shallow4	0.0	0.0	0.0	42.2	5.6	14.4	13.3	15.0	11.2	11.5	6.1	6.0	13.3	10.0		10.6
deep3	0.0	0.0	0.0	12.2	5.4	3.8	12.9	12.3	13.2	17.2	14.9	8.4	8.2	7.0		10.3

Sulfentrazone Parent Residues																
Well id.	33	60	95	125	160	186	213	250	277	305	339	367	395	425	(days)	
shallow4	0.0	0.0	0.0	32.8	1.5	6.0	8.4	9.6	6.6	6.6	3.7	3.5	7.2	6.2		5.9
deep3	0.0	0.0	0.0	8.2	1.3	1.4	6.9	6.7	7.4	9.6	9.0	4.8	4.4	4.9		5.6

Sulfentrazone Acid Residues																
Well id.	33	60	95	125	160	186	213	250	277	305	339	367	395	425	(days)	
shallow4	0.0	0.0	0.0	9.4	4.0	8.4	5.0	5.4	4.6	5.0	2.4	2.5	6.1	3.8		4.7
deep3	0.0	0.0	0.0	4.1	4.1	2.4	6.0	5.6	5.8	7.6	5.8	3.6	3.8	2.0		4.7



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Substantive Review

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Pages 19 through 23 are not included in this copy.

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The material not included contains the following type of information:

- Identity of product inert ingredients.
  - Identity of product impurities.
  - Description of the product manufacturing process.
  - Description of quality control procedures.
  - Identity of the source of product ingredients.
  - Sales or other commercial/financial information.
  - A draft product label.
  - The product confidential statement of formula.
  - Information about a pending registration action.
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- 

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