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

SEP 1 1994

MEMORANDUM

OFFICE OF PREVENTION, PESTICIDES AND TOXIC SUBSTANCES

SUBJECT: Diquat Dibromide Reregistration Science Chapter (D198588)

FROM: Anthony F. Maciorowski, Chief
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Environmental Fate and Effects Division (H7507C)

9-1-94

TO: Evert Byington, Chief
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Environmental Fate and Effects Division (H7507C)

The Ecological Effects Branch has completed a Science Chapter for reregistration of Diquat dibromide. This action is under D198588. The two plant studies that were submitted by Chevron Chemical Company have been reviewed and used in the risk assessment, but the data evaluation reports will be provided under a separate memorandum.

How Application Rates are Used

The LUIS provided application rates in lb cation/acre.

When estimating exposure to aquatic organisms in aquatic habitat, this rate in lb ai cation was used to model exposure. The resulting concentrations (in **ppb cation**) were compared to results of aquatic toxicity tests **also expressed in ppb cation**.

The bird and mammal toxicity data were expressed in a variety of units ranging from ai formulation, cation formulation, 100% ai, and cation ai. All results were extrapolated to cation units to be consistent with the application rate units. Exposure on food items was then calculated in ppm cation.

Risk Summary

1- The LOC for acute effects to non-endangered mammals have not been exceeded; acute risk to non endangered mar mals is assumed to be minimal.

2- The LOC for chronic effects to mammals has been exceeded by uses on turf/ornamental (RQ=2.7) and crops treated at 0.5 lb cation/acre (RQ=1.5). This is based on maximum residues on short grass immediately after application. **Typical** residues on short grass and long grass from turf/ornamental treatment also exceed the NOEL from the rat reproduction study.

3- The LOC for **acute effects** to non-endangered birds has not been exceeded. Acute risk to birds is assumed to be minimal.

4- However, the LOC for **chronic effects** to birds has been exceeded. Therefore, a conclusion of minimal risk to birds cannot be made. Both maximum and typical residue levels on a variety of food items exceed the NOEL from the mallard reproductive study. The risk quotients range from 1.7 to 42.8, all of which exceed the LOC of 1.

5- The LOC for acute risk to non-endangered fish and invertebrates, including estuarine organisms, has not been exceeded from treatment of terrestrial sites (turf, ornamental and crop).

Direct application to water (aquatic weed control) may result in risk (RQ=0.6) that exceeds the LOC (0.5) for acute risk to estuarine invertebrates. However, this risk potential is mitigated by the fact that diquat dibromide quickly binds to suspended particulates in water, and would quickly be come unavailable. Ultimately the risk potential appears to be low.

6- The LOC (1) for chronic effects to aquatic organisms is equaled (RQ=1.1), by treatment of terrestrial use sites. However, chronic exposure is unlikely because diquat dibromide is likely to bind rapidly to suspended particles in the water column making it unavailable, biologically. As above, the risk potential appears to be relatively low.

The LOC of chronic effects to aquatic invertebrates may be exceeded by the risk from immediate concentrations occurring after treatment of aquatic use sites (RQ=0.26 [fish] and 5.5 [aquatic invertebrate]). However, chronic exposure is unlikely because of the environmental fate characteristics of diquat dibromide. Diquat dibromide apparently tends to bind rapidly to suspended matter in the water column and becomes biological unavailable.

Therefore, in spite of the risk quotients, chronic risk to aquatic fish and invertebrates is considered to be minimal.

7- The LOC for aquatic plants has been exceeded by both ground and aerial application. The RQ's range from 3.5 to 967. The LOC for plants is 1. However, due to the environmental fate characteristics of diquat dibromide, it is unlikely that hazardous exposure from runoff alone will occur (RQ=967). The route of exposure likely to represent a risk to aquatic plants is drift from aerial spray. Aerial spray of the following terrestrial sites results in the risk quotients shown. These risk quotients are all from spray drift, which is assumed to be 5% of the applied.

applied:	Cantaloupe 0.25 lb cation/a	Soybeans, etc 0.5 lb cation/a	Turf 0.89 lb cation/a	Aquatic weed control 4 lb cation/a
RQ:	3.5	6.9	12.4	55.6

Note that in the case of aquatic weed control, it is not the intent of this risk assessment to address non-endangered plants in the actual target site nor the untreated band between the 40-foot spray swaths, see the discussion in the next paragraph. It is assumed that the treated and untreated swaths will eventually be treated; i.e they are actually the target site. The risk quotient calculated (55.6) is based on 5% of the spray drifting to some other nontarget aquatic habitat adjacent to the treated lake or pond.

But please also note that the drift that occurs from aerial treatment for aquatic weed control may negate the value of leaving the 40-foot untreated swaths. When diquat is applied to weed infested water, the result and intent is that the weeds die. As these weeds decompose, dissolved oxygen is depleted. The dissolved oxygen reduction may become severe enough to kill aquatic organisms (fish and invertebrates) due to lack of oxygen. The purpose of treating in swaths, and leaving 40-foot untreated bands is to provide these organisms a place to go where the dissolved oxygen may be high enough to support them. If drift from aerial application settles on these "untreated" bands and ends up killing the plants there, the dissolved oxygen could be reduced in these areas along with the treated areas. The fish and invertebrates would then have no where to go, and could also be killed. This risk of this potential impact cannot be expressed with quotients.

8- The LOC (1) for terrestrial plants is not exceeded by risk from runoff, however, it is exceeded by risk from drift from aerial applications to turf and for aquatic weed control.

	Cantaloupe 0.25 lb ai/a	Soybeans, etc 0.5 lb ai/a	Turf 0.89 lb ai/a	Aquatic weed control 4 lb ai/a
RQ	2.7	5.3	9.5	42.5

Discussion of Certainty

Chronic risk to Mammals

The chronic risk to mammals was based on a comparison of immediate residues with the NOEL from a 2-generation reproduction study. It is possible that very short (i.e. immediate) exposures could cause chronic responses; no data is provided to negate this possibility. Furthermore, there is no way of knowing if wild mammals may be more sensitive to diquat dibromide than laboratory rats. However, there is high degree of uncertainty in concluding that adverse effects to mammals would actually occur because of the following factors.

Residues may decline over time to levels lower than the NOEL.

Typical and even maximum residues do not exceed the LOEL (453 ppm).

The residues used to calculate the risk quotients were from food items (short grass) having the highest estimated levels. Other food items would have lower residue levels.

Chronic risk to Birds

Note that the risk quotients for chronic risk to birds were based on both maximum **and** typical residues expected to occur immediately after treatment. Diquat is extremely persistent, but neither the rate of decline on food items, nor rate at which diquat becomes "biologically unavailable" to birds is known. Based on available data, there is moderate to high certainty that some reproductive effects will occur to birds. The likelihood that this impact will occur frequently, or be of ecological significance is less certain.

Risk to aquatic organisms

Except for aquatic plants, which are assumed to be at considerable risk from drift from any aerial treatment, most aquatic risk was assumed to be low. This conclusion was made despite the fact that LOC's were exceeded. There is some uncertainty with this conclusion in that diquat dibromide is extremely persistent. It "dissipates" from the water column quickly, however, once bound to sediment, there is no data showing that it degrades. The current assumption is that once bound it is unavailable to exert adverse effects on aquatic plants and animals. It is unknown what the long term exposure concentrations might be to aquatic life living in the sediment. It is also unknown what affects this long-term exposure might have on aquatic life, especially plants.

Risk to terrestrial plants

There is relatively high certainty that drift from aerial spraying of diquat dibromide will result in adverse effects to plants. There is an element of uncertainty in the terrestrial plant risk assessment because data from the more sensitive plant species is probably not available. It is considered likely that sweet corn and wheat would yield lower EC25's. Failing to have this data does not preclude doing a risk assessment, since other data indicate the LOC is exceeded. However:

1-It is not possible to determine the full extent of risk as would be valuable in comparisons with other herbicides; and

2-EFED would be unable to fully evaluate the effectiveness of risk reduction measures.

Endangered Species

1- Endangered species of mammals and birds may be affected by terrestrial uses of diquat dibromide.

2- Endangered species of aquatic fish and invertebrates may be affected, acutely, by the aquatic weed control use. While RQ's for chronic effects exceed the chronic LOC, chronic exposure in aquatic habitats is not expected and thus potential for chronic effects to endangered aquatic animals is considered unlikely.

3- Endangered species of aquatic plants may be affected from aerial application of terrestrial use sites and from both aerial and non-aerial treatment of aquatic use sites.

4- Endangered species of terrestrial plants may be affected from aerial treatment of all use sites. In the case of the aquatic weed control, it is assumed that 5% of what is sprayed aerially could drift to adjacent terrestrial habitats.

Risk Reduction

The EEB recommends that the EFED diquat dibromide team (EEB, EFGB and SACS meet to discuss risk reduction measures. The following are some suggestions that could be discussed at such a meeting.

Suggestion 1: Reduce or eliminate aerial application

The primary route of hazardous exposure appears to be via aerial spray drift. Elimination of aerial application would reduce to minimal, in most cases, risk to aquatic organisms and terrestrial plants.

Suggestion 2: Modify treatment of water bodies.

According to the current label for aquatic weed control, Diquat is to be applied in 40 foot strips throughout the lake or water body. As was mentioned earlier, this is to avoid a condition that may result in acute reduction of dissolved oxygen throughout a water body. The following suggestion may provide the registrants with alternative labeling practices if the current method has been suspected of causing fish kills or other adverse effects. An alternative practice is to have blocks of the body of water, usually a third of the surface, treated; thereby the fish will be able to avoid the lowered dissolved oxygen areas. After a period of time, usually about 2 weeks, the dissolved oxygen content would return to regular levels. Then another third of the lake can then be treated, etc. This method of application may reduce the potential for fish kills due to depleted oxygen.

Endangered Species

Labeling and use restrictions to protect endangered species are being developed as part of the EFED Endangered Species Protection Program.

Data Adequacy

EEB recommends additional vegetative vigor non-target plant testing (tier II) because only one grass species (corn) was tested. According to an earlier study (40165102), sweet corn and wheat were found to be sensitive to diquat dibromide. It is recommended that two more grass species. Attempts should be made to use seed that has not been treated with fungicide. The value of this additional testing would be medium to high.

EEB recommends additional aquatic plant testing (tier II) because only vascular aquatic plants were tested and therefore only the vascular plant requirement (*Lemna gibba*) was satisfied. An EC_{50} was determined for different species of vascular plants in a dose response study. No unicellular plants (algae and diatoms) were tested. *Skeletonema costatum, Anabaena flos-aquae, Selenastrum capricornutum,* and a freshwater diatom needs to be tested to satisfy the requirements under 123-2 and for EEB to provide a complete risk assessment of diquat to non-target aquatic plants. The added value of this additional testing is medium to high.

Although eco-toxicity data is lacking on algae and grasses, EEB is able to provide a risk assessment for plants. The certainty of such assessment is moderate to low. Additional data may confirm the risk assessment with increased certainty plus more understanding of eco-system wide affects from the labeled use of diquat. Data on the grasses would provide information on the conditions in which endangered species of grasses may be affected. Such data may also help EFED to evaluate risk

reduction measures. For this risk assessment, EFED is assuming that grasses would be affected.

If you have questions, please contact Mike Davy (305-7081).

Ecological Effects Branch
Science Chapter For DIQUAT DIBROMIDE

A. Ecological Hazard

1. Ecological Effects Topical Summaries

a. Effects on Non-Target Birds

In order to establish the toxicity to birds, the following tests are required using the technical grade material: an avian single-dose oral acute study (71-1) on one species (preferably mallard duck or bobwhite quail); two subacute dietary studies (71-2) on one species of waterfowl (preferably mallard duck) and on one species of upland game bird (preferably bobwhite quail); and because of persistence and multiple applications, two avian reproduction studies (71-4) on mallard duck and bobwhite quail.

Nine studies were evaluated under this topic. The activity of Diquat dibromide herbicide is in the cation. In the table below, the cation will be used for risk assessment purposes for birds since the use information is in lb cation per acre. The cation active ingredient is extrapolated from the test values whether it be in diquat formulation or cation. The acceptable toxicity studies for use in a hazard assessment are listed below:

Guideline	Species	LD50 in mg % ai	LD50 in mg cation per kg	MRID No.	Requirements
71-1	Mallard	45.6	60.6	00106559	Yes
71-1	Mallard	30.0	89.6	HCOSTA01	No
			LC50 ppm cation		
71-2	Bobwhite	37.0	575	00034769, ACC # 232514	Yes
71-2	Mallard	37.0	980[1]	00034769	Yes
71-2	Japanese Quail	37.0	264	00034769	No
71-2	Ring-neck Pheasant	37.0	734	00034769	No
71-2	Bobwhite	35.3	106	00116565	No
			NOEL ppm cation		
71-4a	Bobwhite	35.3	>19.6	00119988	Yes
71-4b	Mallard	35.3	>5[2]	00114230 Acc #: 184988	Yes

For hazard assessment, these data indicate that diquat dibromide ranges in toxicity to birds from slightly to moderately toxic. All data requirements for birds are fulfilled. Typically, toxicity testing is to be done with technical grade active ingredients, usually having relatively high per cent purity. In the case of diquat dibromide, a test material containing 35 to 37% represents, apparently, the highest purity produced.

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[1] 30% mortality at 5000 ppm, 980 ppm cation.

[2] The NOEL=5 ppm cations based on number eggs laid, hatching, and 14-day old survival. LOEL=25 ppm cations.

b. **Effects to Non-Target Fish**

In order to establish the toxicity to fish, the following tests are required using the technical grade material: two 96-hour acute fish studies (72-1); one on a species of coldwater fish (preferably rainbow trout) and one on a species of warmwater fish (preferably bluegill sunfish); and because of persistence one fish early life stage study.

Eleven studies were evaluated under this topic. In the table below, the diquat cation will be used for risk assessment purposes for aquatic organisms since the availability of diquat dibromide is as a cation in aquatic environments. The value in ppm cation is extrapolated from the test values whether it be in diquat formulation, cation, or active ingredient. The acceptable toxicity studies for use in a hazard assessment are listed below:

Guide line	Species	% ai	LC50 ppm 100% ai	LC50 ppm as rptd in study	LC50 ppm cation[3]	MRID No.	Fulfills Requirement
72-1	Brown Trout	35.3	35.3	17.8	17.8	00115858	No
72-1	Emerald Shiner	see footnote[4]		25.8	----	00027203	No
72-1	Bluegill	35.3	22.8	64.5[5]	12.1	00115572	No
72-1	Rainbow Trout	35.3[6]	27.9	14.8	14.8	00138961	Yes[7]
72-1	Bluegill	35.3[6]	26.2	13.9	13.9	00138962	Yes
72-1	Rainbow Trout	35.3[6]	>35.3	>100	>18.7	00003503	Yes[10]
72-1	Bluegill	35.3	40.6-307	115-870	21.5	00003503	Yes[10]
72-1	Yellow Perch	35.3	8.3-21	23.5-60	4.4	00003503	No
72-1	Black Bullhead	35.3	8.7-60	24.6-170	4.6	00003503	No

The MATC below is derived from the geometric mean of the fish early life cycle study which shows NOEL= 0.58 ppm and LOEL= 1.5 ppm of the Diquat Concentrate based on wet weight and length of the larvae. There are 50.9% cation in diquat dibromide in the formulation for this study.

			100% MATC (ppm)	test MATC (ppm)	cation MATC (ppm)		
72-4a	Channel Catfish	unknown	----	------	>1.0	090862	No
72-4a	Fathead Minnow	41.4	0.386	0.933	0.197	40380703	Yes

For hazard assessment, these data indicate that diquat dibromide ranges in toxicity to fish from slightly to moderately toxic. Data requirements for freshwater fish are fulfilled. Typically, toxicity testing is to be done with technical grade active ingredients, usually having relatively high per cent purity. In the case of diquat dibromide, a test material containing 35 to 37% represents, apparently, the highest purity obtainable.

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[3] The values express in this column are in ppm cations. It will be assumed that there are approximately 53% cations in diquat dibromide unless otherwise noted.

[4] The study cites the 2 lb ai/imperial gallon. According to the LUIS report, the 2 lb cation per gallon pertains to the 35.3% ai formulation. It is unclear as to what is the actual percentage formulation used.

[5] Results based on 72 hr test rather than on 96 hr test.

[6] The study cites the percentage formulation as 19.8% cation and having 2 lb cation per gallon. According to the LUIS report, the 2 lb cation per gallon is similar to the 35.3% ai formulation (diquat dibromide is made up of about 53% cation).

[7] This study fulfills 72-1(d) guidelines for TEP only.

c. **Effects to Non-Target Aquatic Invertebrates**

In order to establish the toxicity to aquatic invertebrates, a 48-hour aquatic invertebrate acute toxicity test is required using the technical grade material on first instar *Daphnia magna* or early instar amphipods, stoneflies or mayflies; and because of persistence one aquatic invertebrate life cycle study.

Seven studies were evaluated under this topic. In the table below, the diquat cation will be used for risk assessment purposes for aquatic organisms since the availability of diquat dibromide is as a cation in aquatic environments. The value in ppm cation is extrapolated from the test values whether it be in diquat formulation, cation, or active ingredient. The acceptable toxicity studies for use in a hazard assessment are listed below:

Guide line	Species	% ai	EC50 (ppm) 100% ai	test	Cation	MRID No.	Fulfills Requirements
72-2	*Daphnia magna*	46.6	2.1	1.03	1.03	235179	Yes
72-2	*Daphnia magna*	46.6	2.25	1.19	1.19	00115576, 235179	Yes
72-2	*Daphnia magna*	35.2	1.51	0.77	0.77	235179	Yes
72-2	*Gammarus fasciatus*	35.3	>35.3	>100	18.7	00003503	No[•]
72-2	*Hyalella*	unkn	-----	0.14	0.14	00115862	No
N/A	Apple Snail	35.3	0.64	1.80	0.34	00003503	No

The MATC below is derived from the geometric mean of the aquatic invertebrate life-cycle study which shows NOEL= 0.17 ppm and LOEL= 0.27 ppm of the Diquat Concentrate based on survival. There is 50.9% cation in diquat dibromide in the formulation for this study. Typically, toxicity testing is to be done with technical grade active ingredients, usually having relatively high per cent purity. In the case of diquat dibromide, a test material containing 35 to 37% represents, apparently, the highest purity obtainable.

			MATC (ppm)				
72-4b	*Daphnia magna*	41.4	0.086	0.214	0.044	40380702	Yes

For hazard assessment, these data indicate that diquat dibromide ranges in toxicity to aquatic invertebrates from slightly to highly toxic. Data requirements for aquatic invertebrates are fulfilled.

d. **Effects to Non-Target Estuarine and Marine Organisms**

In order to establish the toxicity to estuarine and marine organisms, the following tests are required using the technical grade material: either a Mollusc 48-hour embryo larvae study using Pacific oyster, Eastern oyster, mussel (preferably *Mytilus edulis*) or Quahog (*Mercenaria*) or a Mollusc 96-hour Flow-Through Shell Deposition study using Pacific oyster or Eastern oyster; and a Shrimp 96-hour acute toxicity test using white, pink, brown, grass or mysid shrimp species; an estuarine fish (preferably silverside or sheepshead minnow).

Five studies were evaluated under this topic. In the table below, the diquat cation will be used for risk assessment purposes for aquatic organisms since the availability of diquat dibromide is as a cation in aquatic environments. The value in ppm cation is extrapolated from the test values whether it be in diquat formulation, cation, or active ingredient. The acceptable toxicity studies for use in a hazard assessment are listed below:

[•] 96 hour test

Guide line	Species	% ai	EC50 (ppm) ai	test	cation	MRID No.	Fulfills Requirements
72-3	Mysid Shrimp	41.4	0.83	2.0	0.42	40315701	Yes
72-3	Eastern Oyster	41.4	107	>260	54.8	40316001	Yes
72-3	Sheepshead Minnow	41.4	94.4	228	48	40316101	Yes
72-3	Silvr Salmon	unkn	----	>10[9]	----	090862	No
72-3	Striped Bass	35.3	122.4	43.2	43.2	00028002	No

For hazard assessment, these data indicate that diquat dibromide ranges in toxicity to estuarine species from slightly to highly toxic. Data requirements for estuarine species are fulfilled.

e. Effects to Non-Target Insects (Beneficial Insects)

In order to establish the toxicity to insects, an acute oral toxicity test to honey bees is required using the technical grade material.

Two study was evaluated under this topic. The acceptable toxicity studies for use in a hazard assessment are listed below:

Guide line	Species	% ai	Tox value in Cation	MRID No.	Fulfills Guideline Requirements
141-1	Honey Bee	99.6	LD_{50}=100 µg/bee	072012	Yes
141-1	Honey Bee		LD_{50}=47 µg/bee[10]	40208001	Yes

For hazard assessment, these data indicate that diquat dibromide is practically non-toxic to bees. Data requirements for non-target insects are fulfilled.

f. Effects to Non-Target Plants

Aquatic Plants

In order to establish the toxicity to aquatic plants, an aquatic plant growth study (123-2) comprising of *Selenastrum capricornutum, Lemna gibba, Skeletonema costatum, Anabaena flos-aquae,* and a freshwater diatom is required using the technical grade material.

Two aquatic plant studies were evaluated under this topic. In the table below, the diquat cation will be used for risk assessment purposes for plants since the availability and activity of diquat dibromide is as a cation with plants. The value in ppb cation is extrapolated from the test values whether it be in diquat formulation, cation, or active ingredient. The acceptable toxicity studies for use in a hazard assessment are listed below:

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[9] Value based on 24 hr exposure

[10] This was tested as "Reglone" with LD_{50}=171 µg/bee and as "Reglone + Agral" with an LD_{50}=66µg/bee for acute contact toxicity. This was also tested for oral acute with "Reglone" (LD_{50}=47 µg/bee) and "Reglone + Agral" (LD_{50}=35µg/bee). Agral is a liquid non-ionic wetting and spreading agent.

Guide line	Species	% ai	Tox value	MRID No.	Fulfills Requirements
122-2	see footnote		see footnote[11]	40165103,04,05	No
123-2	see below	35.3	see table below	41883002	No[12]

Most sensitive species	EC_{50} Foliar applied lb cation/A	Rootzone EC_{50} ppb cation
Giant Duckweed	0.0036	0.75
Waterhyacinth	0.0198	14.0
Azolla	0.0277	11.6
Hydrilla	N/A	9.9

See discussion on data requirements in section D page 20 for the need to have additional aquatic plant testing. There are currently outstanding data requirements for plants.

Terrestrial Plants

Three terrestrial plant studies were evaluated under this topic. In order to establish the toxicity to terrestrial plants, a germination, seedling emergence (123-1a) and vegetative vigor study (123-1b) is required. The acceptable toxicity studies for use in a hazard assessment are listed below:

Guide line	Species	% ai	EC25 Tox value	MRID No.	Fulfills Guideline Requirements
122-1(a)	10 species		>7.49 [13]	40165101	Yes[14]
122-1(b)	corn, wheat		see footnote[15]	40165102	No
123-1(b)	see below	35.3	see table below	41883001	No[16]

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[11] Several species of filamentous algae and aquatic vegetation were controlled by 0.25 cation ppm of diquat. Insufficient information was provided to assess the toxicity of these species. However, enough information was given to determine that Tier II testing should be requested with the species cited in subdivision J. These studies indicates that Tier II (123-2) is required to establish an EC_{50} value for *Lemna gibba, Skeletonema costatum, Anabaena flos-aquae, Selenastrum capricornutum,* and freshwater diatom.

[12] This study will satisfy the vascular plant requirements (*Lemna gibba*) because of a number of vascular plants used in a dose response study and an EC_{50} was determined. *Skeletonema costatum, Anabaena flos-aquae, Selenastrum capricornutum,* and a freshwater diatom needs to be tested to satisfy the requirements under 123-2 and for EEB to provide a complete risk assessment of diquat to non-target aquatic plants.

[13] Toxicity value cited is in pounds of active ingredient per acre

[14] This seed emergence study for tier I did not show affect to plants at 8.4 ai kg/ha or 7.49 lb ai/A. Therefore, Tier II for seed emergence and seed germination does not need to be done.

[15] Data provided on corn, sweet corn and wheat indicate that rates as low as 0.016 lb cation/A result in desiccation of certain plants. This would provide information to request testing at the Tier II level vegetative vigor.

[16] Only one grass species was tested. According to earlier study (40165102), sweet corn and wheat were found to be sensitive. Two more grass species should be tested to fulfill guidelines. Untreated seeds of wheat and sweet corn should be tested for tier II. If there are difficulties in finding untreated seeds of sweet corn or wheat, the treated seeds could be washed in

Sensitive species	vegetative vigor (cation)	lb/A
Cotton		0.00470
Soybean		0.00738
Corn		0.01064

See discussion on data requirements in section D on page 18 for the need to have additional terrestrial plant testing. There are currently outstanding data requirements for plants.

2. Ecological Effects Disciplinary Review Summation

a. Use Profile:

Sites: Diquat is a non-selective contact herbicide, desiccant, algicide, and defoliant registered for use in terrestrial non-crop and aquatic areas; as a desiccant for potatoes, carrots, cucumber, cantaloupe, watermelon, tomato, radish, turnip and seed crops of clover, sorghum, soybean. It is also used on residential, industrial and agricultural non-crop land for spot treatment of weeds. It is used on golf courses, turf, and ornamental for desiccation, spot treatment of weeds and pre-renovation. Diquat is used on lakes, ponds, irrigation ditches, reservoirs, rivers, streams, wetlands, shorelines, edging and irrigation systems for submerged, emerged and floating aquatic weed control. Diquat is injected in the water or applied to the surface of the water. Diquat can be applied by aerial or ground application and could be used up to two times a year if needed.

Quantitative Usage: Diquat was applied on 26% of all potato acreage in the US during 1992 (Agricultural Chemical Usage, 1992 Field Crop Summary published by USDA) This would amount to 101,000 pounds on potato. Some major potato production states have diquat applied to a large percentage of the potato crop (ME-93%, MI-53%, MN-43%, NY-43%, PA-70%, WI-71%).

Use Limitations: i) Do not use treated water for drinking or domestic purposes until 14 days after treatment.

ii) Do not graze on treated areas or feed foliage to livestock

iii) Do not use treated water for animal consumption within 14 days after treatment

iv) Do not treated water for spraying or irrigation within 14 days after treatment

v) Do not apply within 880 yards of potable water intake

vi) Do not apply through any type of irrigation system

vii) Do not apply in muddy waters for aquatic weed control

viii) For aquatic weed control, be careful not to stir sediment in water during application

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methanol to remove most of the treatment and then tested after drying.

Rates of application:

Use Site	Maximum Application Rate lb cation/A	Remarks
Lakes, ponds, reservoirs, agricultural drainage systems	4.0/A - 4.2/A ft	apply when needed via injection, and on water surface
Edging Treatment, Shoreline	2.16	apply when needed
Alfalfa, clover, carrot	0.5	apply for desiccation, seed crop seeding
Cucumber, tomato, Watermelon,	0.375	at post final harvest via ground sprayer
Cantaloupe	0.25	at post final harvest via ground sprayer
Pepper, Squash	0.5	at post final harvest via ground sprayer
Potato, Radish, Turnip	0.5	for desiccation at preharvest
Soybean, Sorghum	0.5	for seed crop
Turf, Golf Course, Ornamental,	0.8923	for desiccation, pre-renovation
Spot Treatment on Turf, Agricultural non-crop land, Industrial Sites, Rights-of Ways, Residences,	see footnote[17]	for weed control

b. **Environmental Fate and Exposure Profile**

i. Fate: The following data were gleaned from EFGWB:

Solubility of Diquat= 700,000 ppm in water at 25°C
KOC values for Diquat= 100,000 in soil.
Hydrolysis and Photolysis are stable at all pHs
Vapor Pressure= 1.0×10^{-7} Torr
Henry's Law= 6.47×10^{-14} Atm M3/Mol

Aerobic Soil Metabolism study half-life = stable
Anaerobic Soil Metabolism study half-life = stable
Soil Partition Coefficient (Kd) values for Diquat=15-42 in sandy soils and 1882-10,704 sandy loam to clay loam soils.

Terrestrial Field Dissipation studies show diquat does not degrade after 3 years.
Aquatic Dissipation study shows that diquat dissipates from the water column in Florida ponds with half-lives of 1-2 days.

Bioaccumulation is not significant in fish, daphnids, mayflies and oysters.

Although Diquat is very soluble, it binds strongly to soils. It is not likely to move in soil profile or to runoff unless the soil carries the diquat. There is no data that would suggest that diquat would breakdown. Therefore it is assume that diquat would be very persistent. However, the availability to aquatic organisms over a period of time is minimal since it is closely tied up

[17] Formulation is often in very diluted form, is directly targeted at weed species by hand sprayer and is not applied on an acreage basis.

in the sediment and not available in the water. Aquatic dissipation half-life is 1 to 2 days.

ii. Exposure and Risk

Terrestrial Exposure

Below are the expected residues (ppm) on vegetation immediately after one application of Diquat dibromide (based on Hoerger and Kenaga, 1972).

Plant category:.....	Range shortgrass	long grass	leaves, leafy crop	forage, sm insects	seed pods, lrg insects
Application Rate in **lb. cation per acre:**					
0.8923 (Turf, golf course and ornamental)					
Maximum residue	214	98	111	52	11
Typical residue	112	82	31	29	2.7
0.5 (Alfalfa, carrot, clover, peeper, squash, potato, radish, turnip, soybean, and sorghum)					
Maximum residue	120	55	63	29	6
Typical residue	63	46	18	17	1.5
0.375 (Cucumber and tomato)					
Maximum residue	90	41	47	22	5
Typical residue	47	35	13	12	1
0.25 (Cantaloupe)					
Maximum residue	60	28	31	15	3
Typical residue	31	23	9	8	1

The maximum expected residues (ppm) on vegetation immediately after one application of 0.89 lb ai/A (based on Hoerger and Kenaga, 1972) would be 214 ppm on short grass or range grass. This exposure is characteristic of turf where short grasses predominate. The aquatic weed control use has higher application rates, however, direct treatment of avian and mammalian food items is not expected.

RISK TO MAMMALS

According to HED's Tox Oneliner, the LD50 for rats was identified as 600 mg/kg for a formulation containing diquat dibromide. From that, an LD50 in mg diquat dibromide cation/kg was calculated to be 116[18]. From this LD50, 1-day LC50's can be derived for various small mammals, depending on their body weight and how much they tend to eat per day. Small herbivores may consume approximately 16% to 20% of their body weight per day. Insectivorous, on the other hand, may consume up to 100% of their body weight per day. The following table indicates the range of 1-day LC50's that the LD50 may represent.

	Body Weight	Food Consumed per day	1-day LC50
Herbivore	26 g	4.3 g (16%)	701 ppm cation
Insectivore	5 g	5.5 g (110%)	105 ppm cation

Formula: 1-day LC50= $\frac{\text{LD50 mg/kg X Weight of animal (g)}}{\text{food consumed in a day (g)}}$

The following acute **risk quotients** for mammals have been calculated assuming the above toxicological characteristics:

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[18] This takes into account that the formulation was 19.3% cation. Calculation: 600 X 0.193 = 116 mg cation/kg.

	RQ	LOC for High Acute Risk	LOC for Restricted Use	LOC for Endan Species
		0.5	0.2	0.1
Turf, ornamental				
Herbivores (short grass)	0.30			
Insectivorous (insects)	0.49			
Alfalfa, carrot, clover, pepper, squash, potato, radish, turnip, soybean, and sorghum.				
Herbivores (short grass)	0.17			
Herbivores (leafy crop)	0.09			
Insectivorous (insects)	0.28			
Cucumber, tomato				
Herbivores (short grass)	0.13			
Insectivorous (insects)	0.21			
Cantaloupe				
Herbivores (short grass)	0.08			
Insectivorous (insects)	0.14			

Chronic risk for mammals would be based on maximum and typical residues on small insects or leafy crops, except for the turf use, where short grasses would likely predominate. The 2-generation rat reproduction study showed the NOEL =80 ppm cation and the LOEL = 240 ppm cation.

	Chronic RQ from Maximum Residues (food item)	Chronic RQ from Typical Residues (food item)	LOC for Chronic Risk
			1.0
Turf, ornamental			
Herbivores (short grass)	2.7	1.4	
Insectivorous (insects)	0.6	0.4	
Alfalfa, carrot, clover, pepper, squash, potato, radish, turnip, soybean, and sorghum.			
Herbivores (short grass)*	1.5	0.8	
Herbivores (leafy crop)	0.8	0.2	
Insectivorous (insects)	0.4	0.2	
Cucumber, tomato			
Herbivores (short grass)	1.1	0.6	
Herbivores (leafy crop)	0.6	0.2	
Insectivorous (insects)	0.3	0.2	
Cantaloupe			
Herbivores (short grass)	0.7	0.4	
Herbivores (leafy crop)	0.4	0.1	
Insectivorous (insects)	0.2	0.1	

*It is recognized that there may be relatively few short grasses in alfalfa, clover, or soybean fields, or in some other vegetable growing fields.

Discussion of Acute Risk to Mammals

None of the acute risk quotients exceed the LOC for high acute risk. The LOC for restricted use is exceeded by all uses **except cantaloupe**. The LOC for endangered species has been exceeded by all use patterns and will be discussed in the endangered species section. Some additional factors influencing acute exposure are presented below, and reduce the certainty of the risk assessment conclusions.

1-Small herbivores such as mice actually feed on a variety of food items ranging from short grass to seeds and fruits. The residues on these other food items would be less, yielding lower risk quotients.

2-Small insectivorous feed on insects in a variety of habitats, not just those one the surface exposed to direct spray. Insects that were underground, or otherwise protected during spray may have lower residue levels, also yielding

lower risk quotients. Also, the estimated residues were for small insects. Large insects would have smaller residue levels.

3-The residues used in calculating the above risk quotients represented the maximum expected exposure levels. It should be noted that typical exposure levels would likely be less.

4-The entire risk assessment for mammals is based on one LD50 for laboratory rats. It is not known how sensitive wild mammals may be to diquat dibromide. If they are substantially more sensitive, they may be at greater risk than indicated by the risk quotients above.

5-The acute oral LD50 may not be the best indicator of actual toxicity of diquat dibromide as might occur when ingested as a dietary concentration. Diquat dibromide binds tightly to organic matter such as food items, and may not be as biologically available. Whereas, when intubated directly, as is done during the acute oral test, the test animal is more likely to receive the full impact of the test material.

6-The acute risk quotient for insecivores in turf and ornamental areas was 0.49, which is very close to equaling the LOC of 0.5.

Therefore, it is only with moderate certainty that EEB concludes that non-endangered mammals are **not at acute risk** from diquat dibromide. Based on risk to mammals, diquat dibromide does exceed the restricted use LOC for all uses except cantaloupe (application rate of 0.25 lb cation/acre).

Information that could reduce uncertainty in the acute risk assessment for mammals would be toxicity tests with wild mammals providing actual LC50 values. This testing is **not required** for risk assessment.

Discussion of Chronic Risk to Mammals

Using maximum and typical residues on food items for mammals, the risk quotients exceed the chronic LOC for turf and ornamental use only. However, other factors must be considered when considering the extent of risk and the probability that chronic risk will occur such as:

1- Diquat is very persistence in the environment with data from terrestrial Field Dissipation studies showing diquat does not degrade after 3 years.

2- However, small herbivores such as mice actually feed on a variety of food items ranging from short grass to seeds and fruits. These mammal species may move about, choosing a variety of food items, not just the food items with the maximum residues.

3- The RQ were derived using the NEL of 80 ppm cation. The LEL, where adverse effects were known to occur was at the extrapolated 240 ppm cation. It is not known at what concentration, between 80 and 240 ppm, adverse chronic effects may start to occur. Again, including the turf use, even maximum residues on food items did not exceed the 240 ppm.

4- Small insectivorous feed on insects in a variety of habitats, not just those who are on the surface exposed to direct spray. Insects that were underground, or otherwise protected during spray may have lower residue levels, also yielding lower risk quotients. Also, the estimated residues were for small insects. Large insects would have smaller residue levels.

These factors lead to a conclusion that while the possibility of chronic risk exists, the probability that it will occur may be relatively low. **The extent, or significance, of chronic impact to non-endangered mammals if it occurs, appears to be low.**

Overall Risk to Mammals

Considering it's use patterns, its environmental fate characteristics and toxicity, diquat dibromide represent a relatively low risk to mammals. Effects, if they occur should not result in significant ecological damage.

RISK TO BIRDS

Acute Risk to Birds

The acute dietary toxicity data available for birds shows LC50= 575 ppm ai for bobwhite. This is much higher than the highest exposure of 403 for short grass when diquat is applied to turf. The **risk quotient** derived by dividing the exposure (403 ppm) by the LC50 **is 0.37.** This does **not** exceed the LOC of 0.5, which, according to the new paradigm, if exceeded, indicates the potential for high acute risk. However, it **does exceed the LOC triggering restricted use (0.2), and indicates a "may affect" for endangered bird species (0.1).**

The following table provides an **acute risk quotient** for birds based on the maximum applied rates:

Use Site	RQ	High Risk LOC	Restricted LOC	Endangered LOC
Turf				
short grass	0.37	0.5	0.2	0.1
small insects	0.09			
Alfalfa, carrot, clover, pepper, squash, potato, radish, turnip, soybean, and sorghum.				
short grass	0.21			
leafy crop	0.11			
small insects	0.05			
Cucumber, tomato				
short grass	0.16			
leafy crop	0.08			
small insects	0.04			
Cantaloupe				
short grass	0.10			
leafy crop	0.05			
small insects	0.03			

The estimated residues on avian food items **does not result in risk that exceeds the LOC for high acute risk.** The LOC for restricted use has been exceeded for the turf use. Please see the endangered species section for further discussion concerning the LOC for endangered species.

Chronic Risk to Birds

The NOEL from the mallard reproduction study shows 5 ppm cation. Risk quotients from maximum exposure and typical exposure exceed the chronic LOC (1).

Use Site	Chronic RQ Maximum	Typical
Turf		
short grass	42.8	22.3
small insect	10	5.9
Alfalfa, carrot, clover, pepper, squash, potato, radish, turnip, soybean, and sorghum.		
short grass	24	12.6
leafy crop	12.5	9.1
small insect	5.9	3.3
Cucumber, tomato		
short grass	18	9.5
leafy crop	9.5	6.9
small insect	4	2.4
Cantaloupe		
short grass	12	6.3
leafy crop	6.3	4.6
small insect	3	1.7

Discussion of Chronic Risk to Birds

The avian reproductive study found the NOEL to be 5 ppm cation and LOEL to be 25 ppm cation. These findings were based on number of eggs laid, hatching and 14-day old survival. The risk quotients indicate a chronic risk among birds including endangered species. **Birds feeding on diquat-contaminated food items may experience reproductive problems.** It is recognized that in some field crops such as alfalfa, clover and soybean, there may be few short grasses, so residues on leafy crops and insects may be more representative of actual exposure.

BENEFICIAL INSECTS

For beneficial insects, it appears that there will be minimal adverse effects (LD_{50} 100 and 47 µg/bee) since it is practically non-toxic to honey bees.

AQUATIC RISK ASSESSMENT

Aquatic exposure

Refined EEC

The following are excerpts from EFGWB's 2-7-94 memo to Reregistration Branch: "An estimate of diquat runoff and its effect on surface water quality was evaluated using PRZM-EXAM models from a typical crop use on potatoes with data from a silt loam soil in Maine... This estimate is a worst case senario of the entire yearly application of 0.5 lb ai/A (cation ai/A) to highly eroded soil for 36 years. This assessment includes diquat adsorbed onto eroded soil particles as well as diquat in the runoff water." The Estimated Environmental Concentrations are 48.4 ppb cation (0.7934 lb cation/A) just after application and 43.6 ppb cation 90 days after application. Data from the Aquatic Dissipation study shows that diquat dissipates from the water column in Florida ponds with half-lives of 1-2 days. Since diquat bonds very tightly to organic matter and soil and the diquat is very stable (does not degrade), the diquat in the runoff would dissipate rapidly to the soil bottom and not be readily available to aquatic organisms.

Below is runoff as computed by EFGWB's PRZM-EXAM model showing annual average Environmental Exposure Concentration of diquat in Maine with 10% exceedance. The values are in cations ppb and the time period is that period after application.

Maximum	96 hour	21 days	60 days	90 days
48.4 ppb	47.8 ppb	45.1	45.3 ppb	43.6 ppb

Turf

Application on turf (0.8923 lb cation/A), is higher than the potato application mentioned above. However, the runoff is expected to be much less than the above described "worst case senario". Diquat binds very tightly to soil and organic matter and will not be dislodged to runoff. Soil in turf fields are tightly held in place by the fibrous root system of grasses. Therefore there is minimal soil runoff from turf fields and thereby minimal diquat runoff. The only exposure considered to be of significance from turf and ornamental use is that occurring from drift. it is assumed that 5% of that sprayed by air drifts to adjacent habitat. (0.8923 X 0.05 = 0.0446 lb cation loading per acre X 0.061 ppm = 0.003 ppm concentration in 6 feet of water).

Aquatic Weed Control

This assumes direct application to a water body 6 feet deep (4 lb cation per acre X 61 ppb=244 ppb)

Toxicity Values Used in Risk Quotient Calculation

Freshwater Fish	LC50=13.9 ppm cation (bluegill)
Estuarine Fish	LC50=48 ppm cation (sheepshead minnow)
Aquatic Invertebrate	EC50=0.77 ppm cation (*Daphnia magna*)
Estuarine Invertebrate	EC50=0.42 ppm cation (mysid shrimp)
Freshwater Fish	MATC=0.197 ppm cation (fathead minnow)
Aquatic Invertebrate	MATC=0.044 ppm cation (*Daphnia magna*)

Level's of Concern

	High Acute Risk	Risk triggering restricted use	Chronic Risk
LOC's	0.5	0.1	1

Acute Risk Quotient for Aquatic Organisms

Use Site	Use Rate Cation/acre	Method Appl.	Exposure (cation ppm)	----- Risk Quotients------- Fish	Aqu. Inv.	Est. Inv.
Terr. Crops	0.5	Ground	0.048	0.003	0.06	0.1
		Aerial	Drift less than from turf (below)			
Turf/Orn.	0.8923	Ground	Runoff minimal from this use site			
		Aerial	0.003	0.0002	0.0035	0.006
Aquatic Weed Control	4.0	Aerial	0.244	0.02	0.3	0.6

Chronic Risk Quotient for Aquatic Organisms

Use Site	Use Rate Cation/acre	Method Appl.	Exposure (cation ppm)	--Risk Quotients-------- Fish	Aqu. Invertebrates
Terr. Crops	0.5	Ground	0.048	0.24	1.1
Turf/Orn.	0.8923	Aerial	0.003	0.01	0.07
Aquatic Weed Control	4.0	Aerial	0.244	1.24	5.5

Discussion of Risk to Aquatic Organisms

This discussion will be focused on non-endangered aquatic species. For a discussion on endangered species, please refer to the endangered species section.

Except for the aquatic weed control use which involves direct application to water, the acute LOC for acute risk to aquatic and estuarine organisms has not been exceeded. The acute LOC for high risk is exceeded for **estuarine invertebrates** but not fish and freshwater invertebrates, from aquatic weed control. Diquat is unlikely to result in fish kills from any of its uses.

The LOC for restricted use (0.1 for acute risk) is exceeded for crops treated at 0.5 lb ai/acre, and for aquatic weed control.

The chronic LOC has been exceeded for fish (aquatic weed control) and invertebrates (both terrestrial crops and aquatic weed control). However, other factors must be considered when considering the extent of risk and the probability that chronic risk will occur such as:

1- According to EFGWB scientists, diquat dibromide binds very strongly to clay and organic matter in the soil (KOC=100,000 in soil). Diquat is not expected to be bioavailable to aquatic organisms once it is attached to plants or soil particles. Therefore, it may not be readily bioavailable to aquatic organisms as runoff from potato fields treated with diquat.

2- The aquatic dissipation study shows that diquat dissipates from the water column in Florida ponds with half-lives of 1-2 days. This amount of time is not sufficient for chronic exposure to take effect. The dissipation is believed to be caused by the bonding of the diquat to the soil and then settling down to the bottom of the pond or aquatic body. The label indicates that diquat should only be applied be clear water (not muddy) and under careful conditions as to not disturb the bottom sediments of the body of water.

3- The LC_{50} values of the aquatic organisms are from laboratory conditions, in which there are no soil particles or plant materials to bond. Therefore, the availability to aquatic organisms in the test system would be much higher than in an environmental setting where matter was availabe to "bind" with diquat dibromide.

These factors lead to a conclusion that while the possibility of acute or chronic risk exists, the **probability that it will occur is relatively low.** The extent, or significance, of risk to non-endangered aquatic organisms if it occurs, appears to be low.

PLANTS

Non-target aquatic Plants

Exposure

Exposure to aquatic plants may occur through either runoff from terrestrial sites, or drift from aerial application. Of course, aquatic plants are directly exposed from the aquatic weed control use. However, since they are the "target pest" for that use, risk from such exposure is not estimated. Only risk caused by spray drift from aerial treatment for aquatic weed control is assessed.

Runoff exposure is from the EFGWB refined EEC which yielded a concentration of 48.4 ppb in 2 meters of water resulting from runoff from a potatoe field treated with 0.5 lb ai/acre. See discussion above concerning this model.

Drift from aerial spray is assumed to be 5%. Exposure estimates follow:

Use Site	Application rate lb cation/acre	Exposure lb cation/acre
Turf	0.8923	0.04462
Crops	0.5	0.025
Crops	0.25	0.0125
Aquatic weed con.	4.0	0.2

Data from the aquatic plant studies show that the most sensitive vascular plant tested is giant duckweed (*Spirodela punctata*) with an EC_{50}= 0.75 ppb cation when applied at the rootzone and an EC_{50}= 0.0036 lb cation/A when applied at the foliar level. The EFED is unable to make a complete risk assessment of aquatic plants at this time since data on algae and diatoms are unavailable at this time. Based on available data, the following risk quotients were calculated.

Risk Quotient for Non-target Aquatic Vascular Plants

Use Site	Use Rate Cation/acre	Method Application	Exposure in ppb or (lb/acre)* cation	Risk Quotient
Terr. Crops	0.5	Ground	48.4	967
Terr. Crops	0.5	Aerial	(0.025)	6.9
	0.25	Aerial	(0.0125)	3.5
Turf/Orn.	0.8923	Aerial	(0.04462)	12.4
Aqu. weed Control	4	Aerial	(0.2)	55.6

*Normally, exposure to aquatic plants is always estimated in an aquatic concentration, since typical test endpoints for aquatic plants are reported as an aquatic concentration (i.e. ppb). In this case, however, the test endpoints for the giant duckweed included an EC50 in lb cation/acre representing exposure that could occur from spray drift settling on the plant foliage. Since this yields higher risk quotients than those that would have been calculated from an aquatic concentration in ppb, this is the exposure value that will be used for risk assessment. For example, if 0.025 lb/acre (drift from Terr. Crops treated at 0.5 lb cation per acre) settled on a water body 6 feet deep, the resulting concentration would be 1.5 ppb. The risk quotient from dividing 1.5 ppb by 0.75 ppb (EC50 for giant duckweed) = 2. This is lower than the risk quotient reported (6.9).

Disscussion of risk to aquatic plants: Using the aquatic environmental exposure concentrations, the risk quotient (967) exceeds the LOC for runoff from erodible potato fields in Maine, and drift from aerial application of turf/ornamentals fields, aerial application of potato, pepper, radish, turnip, sorghum, and

soybean fields and aerial application for aquatic weed control. However, other factors must be considered when characterizing risk to aquatic plants such as:

1- According to EFGWB scientists, diquat dibromide binds very strongly to clay and organic matter in the soil (KOC=100,000 in soil). Diquat is not expected to be bioavailable to aquatic plants once it is attached to soil particles. Therefore, it may not be readily bioavailable to aquatic plants as runoff from potato fields treated with diquat.

2- The aquatic dissipation study shows that diquat dissipates from the water column in Florida ponds with half-lives of 1-2 days. The dissipation is believed to be caused by the bonding of the diquat to the soil and then settling down to the bottom of the pond or aquatic body. The label indicates that diquat should only be applied be clear water (not muddy) and under careful conditions as to not disturb the bottom sediments of the body of water.

3- The EC_{50} values of the aquatic plants are from laboratory conditions, in which there are no soil particles to bond. Therefore, the availablity to aquatic plants would be much higher than in an environmental setting.

These factors lead to a conclusion that while the possibility of acute risk exists from runoff, the probability that it will occur is relatively low. However, **the possibility of risk to non-target aquatic plants from aerial application from all sites is relatively high.** The data also suggest that exposure from drift settling on the foliage of aquatic plants represents a greater hazard than if the drift settles on the water first before exposure to the plants occur. Elimination of aerial application can eliminate most of the risk to non-target aquatic plants.

Non-target Terrestrial Plants

Data from the seed germination and seedling emergence studies indicate that diquat is not expected to adversely affect terrestrial plants from runoff.

Vegetative vigor study did not have enough grass species tested and therefore complete data are not available to completely assess the risk to terrestrial plants. The available data do suggest that sweet corn and wheat may be sensitive to diquat; it is recommended that data from vegetative vigor tests on these species be obtained. See section D. Data Requirements section.

The available data do indicate that nearby non-target crops or non-target plants may be adversely affected from aerial drift applications from turf or aquatic weed control. Vegetative vigor testing with cotton (most sensitive species tested) yielded an EC_{25} of 0.0047 lb cation/A. The Risk Quotients for the various use sites are presented below. These risk quotients are compared with the LOC, which is 1 for both endangered and nonendangered plant species.

Aquatic Weed Control (Aerial)	Cantaloupe (Aerial)	Turf/ Ornamental (Aerial)	Crops treated at 0.5 lb cation/acre (Aerial)
42.5	2.7	9.5	5.3

Aerial application of diquat for crops treated at 0.5 lb cation/A, aquatic weed control, cantaloupe and turf/ornamental may result in risk that exceeds the level of concern for non-target terrestrial plants or crops.

The effects to terrestrial plants that are suggested by the LOC exceedances would occur in areas immediately adjacent to the treated site. It is not known exactly how far hazardous spray drift may move, but it would likely be no more than several hundred feet.

Endangered Species

The following table is a compilation of risk quotients for endangered species from previous risk assessments in this science chapter.

Organisms	Use Site	Acute Risk Quot.	Chronic Risk Quot.
The LOC for acute effects to birds and mammals is 0.1. The LOC for chronic effects is 1.			
Mammals	Turf,ornamental	0.49	2.7
	Alfalfa,clover, carrot, pepper, squash, potato, radish, turnip, soybean, sorghum	0.28	<1
	cucumber, tomato, watermelon	0.21	<1
	cantaloupe	0.14	<1
birds	Turf,ornamental	0.37	22.3
	Alfalfa,clover, carrot, pepper, squash, potato, radish, turnip, soybean, sorghum	0.21	12.6
	cucumber,tomato, watermelon	0.16	9.5
	cantaloupe	0.1	6.3
The acute LOC for acute effects to endangered aquatic organisms is 0.05. The LOC for chronic effects for endangered species is 1.			
fish	aquatic weed control	<0.05	1.24
aquatic invertebrates	Alfalfa,clover, carrot, pepper, squash, potato, radish, turnip, soybean, sorghum	<0.05	1.1
	aquatic weed control	0.3	5.5
estuarine	aquatic weed control	0.6	
	Alfalfa, clover, carrot, pepper, radish, potato, squash, turnip, soybean, sorghum	0.1	

Organisms	Use Site	Risk Quotient
The LOC for endangered plants is 1.		
Plants:		
aquatic	aerial application	
	turf/ornamentals	12.4
	cantaloupe	3.5
	aerial application for aquatic weed control	55.6

	crops treated at 0.5 lb/acre ground application	967
terrestrial	aerial application for aquatic weed control	42.5
	turf/ornamental	9.5
	crops (0.5 lb/acre)	5.3
	cantaloupe	2.7

Levels of Concern have been exceeded for endangered species of mammals and birds from all terrestrial use sites.

Levels of Concern have been exceeded for endangered species of aquatic invertebrates, estuarine species, and fish from the use of diquat for aquatic weed control. It is recognized that in places where aquatic weed control is done year after year, endangered species may have already been eliminated. This cannot be assumed, however. Furthermore, the possibility for may affect exists if diquat dibromide were to be applied in new (previously untreated) aquatic ecosystems.

Although Levels of Concern have been exceeded for endangered species of aquatic and estuarine invertebrates and aquatic plants by runoff exposure from fields of alfalfa, clover, carrot, pepper, radish, potato, squash, turnip, soybean, or sorghum for endangered species of aquatic organisms; there is a **high degree of uncertainty** that endangered species in these habitats may actually be affected **by runoff**. The risk quotient was based on exposure provided by EFGWB's EEC model based on erodible potato fields in Maine. However, other environmental fate data, which the model does not take into account, indicate that the diquat that moves with the water will actually become biologically unavailable quickly as it becomes tied up by soil and organic particles. This reduces, significantly, the possiblity of actue effects, and makes chronic exposure extremely unlikely. Therefore, it is unlikley, in spite of the relatively large risk quotient, that endangered aquatic organisms (fish, invertebrates or plants) would be affected from exposure due to runoff alone.

Endangered species of aquatic plants may be affected from drift coming from aerial application of all terrestrial use sites and from aerial application of aquatic weed control. Endangered species of aquatic plants in close proximity to aquatic weed control sites that use diquat may be affected.

Endangered species of terrestrial plants may be affected by drift from aquatic weed control or turf/ornamental use sites only.

Use restrictions to protect endangered species are being developed in the EFED Endangered Species Protection Program scheduled for completion next year.

C. Labelling

1. Manufacturing Use

The following statements must be on the label: "This pesticide is toxic to aquatic invertebrates. Do not discharge effluent containing this product into lakes, streams, ponds, estuaries, oceans, or public waters unless in accordance with the requirements of a National Pollutant Discharge Elimination System permit and the permitting authority has been notified in writing prior to discharge. Do not discharge effluent containing this product to sewer systems without previously notifying the local sewage treatment plant authority. For guidance, contact your State Water Board or Regional Office of the EPA."

2. End Use

a. For products that are for terrestrial non-food site, use this precautionary statement: "This pesticide is toxic to aquatic invertebrates. Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwater or rinsate."

For products that are for outdoor residential site, use this precautionary statement: "This pesticide is toxic to aquatic invertebrates. Do not apply directly to water."

b. Restricted Use: The criteria for restricted use have been exceeded for aquatic weed control and turf use sites. The risk is to bird and aquatic invertebrate species.

D. Data Requirements

For the most part, the EEB was able to assess risk to all organisms with a relatively high degree of confidence. The areas where confidence is not high is in effects to non-target plants (including endangered species).

1. Vegetative Vigor Plant Study (123-1b)

EEB recommends vegetative vigor plant testing (tier II) for the following reasons:

- Not enough grass species were tested. According to an earlier study (40165102), sweet corn and wheat were found to be sensitive. Two more grass species should be tested to fulfill Tier II testing guidelines. Untreated seeds of wheat and sweet corn should be tested.

- It is not clearly understood what the affects of diquat on grasses would be. Additional data on grasses would increase confidence of the risk assessment to plants and help in the evaluation of risk reduction measures. Endangered grass species may or may not be affected. This testing would help determine this.

2. Aquatic Plant Study (123-2)

EEB recommends aquatic plant testing (tier II) for the following reasons:

- Only vascular aquatic plants were tested and therefore only the vascular plant requirements (*Lemna gibba*) was satisfied. An EC_{50} was determined for different species of vascular plants in a dose response study. No unicellular plants (algae and diatoms) were tested. *Skeletonema costatum, Anabaena flos-aquae, Selenastrum capricornutum,* and a freshwater diatom needs to be tested to satisfy the requirements under 123-2 and for EEB to provide a complete risk assessment of diquat to non-target aquatic plants.

- It is not clearly understood what the affects of diquat on algae or diatoms would be. Additional data on these species of plants would increase confidence on the risk assessment to plants and help our understanding of ecosystem affects.

For additional information pertaining to data requirements, please see enclosed data requirement table.

Date:08/15/94
Case No:818767
Chemical No:032201

DIQUAT DIBROMIDE
DATA REQUIREMENTS FOR
ECOLOGICAL EFFECTS BRANCH

Data Requirements	Composition[1]	Use Pattern[2]	Does EPA Have Data To Satisfy This Requirement? (Yes, No)	Bibliographic Citation	Must Additional Data Be Submitted under FIFRA3(c)(2)(B)?
6 Basic Studies in Bold					
71-1(a) Acute Avian Oral, Quail/Duck	(TGAI)	A,B,C,E	Yes	00106559	No
71-1(b) Acute Avian Oral, Quail/Duck	(TEP)		No		No
71-2(a) Acute Avian Diet, Quail	(TGAI)	A,B,C,E	Yes	0034769	No
71-2(b) Acute Avian Diet, Duck	(TGAI)	A,B,C,E	Yes	0034769	No
71-3 Wild Mammal Toxicity			No		No
71-4(a) Avian Reproduction Quail	(TGAI)	A,B,C,E	Yes	00119988	No
71-4(b) Avian Reproduction Duck	(TGAI)	A,B,C,E	Yes	00114230	No
71-5(a) Simulated Terrestrial Field Study			No		No
71-5(b) Actual Terrestrial Field Study			No		No
72-1(a) Acute Fish Toxicity Bluegill	(TGAI)	A,B,C,E	No		No[3]
72-1(b) Acute Fish Toxicity Bluegill	(TEP)	A,B.C,E	Yes	00138962,00003503	No
72-1(c) Acute Fish Toxicity Rainbow Trout	(TGAI)	A,B,C,E	No		No[3]
72-1(d) Acute Fish Toxicity Rainbow Trout	(TEP)	A,B,C,E	Yes	00003503,00138961	No
72-1(e) Acute Fish Toxicity Fathead Minnow	(TGAI)		No		No
72-2(a) Acute Aquatic Invertebrate Toxicity	(TGAI)	A,B,C,E	Yes	235179,00115576	No
72-2(b) Acute Aquatic Invertebrate Toxicity	(TEP)		No		No
72-3(a) Acute Estu/Mari Tox Fish	(TGAI)	A,B,C,E	Yes	40316101	No
72-3(b) Acute Estu/Mari Tox Mollusk	(TGAI)	A,B,C,E	Yes	40316001	No
72-3(c) Acute Estu.Mari Tox Shrimp	(TGAI)	A,B,C,E	Yes	40315701	No

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Date:08/15/94
Case No:818767
Chemical No:032201

DIQUAT DIBROMIDE
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Data Requirements	Composition[1]	Use Pattern[2]	Does EPA Have Data To Satisfy This Requirement? (Yes, No)	Bibliographic Citation	Must Additional Data Be Submitted under FIFRA3(c)(2)(B)?
72-3(d) Acute Estu/Mari Tox Fish	(TEP)		No		No
72-3(e) Acute Estu/Mari Tox Mollusk	(TEP)		No		No
72-3(f) Acute Estu/Mari Tox Shrimp	(TEP)		No		No
72-4(a) Early Life-Stage Fish	(TGAI)	A,B,C,E	Yes	40380703	No
72-4(b) Live-Cycle Aquatic Invertebrate	(TGAI)	A,B,C,E	Yes	40380702	No
72-5 Life-Cycle Fish	(TGAI)		No		No
72-6 Aquatic Org. Accumulation	(TEP)		No		No
72-7(a) Simulated Aquatic Field Study	(TEP)		No		No
72-7(b) Actual Aquatic Field Study	(TEP)		No		No
122-1(a) Seed Germ./Seedling Emerg.	(TGAI)	A,B,C,E	Yes	40165101	No[4]
122-1(b) Vegetative Vigor	(TGAI)	A,B,C,E	No	40165102	No[5]
122-2 Aquatic Plant Growth	(TGAI)	A,B,C,E	No	40165103,40165104,40165105	No[6]
123-1(a) Seed Germ./Seedling Emerg.	(TGAI)		No		No
123-1(b) Vegetative Vigor	(TGAI)	A,B,C,E	No	41883001	Yes[7]
123-2 Aquatic Plant Growth	(TGAI)	A,B,C,E	No	41883002	Yes[8]
124-1 Terrestrial Field Study	(TEP)		No		No
124-2 Aquatic Field Study	(TEP)		No		No
141-1 Honey Bee Acute Contact	(TGAI)	A,B,C,E	Yes	072012,40208001	No
141-2 Honey Bee Residue on Foliage	(TEP)	A,B,C,E	No		No[9]
141-5 Field Test for Pollinators	(TEP)	A,B,C,E	No		No[9]

.Composition: TGAI = Technical grade of the active ingredient; P = Pure active ingre · fiolabeled; TEP = Typical end-use product

.Use Patterns: A = Terrestrial Food Crop; B = Terrestrial Feed Crop; C = Terrestrial Non-Fo ·) = Aquatic Food Crop; E = Aquatic Non-Food Outdoor; F = Aquatic Non-Food Industrial; G = Aquatic Non-Food Residential; H = Greenhouse Food Crop; I · nouse Non-Food Crop; J = Forestry; K = Outdoor Residential; L = Indoor Food; M = Indoor Non-Food; N = Indoor Medical; O = Indoor Residential; Z = Use Group for Site 00000

3. Other data from TEP will suffice for TGAI on trout a·

4. This seed emergence st · did · 8.4 ai kg/ha or 7.49 lb ai/A. Therefore, Tier II for seed em · germ. to be done.

5. Data provided on corn, sweet corn and wheat indicate that rates as low as 0.016 lb cation/A result in desiccation of certain plants. This would provide information to request testing at the Tier II level vegetative vigor.

6. Several species of filamentous algae and aquatic vegetation were controlled by 0.25 cation ppm of diquat. Insufficient information was provided to assess the toxicity of these species. However, enough information was given to determine that Tier II testing should be requested with the species cited in subdivision J. These studies indicates that Tier II (123-2) is required to establish an EC_{50} value for *Lemna gibba, Skeletonema costatum, Anabaena flos-aquae, Selenastrum capricornutum,* and freshwater diatom.

7. Not enough grass species were tested. According to earlier study (40165102), sweet corn and wheat were found to be sensitive. Two more grass species should be tested to fulfill guidelines. Untreated seeds of wheat and sweet corn should be tested for tier II. If there are difficulties in finding untreated seeds of sweet corn or wheat, the treated seeds could be washed in methanol to remove most of the treatment and then tested after drying.

8. This study will satisfy the vascular plant requirements (*Lemna gibba*) because of a number of vascular plants used in a dose response study and an EC_{50} was determined. *Skeletonema costatum, Anabaena flos-aquae, Selenastrum capricornutum,* and a freshwater diatom needs to be tested to satisfy the requirements under 123-2 and for EEB to provide a complete risk assessment of diquat to non-target aquatic plants.

9. Data from the acute contact study show low toxicity, no further testing is required.

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