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

OPP OFFICIAL RECORD
HEALTH EFFECTS DIVISION
SCIENTIFIC DATA REVIEWS
EPA SERIES 361

OFFICE OF PREVENTI
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September 27, 20

MEMORANDUM

SUBJECT: OCCUPATIONAL AND RESIDENTIAL EXPOSURE ASSESSMENT AND RECOMMENDATIONS FOR THE REREGISTRATION ELIGIBILITY DECISION DOCUMENT FOR MSMA and DSMA.

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Please find the review of MSMA and DSMA.

DP Barcode: D265869

Pesticide Chemical Codes: 013802 (DSMA) and 013803 (MSMA)

EPA Reg Numbers: 4-335, 538-10, 1001-14, 2217-229, 2217-434, 2290-35, 5481-227
7401-130, 7679-22, 8660-48, 9779-128, 9779-174, 19713-45, 19
113, 19713-276, 34704-112, 34704-113, 42519-6, 42519-7, 4251
42519-16, 50534-15, 50534-27, 50534-38, 50534-39, 50534-42,
50534-46, 50534-52, 50534-158, 50534-186, 63239-4, 63239-14,
63239-16, and 63239-17 (DSMA). 538-178, 769-635, 769-636,
637, 769-705, 1386-643, 1386-644, 1386-645, 2217-512, 2217-5
2217-630, 2217-709, 2217-797, 2217-808, 2217-815, 2935-463,
5481-228, 5481-229, 5481-230, 5481-231, 5887-172, 5905-66, 5
67, 5905-162, 5905-164, 7401-7, 7401-23, 7401-31, 7401-45, 74

168, 7401-183, 7401-185, 7401-194, 7401-196, 7401-198, 7401-240, 7401-246, 7401-263, 7401-332, 7401-358, 7401-366, 7679-19, 8660-86, 8660-120, 8660-121, 9779-84, 9779-86, 9779-96, 9779-133, 9779-155, 9779-170, 9779-317, 9779-319, 10088-74, 10159-3, 10827-39, 11474-3, 11474-4, 17545-5, 19713-40, 19713-41, 19713-42, 19713-151, 19713-153, 19713-162, 19713-267, 19713-278, 34704-111, 34704-115, 34704-764, 42519-1, 42519-3, 42519-9, 42519-12, 42750-28, 42750-29, 50534-2, 50534-2, 50534-5, 50534-6, 50534-16, 50534-18, 50534-31, 50534-36, 50534-37, 50534-41, 50534-43, 50534-44, 50534-45, 50534-47, 50534-48, 50534-49, 50534-50, 50534-51, 50534-53, 50534-54, 50534-105, 50534-212, 62719-339, 62719-340, 62719-343, 63239-1, 63239-2, 63239-13, 66222-29, 72155-1, and 72155-3 (MSMA).

EPA MRID Numbers: 44958901, 43720501, and 43720401

PHED: Yes, Version 1.1

OCCUPATIONAL AND RESIDENTIAL EXPOSURE/RISK ASSESSMENT AND CHARACTERIZATION

Executive Summary

Monosodium methanearsonate (MSMA) and disodium methanearsonate (DSMA) are organic arsenical herbicides registered for weed control on cotton, under trees, vines and shrubs, and for lawn care. At this time, products containing MSMA and DSMA are intended for both occupational and residential uses. The same toxicity endpoints were selected for both monosodium methanearsonate (MSMA) and disodium methanearsonate (DSMA). This was done because, when MSMA and DSMA are dissolved in water, the sodium ions disassociate and do not participate in the reaction. Once the sodium ions have disassociated, both MSMA and DSMA become methanearsonic acid. Since both compounds become methanearsonic acid in solution, individual studies for each compound are not necessary. The Agency has previously accepted toxicity studies performed with methanearsonic acid for MSMA and DSMA registration. All endpoints selected by the HIARC for methanearsonic are applicable to both MSMA and DSMA. The MSMA technical is 59 percent active ingredient and is formulated as a granular (2.34 percent active ingredient), an emulsifiable concentrate liquid (16.6 to 58 percent active ingredient), a ready-to-use solution (0.36 to 47.8 percent active ingredient), a dry flowable (55 percent active ingredient) and a soluble concentrate liquid (11.6 to 59.0 percent active ingredient). MSMA is also formulated with cacodylic acid, fluometuron, diuron and prometryn. DSMA formulation intermediate is 81 percent active ingredient and is formulated as a granular (2.9 to 4.75 percent active ingredient), an emulsifiable concentrate liquid (21.8 percent active ingredient), a wettable powder (63 to 81 percent active ingredient) and a soluble concentrate liquid (12.5 to 36.9 percent active ingredient). MSMA and DSMA are applied using the following equipment: aircraft, groundboom, rights-of-way sprayer, turf handgun sprayer, high and low pressure handwand, Hypo-Hatchet injector, belly grinder, push-type spreader, backpack sprayer, and sprinkler can. Application rates range from 1.87 lbs ai/acre to 7.56 lbs ai/acre.

HED has determined that there are potential exposures to mixer, loader, applicator and other handlers during the usual use-patterns associated with MSMA/DSMA. Based on the use patterns, 26 major occupational exposure scenarios were identified for MSMA/DSMA: (1a) mixing/loading liquids for aerial application; (1b) mixing/loading liquids for ground application; (1c) mixing/loading liquids for rights-of-way application; (1d) mixing/loading liquids for turf handgun sprayer; (1e) mixing/loading liquids for a high pressure handwand; (2a) mixing/loading wettable powders for aerial application; (2b) mixing/loading wettable powders for ground application; (2c) mixing/loading wettable powders for rights-of-way application; (2d) mixing/loading wettable powders for turf handgun sprayer; (2e) mixing/loading wettable powders for a high pressure handwand; (3a) mixing/loading dry flowable for aerial application; (3b) mixing/loading dry flowable for ground application; (3c) mixing/loading dry flowable for rights-of-way application; (3d) mixing/loading dry flowable for turf handgun sprayer; (3e) mixing/loading dry flowable for a high pressure handwand; (4) applying liquids with

groundboom sprayer; (5) applying sprays with aerial equipment; (6) applying sprays with a turf handgun sprayer; (7) applying sprays with rights-of-way sprayer; (8) applying sprays with a high pressure handwand; (9) mixing/loading/applying liquids with low pressure hand wand; (10) mixing/loading/applying wettable powders with low pressure hand wand; (11) mixing/ loading/applying liquids with back pack sprayer; (12) loading/applying granulars with push-type spreader; (13) loading/applying granulars with a bellygrinder; and (14) flagging sprays for aerial application. MSMA/DSMA label prohibit application by chemigation.

Calculations of non-cancer risk based on dermal and inhalation exposure indicate that the dermal and inhalation margins of exposure (MOEs) are **more than 100** with maximum risk reduction measures for all of the short and intermediate term occupational exposure scenarios listed.

HED has determined that there are potential exposures to post-application workers during usual use-patterns associated with MSMA/DSMA. The following activities were assessed for post-application exposure: mowing/maintaining golf course turfgrass, hand and mechanical harvesting, hand weeding and transplanting of sod, and irrigating, scouting, and hand harvesting cotton. For all assessed post-application exposures, the target MOE is reached on the day of application, after sprays have dried (12 hours after application). MSMA and DSMA are also used under trees, vines and shrubs. Occupational post-application exposures resulting from this type of application are assumed to be less than the exposures from the assessed post-application exposure scenarios.

HED has determined that there are potential exposure to residential mixer, loader, and applicators during the usual use-patterns associated with MSMA/DSMA. Based on the use patterns, 6 major residential exposures were identified for MSMA/DSMA: (1) mixing/loading/ applying liquids with a low pressure hand wand; (2) mixing/ loading/applying liquids with a back pack sprayer; (3) mixing/loading/applying liquids with a sprinkler can or ready-to-use liquid, (4) loading/applying granulars with a belly grinder, (5) loading/applying granulars with a push-type spreader, and (6) applying granular with hand/spoon. Hose-end sprayer use is prohibited on MSMA and DSMA labels.

For residential handlers, calculations of non-cancer risk based on dermal and inhalation exposure indicate that the dermal and inhalation MOEs are **more than 100** for all of the short-term occupational exposure scenarios listed.

The following residential post-application scenarios were identified: dermal exposure from residue on lawns (adult and toddler), hand-to-mouth transfer of residues on lawns (toddler), ingestion of pesticide residue on treated grass (toddler), ingestion of pesticide granulars in treated areas (toddler), incidental ingestion of soil from pesticide-treated residential areas (toddler), dermal exposure from residue on golf course turfgrass (adult and child). For non-cancer residential post-application risks, the following scenarios were a risk of concern (MOE <300) : hand-to-mouth transfer (toddler), and granular ingestion (toddler).

BACKGROUND

Purpose

In this document, which is for use in EPA's development of the MSMA/DSMA Reregistration Eligibility Decision Document (RED), EPA presents the results of its review of the potential human health effects of occupational and residential exposure to monosodium methanearsonate (MSMA) and disodium methanearsonate (DSMA).

Criteria for Conducting Exposure Assessments

An occupational and/or residential exposure assessment is required for an active ingredient if (1) certain toxicological criteria are triggered and (2) there is potential exposure to handlers (mixers, loaders, applicators, etc.) during use or to persons entering treated sites after application is complete. For MSMA and DSMA, both criterion are met.

Summary of Toxicity Concerns Relating to Occupational and Residential Exposures

The same toxicity endpoints were selected for both monosodium methanearsonate (MSMA) and disodium methanearsonate (DSMA). This was done because, when MSMA and DSMA are dissolved in water, the sodium ions disassociate and do not participate in the reaction. Once the sodium ions have disassociated, both MSMA and DSMA become methanearsonic acid. Since both compounds become methanearsonic acid in solution, individual studies for each compound are not necessary. The Agency has previously accepted toxicity studies performed with methanearsonic acid for MSMA and DSMA registration. All endpoints selected by the HIARC for methanearsonic are applicable to both MSMA and DSMA.

Acute Toxicology Categories

Table 1 and 2 present the acute toxicity categories as outlined in the *MSMA and DSMA* - Report of the Hazard Identification Assessment Review Committee (HIARC).[1]

Table 1. Acute Toxicity Categories for MSMA (37-38% a.i.)

Study Type	Toxicity Category
Acute Oral Toxicity	II
Acute Dermal Toxicity	III
Acute Inhalation Toxicity	III
Primary Eye Irritation	III
Primary Dermal Irritation	III
Dermal Sensitization	not a sensitizer

Table 2. Acute Toxicity Categories for DSMA (technical 81-83% ai)

Study Type	Toxicity Category
Acute Oral Toxicity	III
Acute Dermal Toxicity	III
Acute Inhalation Toxicity	IV
Primary Eye Irritation	III
Primary Dermal Irritation	IV
Dermal Sensitization	not a sensitizer

Non-Cancer Endpoints of Concern

The HIARC memo, dated July 26, 2000, indicates that there are toxicological endpoints of concern for MSMA and DSMA.[1] The endpoints, and associated uncertainty factors used in assessing the risks for MSMA and DSMA are presented in Table 3.[1]

Table 3. MSMA and DSMA Hazard Endpoints and Uncertainty Factors.

Route / Duration	NOAEL (mg/ kg/day)	Effect	Study	Uncertainty Factors[b]	Comments
Incidental Oral Exposure	2	body weight gain in females and clinical signs (severe diarrhea, vomiting, and excessive salivation) in both sexes.	Chronic oral toxicity study in dogs.	Interspecies: 10x Intraspecies: 10x FQPA: 3x	needed for toddler post-application oral exposure
Short-and intermediate term Dermal (1-7 days and one week to several months)	1000	No systemic toxicity was observed at the limit dose of 1000 mg/kg/day. No dermal irritation was observed at 1000 mg/kg/day.	21-day dermal toxicity study in rabbits.	Interspecies: 10x Intraspecies: 10x FQPA: 3x	
Short- and Intermediate-Term Inhalation (1-7 days and one week to several months)	4.38 (0.010 mg/L)[a]	Presence of moderate and marked intracytoplasmic eosinophilic granules (IEG) in the cells of the nasal turbinates observed at the LOAEL of 0.034 mg/L/day.	90 day inhalation study in rats.	Interspecies: 10x Intraspecies: 10x FQPA: 3x	Sprague-Dawley Rats, 6 hours/day, 100 percent lung absorption assumed

Footnote

a 0.0.10 mg/m^3 was converted to 4.38 mg/kg/day by the following formula: NOAEL (mg/kg/day) = NOAEL (mg/m^3) * Sprague-Dawley Rat Respiratory Volume for Males and Females (10.26 L/hr) * Body Weight of Sprague-Dawley Rats for Males and Females (1/0.236 kg) * Exposure Duration per day (6 hrs/day) * Absorption (100%) * (5 days/week)/(7days/week). This was then adjusted for the use of a 33.3% formulation, instead of a 100% technical, to be 4.38 mg/kg/day.

b FQPA safety factor is used only for residential/non-occupational populations.

FQPA Safety Factor

The FQPA Safety Factor Committee memo dates August 3, 2000 recommended that an FQPA safety factor be maintained for MSMA/DSMA since there are data gaps for acute and subchronic neurotoxicity studies in mice (the requirement of a developmental neurotoxicity study is "reserved"). The Committee concluded that the safety factor could be reduced to 3x for MSMA/DSMA because there is no quantitative or qualitative evidence of increased susceptibility following *in utero* exposure to rats and rabbits and/or following pre-/postnatal exposure to rats. The FQPA safety factor for MSMA is applicable to all population subgroups for acute and chronic dietary assessments and residential exposures assessments of all duration since there are data gaps for acute and subchronic neurotoxicity studies in mice. Additionally, the requirement for a developmental neurotoxicity (DNT) study is "reserved" pending receipt of the neurotoxicity studies with MSMA (as well as the DNT with cacodylic acid). These studies will characterize the potential for neurotoxicity and may provide data that could be used in the toxicology endpoint selection for dietary and non-dietary risk assessments.[2]

Cancer Determination

The Hazard Identification Assessment Review Committee (HIARC) classified MSMA as "not likely" a human carcinogen.[1] Although the parathyroid adenomas described above in rats were outside of the historical controls (0.1% for both sexes), the tumors are not a concern because of the following rationale:

1) Only the benign tumors were increased in incidence.
2) Pair wise significance was not attained for either sex. A significant trend test was observed only for males.
3) An increase in tumor incidence was not observed in mice.
4) The acceptable genetic toxicology studies indicate that MSMA is not mutagenic in bacteria (*Salmonella typhimurium*) or cultured mammalian cells (Chinese hamster ovary). Similarly, MSMA did not induce unscheduled DNA synthesis (UDS) in primary rat hepatocytes.[1]

Metabolite of Concern

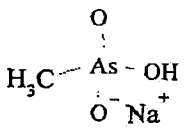
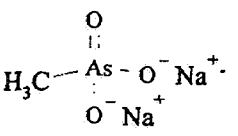
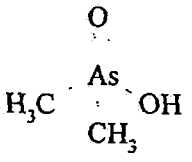
It has been shown in environmental fate studies that MSMA/DSMA are stable under all tested conditions but can be converted into cacodylic acid, a metabolite of concern, after application via microbial or plant metabolism. For MSMA/DSMA to be converted to cacodylic acid, a methyl group (CH_3) must be added to the methanearsonic acid molecule (see structures in figure 1 below). This reaction does not happen spontaneously. That is, MSMA/DSMA do not degrade under the influence of abiotic (sterile) chemical or photochemical processes in soil or water.

The magnitude of the residue studies also demonstrate that MSMA/DSMA need to be metabolized in order to convert to cacodylic acid. For instance, in the MSMA/DSMA magnitude

of the residue in citrus studies, where MSMA/DSMA are not directly applied to the tree, there were no detectable residues of MSMA or DSMA in the fruit; however, there were detectable residues of cacodylic acid.[3,4] Conversely, when directly applied to cotton, the magnitude of the residue in cotton studies exhibit no detectable residues of cacodylic acid, but detectable residues of MSMA/DSMA.[5,6]

Post-application exposures are only to surface residues where it is unlikely that cacodylic acid will be present based on the weight of the evidence that the Agency has at this time. Therefore, a post-application assessment was not conducted for cacodylic acid. A post-application dislodgeable residue decline study on plants and turfgrass is requested to confirm these conclusions.

Figure 1. Organic Arsenical Acid Structures

		
MSMA (Monosodium salt of MAA)	DSMA (Disodium salt of MAA)	Cacodylic acid

Summary of Use Pattern and Formulations

Occupational-Use and Homeowner-Use Products

At this time, products containing MSMA and DSMA are intended for both occupational and residential uses. Both MSMA and DSMA are organic arsenical herbicides registered for weed control on cotton, under trees, vines, and shrubs and for lawn care. The MAA (Methanearsonic Acid) Task Force, consisting of the primary registrants for MSMA and DSMA which are Luxembourg-Pamol, Inc., Zeneca Agricultural Products/GP Biosciences, Drexel/APC Holdings and Albaugh Inc. (MSMA only), was formed to support re-registration of MSMA and DSMA. There are 27 end use product registrants.

Type of Pesticide/Targeted Pest

MSMA and DSMA are selective herbicides used in commercial/residential settings for pre- and post-emergent weed control of annual grasses and broadleaf weeds, which include (but, are not limited to) the following:[7,8,9]

- **Grasses**: Bahiagrass, Barnyard grass, Brachiaria, Carpetgrass, Centipedegrass , Crabgrass, Crowfootgrass, Dallisgrass, Foxtail, Goosegrass, Guineagrass,

Johnsongrass, Lemongrass, Lovegrass, Nutgrass, Nutsedge, Panicum, Paspalum, Peppergrass, Ryegrass, Saint Augustine grass, Sandbur, Sedge, Signalgrass, Watergrass, Wild Oats, and Witchgrass.

- **Weeds**: Aster, Bedstraw, Beggarweed, Bindweed, Blackgum, Black Medic, Bullnettle, Burclover, Burdock, Buttonweed, Carpetweed, Carelessweed, Chickweed, Chicory, Clover, Cocklebur, Coffeeweed, Dandeloins, Dayflower, Dock, Fiddleneck, Goathead, Gooseberry, Groundcherry, Hairy Beggarticks, Healall, Henbit, Ironweed, Ivy, Jimsonweed, Knotweed, Lambsquarters, Lespedeza, Mallow, Malva, Morning Glory, Mustard, Pigweed, Plantain, Posion Ivy, Posion Oak, Puncture Vine, Oxalis, Punturevine, Purslane, Pusley, Ragweed, Sesbania, Shepherdspurse, Sicklepod, Sida, Smartweed, Sourwood, Speedwell, Spurge, Teaweed, Tules, Tumbleweed, Velvetleaf, Wild Carrot, Wild Garlic, Wild Lettuce, Wild Onion, Wood Sorrel, Yarrow.

- **Trees:** (MSMA only) Cedar, Conifers, Fir, Hemlock, Hickory, Maple, Oak, Pine, Sumac, and Sweet Gum.

Formulation Types and Percent Active Ingredient

MSMA technical is 59 percent active ingredient (ai) and is formulated as a granular (2.34 percent active ingredient), an emulsifiable concentrate liquid (16.6 to 58 percent active ingredient), a ready-to-use solution (0.36 to 47.8 percent active ingredient), a dry flowable (55 percent active ingredient) and a soluble concentrate liquid (11.6 to 59.0 percent active ingredient). MSMA is also formulated with cacodylic acid, fluometuron, and prometryn.[7]

DSMA formulation intermediate is 81 percent active ingredient and is formulated as a granular (2.9 to 4.75 percent active ingredient), an emulsifiable concentrate liquid (21.8 percent active ingredient), a wettable powder (63 to 81 percent active ingredient) and a soluble concentrate liquid (12.5 to 36.9 percent active ingredient).[7]

Registered Use Sites

Occupational-Use Sites

- **Agricultural Crops:** cotton, bearing and non-bearing citrus trees (grapefruit, lemons, limes, oranges, and tangerines), non-bearing fruit and nut trees (almonds, pecans, walnuts, apples, pears, apricots, cherries, peaches, plums), and non-bearing grape vines.

- **Forestry:** (MSMA only) Cedar, Conifers, Fir, Hemlock, Hickory, Maple, Oak, Pine, Sumac, and Sweet Gum.

- **Ornamentals:** trees, shrubs, and plants.

- **Turf** (including residential lawns, parks, athletic fields, sod farms, and golf courses).

- **Non-Crop Areas:** drainage systems, vacant lots, storage areas, recreational areas, around buildings, fences, walls, flower beds, and gardens, railroad, highway and utility rights-of-way, pre-paving areas, parking lots, brick and gravel walks, patios, curbs, gutters, industrial sites, sidewalks, and driveways.

Residential/Non-occupational Use Sites Include:

- **Ornamentals:** trees, shrubs, and plants.

- **Turf** (including residential lawns, parks, athletic fields and golf courses).

- **Non-Crop Areas:** around buildings, fences, walls, flower beds, and gardens, brick and gravel walks, patios, curbs, gutters, sidewalks, and driveways.

Application Rates[7,8,9]

The crop groupings with their corresponding range of application rates are as follows (WP is wettable powder, L is liquid (emulsifiable concentrate or soluble concentrate), DF is dry flowable, and G is granular):

- **Cotton:** The maximum application rates for MSMA are 3 lbs ai/acre (L) and 1.87 lbs ai/acre (DF). The maximum application rates for DSMA are 3.6 lbs ai/acre (L) and 2.3 lbs ai/acre (WP).

- **Weeds or Undesirable Grass Control (occupational):** Maximum application rates for MSMA are 4.1 lbs ai/acre or 0.08 lbs ai/gallon spray (L) and 4.7 lbs ai/acre or 0.05 lbs ai/gallon spray (DF) on non-bearing vines, fruit and nut trees, 4.1 lbs ai/acre or 0.08 lbs ai/gallon spray (L) on bearing citrus trees, 6 lbs ai/acre (L) on grasses grown for seed, and 4.1 lbs ai/acre or 0.094 lbs ai/gallon spray (L) and 2.2 lbs ai/acre or 0.01 lbs ai/gallon spray (WP) or 2.65 lbs ai/acre (G) on turf. Maximum application rates for DSMA are 6.3 lbs ai/acre or 0.063 lbs ai/gallon spray on non-bearing vines, fruit and nut trees and 4.5 lbs ai/acre or 0.045 lbs ai/gallon spray for bearing citrus trees(L) and 2.3 lbs ai/acre or 0.049 lbs ai/gallon spray (WP) on non-bearing vines, fruit and nut trees and bearing citrus trees and 6.1 lbs ai/acre or 0.056 lbs ai/gallon spray (L) and 7.56 lbs ai/acre or 0.076 lbs ai/gallon spray (WP) or 3.9 lbs ai/acre (G) on turf. The application equipment for these uses are: low pressure handwand, turf handgun sprayer, and backpack sprayer.

- **Non-Crop/Rights-of-Way Areas (occupational):** Maximum application rate for MSMA is 0.15 lbs ai/gallon spray (L & DF) and for DSMA are 0.063 lbs ai/gallon spray(WP) and 0.072 lbs ai/gallons spray (L). The equipment for this use is a rights-of-way sprayer.

- **Forestry (occupational):** 0.0035 lbs ai/inch diameter at breast height (DBH). The equipment for this use is a "hypo-hatchet" injector.

- **Weeds or Undesirable Grasses (residential):** Maximum application rate of 6 lbs ai/acre or 0.094 lbs ai/gallon (L) and 3.9 lbs ai/acre (G) for lawns and general weed control.

Typical Application Rates

Information on the typical application rates for MSMA and DSMA uses were not available and are requested.

Method and Types of Equipment Used for Mixing, Loading and Application[7,8,9]

- **Cotton:** Equipment for commercial use includes: groundboom sprayer and aerial application.

- **General Weeds or Undesirable Grasses:** Equipment for commercial use includes: turf handgun sprayer, low pressure hand wand, high pressure handwand, backpack sprayer, Hypo-Hatchet injector, and rights-of-way sprayer. Equipment for residential use includes: low pressure hand wand, backpack sprayer, sprinkler can, and ready-to-use liquid.

- **Bearing Citrus Trees and Non-bearing Fruit/Nut Trees and Vines:** Equipment for commercial use includes: turf handgun sprayer, high and low pressure hand wand, backpack sprayer, and rights-of-way.

- **Forestry:** Equipment for commercial use includes: Hypo-Hatchet Injector.

Timing and Frequency of Application

MSMA/DSMA are typically applied post-emergent at any time of the year, but for best results it should be applied during warm, sunny weather. For general weed control, it may be applied as often as necessary. For weed control on cotton, they are usually applied twice a year and for weed control on bearing and non-bearing fruit and nut trees, they are usually applied three times a year.[8,9]

OCCUPATIONAL EXPOSURE AND RISKS

Occupational Handler Exposures and Risk Estimates

Chemical-specific data for assessing human exposures during pesticide handling activities were not submitted to the Agency in support of the reregistration of MSMA/DSMA. It is the policy of the HED to use data from the Pesticide Handlers Exposure Database (PHED) Version 1.1 to assess handler exposures for regulatory actions when chemical-specific monitoring data are not available.[10]

PHED was designed by a task force of representatives from the U.S. EPA, Health Canada, the California Department of Pesticide regulation, and member companies of the American Crop Protection Association. PHED is a software system consisting of two parts -- a database of measured exposure values for workers involved in the handling of pesticides under actual field conditions and a set of computer algorithms used to subset and statistically summarize the selected data. Currently, the database contains values for over 1,700 monitored individuals (i.e., replicates)

Users select criteria to subset the PHED database to reflect the exposure scenario being evaluated. The subsetting algorithms in PHED are based on the central assumption that the magnitude of handler exposures to pesticides are primarily a function of activity (e.g., mixing/loading, applying), formulation type (e.g., wettable powders, granulars), application method (e.g., aerial, groundboom), and clothing scenarios (e.g., gloves, double layer clothing).

Once the data for a given exposure scenario have been selected, the data are normalized (i.e., divided by) by the amount of pesticide handled resulting in standard unit exposures (milligrams of exposure per pound of active ingredient handled). Following normalization, the data are statistically summarized. The distribution of exposure values for each body part (e.g., chest upper arm) is categorized as normal, lognormal, or "other" (i.e., neither normal nor lognormal). A central tendency value is then selected from the distribution of the exposure values for each body part. These values are the arithmetic mean for normal distributions, the geometric mean for lognormal distributions, and the median for all "other" distributions. Once selected, the central tendency values for each body part are composited into a "best fit" exposure value representing the entire body.

The unit exposure values calculated by PHED generally range from the geometric mean to the median of the selected data set. To add consistency and quality control to the values produced from this system, the PHED Task Force has evaluated all data within the system and has developed a set of grading criteria to characterize the quality of the original study data. The assessment of data quality is based on the number of observations and the available quality control data. These evaluation criteria and the caveats specific to each exposure scenario are summarized in Table 6. While data from PHED provide the best available information on handler exposures, it should be noted that some aspects of the included studies (e.g., duration,

acres treated, pounds of active ingredient handled) may not accurately represent labeled uses in all cases. HED has developed a series of tables of standard unit exposure values for many occupational scenarios that can be utilized to ensure consistency in exposure assessments.[11]

Occupational Handler Exposure Scenarios

HED has determined that there are potential exposures to mixer, loader, applicator and other handlers during the usual use-patterns associated with MSMA/DSMA. Based on the use patterns, 26 major occupational exposure scenarios were identified for MSMA/DSMA: (1a) mixing/loading liquids for aerial application; (1b) mixing/loading liquids for ground application; (1c) mixing/loading liquids for rights-of-way application; (1d) mixing/loading liquids for turf handgun sprayer; (1e) mixing/loading liquids for a high pressure handwand; (2a) mixing/loading wettable powders for aerial application; (2b) mixing/loading wettable powders for ground application; (2c) mixing/loading wettable powders for rights-of-way application; (2d) mixing/loading wettable powders for turf handgun sprayer; (2e) mixing/loading wettable powders for a high pressure handwand; (3a) mixing/loading dry flowable for aerial application; (3b) mixing/loading dry flowable for ground application; (3c) mixing/loading dry flowable for rights-of-way application; (3d) mixing/loading dry flowable for turf handgun sprayer; (3e) mixing/loading dry flowable for a high pressure handwand; (4) applying liquids with groundboom sprayer; (5) applying sprays with aerial equipment; (6) applying sprays with a turf handgun sprayer; (7) applying sprays with rights-of-way sprayer; (8) applying sprays with a high pressure handwand; (9) mixing/loading/applying liquids with low pressure hand wand; (10) mixing/loading/applying wettable powders with low pressure hand wand; (11) mixing/ loading/applying liquids with back pack sprayer; (12) loading/applying granulars with push-type spreader; (13) loading/applying granulars with a bellygrinder; and (14) flagging sprays for aerial application. MSMA/DSMA label prohibit application by chemigation.

There are four scenarios in addition to the ones listed above: mixing/loading/applying dry flowable with a low pressure handwand; mixing/loading/applying dry flowable with a back pack sprayer; mixing/loading/applying wettable powders with a backpack sprayer; and mixing/loading/applying liquids with a "Hypo-Hatchet" injector. No PHED unit exposure data exists for these scenarios. Since the dry flowable unit exposure data for mixing/loading is lower than the unit exposure data for mixing/loading for liquids, it is assumed that the exposure from mixing/loading/applying a dry flowable for both the backpack and the low pressure handwand would be less than the exposure from mixing/loading/applying liquids for both the backpack sprayer and the low pressure handwand. The exposure from mixing/loading/applying wettable powders with a backpack sprayer is assumed to be similar to the exposure from mixing/loading/applying wettable powders with a low pressure handwand. The exposure from mixing/loading/applying liquids with a "Hypo-Hatchet" injector is assumed to be similar to mixing/loading/applying liquids with backpack sprayer, since many "hypo-hatchets" have a container of liquid concentrate that they wear on their backs.

The amount of PPE that the current MSMA and DSMA labels require differs widely from label to label, with many labels requiring no PPE. Some labels have the following PPE requirements for handlers: long sleeve shirt, long pants, waterproof gloves, shoes, socks, protective eye wear or face shield, and a chemical resistant apron when cleaning equipment, mixing, or loading. For exposure in enclosed areas, a respirator with either an organic-vapor removing cartridge or canister with a prefilter approved for pesticides should be worn. For exposure outdoors, a dust/mist filtering respirator should be worn. Other labels have additional PPE requirements of chemical resistant footwear, flaggers should be fully protected during spray operations or mechanical flaggers should be used, and pilots and ground spray rig applicators should wear a mask or respirator approved by the Mining Enforcement and Safety Administration and the National Institute for Occupational Safety and Health. The vapor pressure for MSMA is 7.5×10^{-7} mm Hg and for DSMA is 1×10^{-7} mm Hg.

Assumptions for Handler Exposure Scenarios

The following assumptions and factors were used in order to complete this exposure assessment:

- Average body weight of an adult handler is 70 kg.
- Average work day interval represents an 8 hour workday (e.g., the acres treated or volume of spray solution prepared in a typical day).
- A range of the possible amount of acres that can be treated with MSMA/DSMA aerially on cotton in one day are given in this assessment for risk mitigation decision purposes. Exposures were estimated for handlers using 1,200 and 350 acres per day for aerial equipment. The use of 1,200 acres treated in one day by either the mixer/loader or the applicator is considered a reasonable high end estimate, because cotton is a high acreage field crop. This maximum acres treated aerially per day is based on published scientific literature, surveys, knowledge of agricultural practices, and calculated acreage estimates. Until actual use pattern data for MSMA/DSMA use on cotton is supplied, 1,200 acres maximum treated per day for either the aerial mixer/loader or the aerial applicator is considered to be a reasonable estimate.[12]
- Exposures were estimated for handlers using 40 gallons spray per day for low pressure handwand, 1000 gallons spray per day for a rights of way sprayer and high pressure handwand, and 5 acres per day for turf handgun sprayer. For groundboom equipment use on cotton, since it is a large acre crop, a range of 200 acres per day to 80 acres per day was used.[12] For ready-to-use formulations, the entire container is assumed to be applied in one day.

- If more than an acre is being treated, HED assumes that a rights-of-way sprayer or a turf handgun sprayer is typically used for applying sprays.

- Calculations are completed at the maximum application rates for crops as stated on the designated on either MSMA or DSMA labels.

- Due to a lack of scenario-specific data, HED calculates unit exposure values using generic protection factors that are applied to represent various risk mitigation options (i.e., the use of PPE and engineering controls).

Occupational Handler Exposures and Non-Cancer Risk Assessment

Equations to Calculate Handler Exposure

Potential daily dermal exposure is calculated using the following formula:

$$\text{Daily Dermal Exposure}\left(\frac{mg\ ai}{day}\right) = \text{Unit Exposure}\left(\frac{mg\ ai}{lb\ ai}\right) \times \text{Use Rate}\left(\frac{lb\ ai}{A}\right) \times \text{Daily Acres Treated}\left(\frac{A}{day}\right)$$

Potential daily inhalation exposure is calculated using the following formula:

$$\text{Daily Inhalation Exposure}\left(\frac{mg\ ai}{day}\right) =$$
$$\text{Unit Exposure}\left(\frac{\mu g\ ai}{lb\ ai}\right) \times \text{Conversion Factor}\left(\frac{1mg}{1{,}000\ \mu g}\right) \times \text{Use Rate}\left(\frac{lb\ ai}{A}\right) \times \text{Daily Acres Treated}\left(\frac{A}{day}\right)$$

The daily dermal and inhalation dose is calculated as follows using a 70 kg body weight:

$$\text{Daily Inhalation Dose}\left(\frac{mg\ ai}{kg/day}\right) = \text{Daily Inhalation Exposure}\left(\frac{mg\ ai}{day}\right) \times \left(\frac{1}{\text{Body Weight (kg)}}\right)$$

$$\text{Daily Dermal Dose}\left(\frac{mg\ ai}{Kg/Day}\right) = \text{Daily Dermal Exposure}\left(\frac{mg\ ai}{Day}\right) \times \left(\frac{1}{\text{Body Weight (Kg)}}\right)$$

The inhalation and dermal MOEs were calculated using the following formulas:

$$\text{Dermal MOE} = \frac{\text{NOAEL}\left(\frac{mg}{kg/day}\right)}{\text{Dermal Daily Dose}\left(\frac{mg}{kg/day}\right)}$$

$$\text{Inhalation MOE} = \frac{\text{NOAEL}\left(\frac{mg}{kg/day}\right)}{\text{Inhalation Daily Dose}\left(\frac{mg}{kg/day}\right)}$$

Based on the available toxicity data, it is not appropriate to combine dermal and inhalation MOEs because the effects observed in both the dermal and the inhalation studies were different. The short-term and intermediate-term MOEs for dermal exposure were calculated using a NOAEL of 1000 mg/kg/day. The short- and intermediate-term MOE for inhalation exposure were calculated using a NOAEL of 4.38 mg/kg/day.[1]

Tables 4, 5 and 6 present the risk assessments for short (1-7 days) and intermediate (one week to several months) term dermal and inhalation exposures at baseline, with additional personal protective equipment, and with engineering controls, respectively. Table 7 lists the caveats and parameters specific to the surrogate data used for each scenario and corresponding exposure/risk assessment.

Table 4. Occupational Handler Short-and Intermediate-term Dermal and Inhalation Exposure and Risks to MSMA/DSMA at Baseline

Exposure Scenario (Scenario #)	Baseline Dermal Unit Exposure (mg/lb ai)[a]	Baseline Inhalation Unit Exposure (µg/lb ai)[b]	Crop Type/Use	Application Rate (lbs ai/acre or gallon)[c]	Amount Treated per Day[d]	Short- and Intermediate term Daily Dermal Dose (mg/kg/day)[e]	Short-and Intermediate term Dermal MOE[f]	Short and Intermediate term Daily Inhalation Dose (mg/kg/day)[g]	Short and Intermediate term Inhalation MOE[h]
MIXER/LOADER EXPOSURE									
lixing/Loading Liquids for Aerial pplication (1a)	2.9	1.2	Cotton	3.6 lbs ai/A	1200 acres	180	6	0.074	59
					350 acres	52	19	0.022	200
lixing/Loading Liquids for round Application (1b)			Cotton	3.6 lbs ai/A	200 acres	30	34	0.012	350
					80 acres	12	84	0.0049	890
			Golf Course Turf	6.1 lbs ai/A	40 acres	10	99	0.0042	1000
lixing/Loading Liquids for ights-of-Way Application (1c)			Under Trees/Vines and ROW	0.15 lbs ai/gal	1000 gallons	6	160	0.0026	1,700
lixing/Loading Liquids for Turf andgun Sprayer (1d)			Under Trees/Vines Weed Control	6.3 lbs ai/A	5 acres	1	770	0.0005	8100
ixing/Loading Liquids for High essure Handwand (1e)			Under Trees/Vines and ROW	0.15 lbs ai/gal	1000 gallons	6	160	0.0026	1,700
ixing/Loading Wettable wders for Aerial Application a)	3.7	43	Cotton	2.3 lbs ai/A	1200 acres	150	7	1.7	2.6
					350 acres	43	24	0.49	8.9
ixing/Loading Wettable wders for Ground Application b)			Cotton	2.3 lbs ai/A	200 acres	24	41	0.28	16
					80 acres	10	100	0.11	39
			Golf Course Turf	7.6 lbs ai/A	40 acres	16	62	0.19	23
ixing/Loading Wettable wders for Rights-of-Way plication (2c)			Under Trees/Vines	0.05 lbs ai/gal	1000 gallons	2.6	380	0.031	140
			ROW	0.063 lbs ai/gal		3.3	300	0.039	110
ixing/Loading Wettable wders for Turf Handgun rayer (2d)			Under Trees/Vines	4.7 lbs ai/A	5 acres	1.2	810	0.014	300
			Weed Control	7.6 lbs ai/A		2	500	0.023	190
ixing/Loading Wettable wders for High Pressure andwand (2e)			Under Trees/Vines	0.05 lbs ai/gal	1000 gallons	2.6	380	0.031	140
			ROW	0.063 lbs ai/gal		3.3	300	0.039	110
ixing/Loading Dry Flowable for rial Application (3a)	0.066	0.77	Cotton	1.87 lbs ai/A	1200 acres	2	470	0.025	180
					350 acres	0.62	1,600	0.0072	610
ixing/Loading Dry Flowable for ound Application (3b)			Cotton	1.87 lbs ai/A	200 acres	0.35	2,800	0.0041	1,100
					80 acres	0.14	7,100	0.0016	2,700

Exposure Scenario (Scenario #)	Baseline Dermal Unit Exposure (mg/lb ai)[a]	Baseline Inhalation Unit Exposure (μg/lb ai)[a]	Crop Type/Use	Application Rate (lbs ai/acre or gallon)[d]	Amount Treated per Day[d]	Short- and Intermediate term Daily Dermal Dose (mg/kg/day)[e]	Short-and Intermediate term Dermal MOE[f]	Short and Intermediate term Daily Inhalation Dose (mg/kg/day)[g]	Short and Intermediate term Inhalation MOE[h]
ixing/Loading Dry Flowable for ghts-of-Way Application (3c)	0.066	0.77	Golf Course Turf	6.1 lbs ai/A	40 acres	0.08	12,000	0.0010	4500
			Under Trees/Vines	0.05 lbs ai/gal	1000 gallons	0.05	21,000	0.0006	8,000
			ROW	0.15 lbs ai/gal		0.14	7,100	0.0017	2,700
ixing/Loading Dry Flowable for rf Handgun Sprayer (3d)			Under Trees/Vines	4.9 lbs ai/A	5 acres	0.02	43,000	0.0003	16,000
			Weed Control	2.2 lbs ai/A		0.01	96,000	0.0001	36,000
ixing/Loading Dry Flowable for gh Pressure Handwand (3e)			Under Trees/Vines	0.05 lbs ai/gal	1000 gallons	0.05	21,000	0.0006	8,000
			ROW	0.15 lbs ai/gal		0.14	7,100	0.0017	2,700
APPLICATOR EXPOSURES									
plying Spray with a oundboom Sprayer (4)	0.014	0.74	Cotton	3.6 lbs ai/A	200 acres	0.14	6900	0.0076	570
					80 acres	0.06	17000	0.0030	1400
			Golf Course Turf	7.6 lbs ai/A	40 acres	0.06	16000	0.0032	1400
plying Sprays with Aerial uipment (5)	See Eng Controls	See Eng Controls	Cotton	3.6 lbs ai/A	1200 acres	See Eng Controls	See Eng Control	See Eng Controls	See Eng Control
					350 acres				
plying Spray with a Turf ndgun Sprayer (6)	0.77	1.4	Under Trees/Vines	6.3 lbs ai/A	5 acres	0.35	2900	0.0006	7000
			Weed Control	7.6 lbs ai/A		0.4	2,400	0.0008	5,800
plying Sprays with a Rights-of-ay Sprayer (7)	1.3	3.9	Under Trees/Vines ROW	0.15 lbs ai/gal	1000 gallons	2.8	360	0.0084	520
plying Sprays with a High ssure Handwand (8)	1.8	79	Under Trees/Vines ROW	0.15 lbs ai/gal	1000 gallons	3.86	260	0.17	26
MIXER/LOADER/APPLICATOR EXPOSURES									
xing/Loading/Applying Liquids th a Low Pressure Hand Wand	100	30	Under Trees/Vines Weed Control	0.063 lbs ai/gal	40 gallons	3.6	280	0.0011	4100
xing/Loading/Applying ettable Powders with a Low ssure Hand Wand (10)	8.6	1100	Under Trees/Vines	0.05 lbs ai/gal	40 gallons	0.25	4,100	0.031	140
			Weed Control	0.076 lbs ai/gal		0.37	2,700	0.048	92
xing/Loading/Applying Liquids th a Backpack Sprayer (11)	2.5 (gloves)	30	Under Trees/Vines Weed Control	0.063 lbs ai/gal	40 gallons	0.09	11000	0.0011	4100

Exposure Scenario (Scenario #)	Baseline Dermal Unit Exposure (mg/lb ai)[a]	Baseline Inhalation Unit Exposure (μg/lb ai)[b]	Crop Type/Use	Application Rate (lbs ai/acre or gallon)[c]	Amount Treated per Day[d]	Short- and Intermediate term Daily Dermal Dose (mg/kg/day)[e]	Short-and Intermediate term Dermal MOE[f]	Short and Intermediate term Daily Inhalation Dose (mg/kg/day)[g]	Short and Intermediate term Inhalation MOE[h]
ading/Applying Granulars with ush-Type Spreader (12)	2.9	6.3	Weed Control	3.9 lbs ai/A	5 acres	0.81	1200	0.0018	2500
ading/Applying Granulars with elly Grinder (13)	10	62	Weed Control	3.9 lbs ai/A	1 acres	0.56	1800	0.0035	1300
FLAGGER EXPOSURE									
gging Spray Applications (14)	0.011	0.35	Cotton	3.6 lbs ai/A	350 acres	0.2	5100	0.0063	700

Footnotes:

a Baseline dermal unit exposure represents long pants, long sleeved shirt, no gloves, open mixing/loading, open cab tractor, except scenario 10 that also includes gloves.

b Baseline inhalation unit exposure represents no respirator[a].

c Application Rates are based on the maximum application rates listed on the MSMA or DSMA labels.

d Amount handled per day are from Science Advisory Council on Exposure's Policy #9.[11]

e Daily Dermal Dose (mg/kg/day) = (Dermal Unit Exposure (mg/lb ai) x Application Rates (lb ai/A) x Area Treated per day (acres))/ Body Weight (kg).

f Short-and Intermediate term Dermal MOE = Short-and Intermediate term NOAEL (1000 mg/kg/day)/ Daily Dermal Dose (mg/kg/day).

g Daily Inhalation Dose (mg/kg/day) =(Inhalation Unit Exposure (μg/lb ai) x (1mg/1000 μg) Conversion Factor x Application Rate (lb ai/A) x Area Treated per day (acres))/ Body Weight (kg).

h Short- and Intermediate-term MOE = Short- and Intermediate-term NOAEL (4.38 mg/kg/day)/ Daily Inhalation Dose (mg/kg/day).

Table 5. Occupational Handler Short-and Intermediate-term Dermal and Inhalation Risk to MSMA/DSMA with Additional PPE.

Exposure Scenario (Scenario, #)	Crop Type/Use	Additional PPE - Dermal			Additional PPE - Inhalation		
		Unit Exposure (mg/lb ai)[a]	Short- and Intermediate term Daily Dose (mg/kg/day)[b]	Short-and Intermediate term MOE[c]	Unit Exposure (µg/lb ai)[d]	Short and Intermediate term Daily Dose (mg/kg/day)[e]	Short and Intermediate term MOE[f]
MIXER/LOADER EXPOSURE							
Mixing/Loading Liquids for Aerial Application (1a)	Cotton -1200 acres	0.017	1.05	950	0.24	0.015	300
	Cotton - 350 acres		0.31	3,300		0.0043	-
Mixing/Loading Liquids for Ground Application (1b)	Cotton -200 acres		0.18	5,700		0.0025	-
	Cotton - 80 acres		0.070	14000		0.00099	-
	Golf Course Turf		0.059	17000		0.00084	-
Mixing/Loading Liquids for Rights-of-Way application (1c)	Under Trees/Vines ROW		0.036	-		0.00051	-
Mixing/Loading Liquids for Turf Handgun Sprayer (1d)	Under Trees/Vines Weed Control		0.008	-		0.00011	-
Mixing/Loading Liquids for High Pressure Handwand (1e)	Under Trees/Vines ROW		0.036	-		0.00051	-
Mixing/Loading Wettable Powders for Aerial Application (2a)	Cotton -1200 acres	0.13	5.1	200	8.6	0.34	13
	Cotton - 350 acres		1.5	670		0.099	44
Mixing/Loading Wettable Powders for Ground Application (2b)	Cotton -200 acres		0.85	1,200		0.057	78
	Cotton - 80 acres		0.34	-		0.023	194
	Golf Course Turf		0.57	1800		0.038	120
Mixing/Loading Wettable Powders for Rights-of-Way Application (2c)	Under Trees/Vines		0.093	-		0.0061	-
	ROW		0.117	-		0.0077	-
Mixing/Loading Wettable Powders for Turf Handgun Sprayer (2d)	Under Trees/Vines		0.044	-		0.0029	-
	Weed Control		0.071	-		0.0047	-
Mixing/Loading Wettable Powders for High Pressure Handwand (2e)	Under Trees/Vines		0.093	-		0.0061	-
	ROW		0.117	-		0.0077	-
Mixing/Loading Dry Flowable for Aerial Application (3a)	Cotton -1200 acres	0.047	1.5	-	0.15	0.0048	-
	Cotton - 350 acres		0.44	-		0.0014	-
Mixing/Loading Dry Flowable for Ground Application (3b)	Cotton -200 acres		0.25	-		0.00080	-
	Cotton - 80 acres		0.10	-		0.00032	-
	Golf Course Turf		0.059	-		0.00019	-

Exposure Scenario (Scenario. #)	Crop Type/Use	Additional PPE - Dermal			Additional PPE - Inhalation		
		Unit Exposure (mg/lb ai)[a]	Short- and Intermediate term Daily Dose (mg/kg/day)[b]	Short-and Intermediate term MOE[c]	Unit Exposure (µg/lb ai)[d]	Short and Intermediate term Daily Dose (mg/kg/day)[e]	Short and Intermediate term MOE[f]
Mixing/Loading Dry Flowable for Rights-of-Way Application (3c)	Under Trees/Vines	0.047	0.034	-	0.15	0.00011	-
	ROW		0.10	-		0.00032	-
Mixing/Loading Dry Flowable for Turf Handgun Sprayer (3d)	Under Trees/Vines		0.016	-		0.00005	-
	Weed Control		0.007	-		0.00002	-
Mixing/Loading Dry Flowable for High Pressure Handwand (3e)	Under Trees/Vines		0.034	-		0.00011	-
	ROW		0.10	-		0.00032	-
APPLICATOR EXPOSURES							
Applying Spray with a Groundboom Sprayer (4)	Cotton -200 acres	0.011	0.11	-	0.15	0.0015	-
	Cotton - 200 acres		0.045	-		0.00062	-
	Golf Course Turf		0.048	-		0.00065	-
Applying Sprays with Aerial Equipment (5)	Cotton -1200 acres	See Engineering Controls	See Engineering Controls	See Engineering Controls	See Engineering Controls	See Engineering Controls	See Engineering Controls
	Cotton - 350 acres						
Applying Spray with a Turf Handgun Sprayer (6)	Under Trees/Vines	0.19	0.086	-	0.28	0.00013	-
	Weed Control		0.103	-		0.00015	-
Applying Sprays with a Rights-of-Way Sprayer (7)	Under Trees/Vines ROW	0.29	0.621	-	0.78	0.0017	-
Applying Sprays with a High Pressure Handwand (8)	Under Trees/Vines ROW	0.36	0.77	-	16	0.034	130
MIXER/LOADER/APPLICATOR EXPOSURES							
Mixing/Loading/Applying Liquids with a Low Pressure Hand Wand (9)	Under Trees/Vines Weed Control	0.37	0.013	-	6.0	0.00022	-
Mixing/Loading/Applying Wettable Powders with a Low Pressure Hand Wand (10)	Under Trees/Vines	6.2	0.177	-	220	0.0063	-
	Weed Control		0.269	-		0.0096	460
Mixing/Loading/Applying Liquids with a Backpack Sprayer (11)	Under Trees/Vines Weed Control	1.6	0.058	-	6.0	0.00022	-

Exposure Scenario (Scenario. #)	Crop Type/Use	Additional PPE - Dermal			Additional PPE - Inhalation		
		Unit Exposure (mg/lb ai)[a]	Short- and Intermediate term Daily Dose (mg/kg/day)[b]	Short-and Intermediate term MOE[c]	Unit Exposure (μg/lb ai)[d]	Short and Intermediate term Daily Dose (mg/kg/day)[e]	Short and Intermediate term MOE[f]
Loading/Applying Granular with a Push-type Spreader (12)	Weed Control	0.73	0.203	-	1.3	0.00036	-
Loading/Applying Granular with a Belly Grinder (13)	Weed Control	5.7	0.32	-	12	0.00067	-
FLAGGER EXPOSURE							
Flagging Spray Applications (14)	Cotton - 350 acres	0.01	0.18	-	0.07	0.0013	-

Footnotes:

a Additional PPE for all dermal scenarios includes double layer of clothing (50% Protection Factor for clothing) and chemical resistant gloves (90% Protection Factor).

b Daily Dermal Dose (mg/kg/day) = (Daily Dermal Exposure (mg/day) / Body Weight (70 kg)).

c Short-and Intermediate term Dermal MOE = NOAEL (1000 mg/kg/day) / Daily Dermal Dose (mg/kg/day). The target MOE value is 100.

d Additional PPE for all inhalation scenarios includes a dust/mist respirator (5-fold Protection Factor).

e Daily Inhalation Dose (mg/kg/day) = Daily Inhalation Exposure (mg/day) / Body weight (70kg).

f Short and Intermediate-term Inhalation MOE = NOAEL (4.38 mg/kg/day) / Daily Inhalation Dose (mg/kg/day). The target MOE value is 100.

- Calculated MOEs are below HED's the level of concern at the previous level of mitigation. (MOE $\geq$ 100).

Table 6. Occupational Handler Short-and Intermediate-term Dermal and Inhalation Risk to MSMA/DSMA with Engineering Controls.

Exposure Scenario (Scenario. #)	Crop Type/Use	Engineering Controls - Dermal			Engineering Controls - Inhalation		
		Unit Exposure (mg/lb ai) [a]	Short and Intermediate term Daily Dose (mg/kg/day)[b]	Short and Intermediate term MOE[c]	Unit Exposure (µg/lb ai)[d]	Short and Intermediate term Daily Dose (mg/kg/day)[e]	Short and Intermediate term MOE[f]
MIXER/LOADER EXPOSURE							
Mixing/Loading Liquids for Aerial Application (1a)	Cotton - 1200 acres	0.0086	0.53	-	0.083	0.0051	-
	Cotton -350 acres		0.16	-		0.0015	-
Mixing/Loading Liquids for Ground Application (1b)	Cotton - 200 acres		0.088	-		0.00085	-
	Cotton - 80 acres		0.035	-		0.00034	-
	Golf Course Turf		0.030	-		0.00029	-
Mixing/Loading Liquids for Rights-of-Way Application (1c)	Under Trees/Vines		0.018	-		0.00018	-
	ROW		0.004	-		0.00004	-
Mixing/Loading Liquids for Turf Handgun Sprayer (1d)	Under Trees/Vines Weed Control		0.004	-		0.00004	-
Mixing/Loading Liquids for High Pressure Handwand (1e)	Under Trees/Vines		0.018	-		0.00018	-
	ROW		0.004	-		0.00004	-
Mixing/Loading Wettable Powders for Aerial Application (2a)	Cotton - 1200 acres	0.021	0.83	-	0.083	0.0095	460
	Cotton -350 acres		0.24	-		0.0028	1600
Mixing/Loading Wettable Powders for Ground Application (2b)	Cotton - 200 acres		0.14	-		0.0016	2800
	Cotton - 80 acres		0.055	-		0.00063	-
	Golf Course Turf		0.091	-		0.0010	-
Mixing/Loading Wettable Powders for Rights-of-Way Application (2c)	Under Trees/Vines		0.015	-		0.00017	-
	ROW		0.019	-		0.00022	-
Mixing/Loading Wettable Powders for Turf Handgun Sprayer (2d)	Under Trees/Vines		0.007	-		0.00008	-
	Weed Control		0.011	-		0.00013	-
Mixing/Loading Wettable Powders for High Pressure Handwand (2e)	Under Trees/Vines		0.015	-		0.00017	-
	ROW		0.019	-		0.00022	-
Mixing/Loading Dry Flowable for Aerial Application (3a)	Cotton - 1200 acres	0.0013	0.042	-	0.083	0.00049	-
	Cotton -350 acres		0.012	-		0.00014	-
Mixing/Loading Dry Flowable for Ground Application (3b)	Cotton - 200 acres		0.007	-		0.00008	-
	Cotton - 80 acres		0.003	-		0.00003	-
	Golf Course Turf		0.002	-		0.00002	-

Exposure Scenario (Scenario. #)	Crop Type/Use	Engineering Controls - Dermal			Engineering Controls - Inhalation		
		Unit Exposure (mg/lb ai) [a]	Short and Intermediate term Daily Dose (mg/kg/day)[b]	Short and Intermediate term MOE[c]	Unit Exposure (μg/lb ai)[d]	Short and Intermediate term Daily Dose (mg/kg/day)[e]	Short and Intermediate term MOE[f]
Mixing/Loading Dry Flowable for Rights-of-Way Application (3c)	Under Trees/Vines	0.0013	0.001	-	0.083	0.00001	-
	ROW		0.003	-		0.00003	-
Mixing/Loading Dry Flowable for Turf Handgun Sprayer (3d)	Under Trees/Vines		0.00046	-		0.00001	-
	Weed Control		0.00021	-		0.0000024	-
Mixing/Loading Dry Flowable for High Pressure Handwand (3e)	Under Trees/Vines		0.001	-		0.00001	-
	ROW		0.003	-		0.00003	-
APPLICATOR EXPOSURES							
Applying Spray with a Groundboom Sprayer (4)	Cotton - 200 acres	0.005	0.051	-	0.043	0.00044	-
	Cotton -80 acres		0.021	-		0.00018	-
	Golf Course Turf		0.022	-		0.00019	-
Applying Sprays with Aerial Equipment (5)	Cotton - 1200 acres	0.005	0.31	3,200	0.068	0.0035	1000
	Cotton - 3500 acres		0.090	11,000		0.0010	3600
Applying Spray with a Turf Handgun Sprayer (6)	Under Trees/Vines Weed Control	NF	NF	NF	NF	NF	NF
Applying Sprays with a Rights-of-Way Sprayer (7)	Under Trees/Vines	NF	NF	NF	NF	NF	NF
	ROW		NF	NF		NF	NF
Applying Sprays with a High Pressure Handwand (8)	Under Trees/Vines	NF	NF	NF	NF	NF	NF
	ROW		NF	NF		NF	NF
MIXER/LOADER/APPLICATOR EXPOSURES							
Mixing/Loading/Applying Liquids with a Low Pressure Hand Wand (9)	Under Trees/Vines	NF	NF	NF	NF	NF	NF
	Weed Control		NF	NF		NF	NF
Mixing/Loading/Applying Wettable Powders with a Low Pressure Hand Wand (10)	Under Trees/Vines	NF	NF	NF	NF	NF	NF
	Weed Control		NF	NF		NF	NF
Mixing/Loading/Applying Sprays with a Backpack Sprayer (11)	Under Trees/Vines	NF	NF	NF	NF	NF	NF
	Weed Control		NF	NF		NF	NF

Exposure Scenario (Scenario. #)	Crop Type/Use	Engineering Controls - Dermal			Engineering Controls - Inhalation		
		Unit Exposure (mg/lb ai) [a]	Short and Intermediate term Daily Dose (mg/kg/day)[b]	Short and Intermediate term MOE[c]	Unit Exposure (μg/lb ai)[d]	Short and Intermediate term Daily Dose (mg/kg/day)[e]	Short and Intermediate term MOE[f]
Loading/Applying Granulars with a Push Type Spreader (12)	Weed Control	NF	NF	NF	NF	NF	NF
Loading/Applying Granulars with a Belly Grinder (13)	Weed Control		NF	NF		NF	NF
FLAGGER EXPOSURE							
Flagging Spray Applications (14)	Cotton -350 acres	0.00022	0.004	-	0.007	0.00013	-

Footnotes:

a Engineering Controls (scenario #): Closed mixing / loading, single layer clothing, chemical resistant gloves (1, 2, 3 (a /b/c/d)) and Enclosed cockpit, cab or truck, single layer clothing, no gloves.(4, 5, 13).

b Daily Dermal Dose (mg/kg/day) = (Daily Dermal Exposure (mg/day) / Body Weight (70 kg)).

c Short- and Intermediate term Dermal MOE = NOAEL (1000 mg/kg/day) / Daily Dermal Dose (mg/kg/day) . The target MOE value is 100.

e Daily Inhalation Dose (mg/kg/day) = Daily Inhalation Exposure (mg/day) / Body weight (70kg).

f Short and Intermediate-term Inhalation MOE = NOAEL (4.38 mg/kg/day) / Daily Inhalation Dose (mg/kg/day). The target MOE value is 100.

• Calculated MOEs are below HED's the level of concern at the previous level of mitigation. (MOE ≥ 100).

Table 7. Occupational Handler Exposure Scenario Descriptions for the Use of MSMA/DSMA

Exposure Scenario (Scenario Number)	Data Source	Standard Assumption[a] (8-hr work day)	Comments[b]
Mixer/Loader Descriptors			
Mixing/Loading Liquid Formulations (1a/1b/1c/1d/1e)	PHED V1.1	350, 1200 acres for aerial on cotton ,80, 200 acres for groundboom on cotton, 40 acres for rights-of way sprayer and groundboom for golf courses, and 5 acres for Turf Handgun sprayer.	**Baseline:** Hand, dermal, and inhalation data are AB grades. Hand = 72 to 122 replicates; dermal = 53 replicates; and inhalation = 85 replicates. High confidence in hand/dermal and inhalation data. No protection factor was needed to define the unit exposure value. **PPE:** The same dermal and inhalation data are used as for the baseline coupled with a 50% protection factor to account for an additional layer of clothing, and an 80% protection factor to account for the use of a dust/mist respirator, respectively. Hand data are AB grades, with 59 replicates. High confidence in hand/dermal data. **Engineering Controls:** Hand, dermal, and inhalation data are AB grades. Hand = 31 replicates; dermal =16 to 22 replicates; inhalation = 27 replicates. High confidence in hand/dermal and inhalation data.
Mixing/Loading Wettable Powder Formulations (2a/2b/2c/2d/2e)	PHED V1.1	350, 1200 acres for aerial on cotton ,80, 200 acres for groundboom on cotton, 40 acres for rights-of way sprayer and groundboom on golf courses, and 5 acres for Turf Handgun sprayer.	**Baseline:** Hand, dermal and inhalation are ABC grades. Hand = 7 replicates; dermal = 22 to 45 replicates; and inhalation = 44 replicates. Low confidence in hand/dermal data, and medium confidence in inhalation data. **PPE:** Hand/dermal data are ABC grades. The same inhalation data are used as for the baseline coupled with an 80% protection factor to account for the use of a dust/mist respirator. Hand = 24 replicates and dermal = 22 to 45 replicates. Medium confidence in hand/dermal data. **Engineering:** Hand and dermal data are AB grades; inhalation data are all grades. Hand = 5 replicates; dermal = 6 to 15 replicates; and inhalation = 15 replicates. Low confidence in hand/dermal and inhalation data.
Mixing/Loading Dry Flowable Formulations (3a/3b/3c/3d/3e)	PHED V1.1	350, 1200 acres for aerial on cotton ,80, 200 acres for groundboom on cotton, 40 acres for rights-of way sprayer and groundboom on golf courses, and 5 acres for Turf Handgun sprayer.	**Baseline:** Hand, dermal and inhalation data are AB grades. Hand = 7 replicates; dermal = 16 to 26 replicates; and inhalation = 23 replicates. Low confidence in hand/dermal data and high confidence in inhalation data. **PPE:** Hand/dermal data are AB grades. The same inhalation data are used as for the baseline coupled with an 80% protection factor to account for the use of a dust/mist respirator. Hand = 21 replicates and dermal = 16 to26 replicates. High confidence in hand/dermal data. **Engineering Controls:** No data
Applicator Exposure			
Applying sprays with a groundboom sprayer (4)	PHED V1.1	80, 200 acres on cotton and 40 acres on golf course turf	**Baseline:** Hand, dermal, and inhalation data are AB grades. Hand = 29 replicates; dermal = 23 to 42 replicates; and inhalation = 22 replicates. High confidence in hand/dermal and inhalation data. No protection factor was needed to define the unit exposure value. **PPE:** The same dermal and inhalation data are used as for the baseline coupled with a 50% protection factor to account for an additional layer of clothing, and an 80% protection factor to account for the use of a dust/mist respirator, respectively. Hand data are ABC grades, with 21 replicates. Medium confidence in hand/dermal data. **Engineering Controls:** Hand and dermal data are ABC grades, and inhalation are AB grades. Hand = 16 replicates; dermal =20 to 31 replicates; inhalation = 16 replicates. Medium confidence in hand/dermal data, and high confidence in inhalation data.

Exposure Scenario (Scenario Number)	Data Source	Standard Assumption[a] (8-hr work day)	Comments[b]
Applying sprays for Aerial Applications (5)	PHED V1.1	350, 1,200 acres on cotton	**Baseline:** Not feasible for this scenario. **PPE:** Not feasible for this scenario. **Engineering Controls:** Hand data are AB grades, dermal are ABC grades, and inhalation data are ABC grades. Hand = 34 replicates; dermal = 24 to 48 replicates; and inhalation = 23 replicates. Medium confidence in hand/dermal data, and medium confidence inhalation data.
Apply sprays with a Turf Handgun sprayer (6)	PHED V1.1	5 acres or 200 gallons spray	**Baseline:** Hand and dermal data are C grades, and inhalation data are AB grades. Hand = 14 replicates; dermal = 0 to 14 replicates; and inhalation = 14 replicates. Low confidence in hand/dermal data, and low to medium confidence inhalation data. Baseline data includes chemical resistant gloves. No protection factor was needed to define the unit exposure value. **PPE:** The same hand data are used as for the baseline, as chemical resistant glove data were used. The same dermal and inhalation data are used as for the baseline coupled with a 50% protection factor to account for an additional layer of clothing, and an 80% protection factor to account for the use of a dust/mist respirator, respectively. **Engineering Controls:** Not feasible for this scenario.
Applying sprays with a rights-of way sprayer (7)	PHED V1.1	40 acres or 1000 gallons spray	**Baseline:** Hand data are AB grades, dermal are ABC grades, and inhalation data are A grades. Hand = 16 replicates; dermal = 4 to 30 replicates; and inhalation = 16 replicates. Low confidence in hand/dermal data , and high confidence inhalation data. No protection factor was needed to define the unit exposure value. **PPE:** The same dermal and inhalation data are used as for the baseline coupled with a 50% protection factor to account for an additional layer of clothing, and an 80% protection factor to account for the use of a dust/mist respirator, respectively. Hand data are AB grades, with 4 replicates. Low confidence in hand/dermal data. **Engineering Controls:** Not feasible for this scenario.
Applying liquids with a high pressure handwand (8)	PHED V1.1	1000 gallons	**Baseline:** Hand, dermal, and inhalation data are all grades. Hand = 2 replicates; dermal = 9 to 11 replicates; and inhalation = 11 replicates. Low confidence in hand/dermal and inhalation data. No protection factor was needed to define the unit exposure value. **PPE:** Hand/dermal data are all grades. The same inhalation data are used as for the baseline coupled with an 90% protection factor to account for the use of a organic vapor respirator. Hand = 9 replicates and dermal = 9 to 11 replicates.. Low confidence in hand/dermal data. **Engineering Controls:** Not feasible for this scenario. A 50% PF was added to the PPE scenario to simulate coveralls. 90% for the addition of a organic vapor respirator.

Exposure Scenario (Scenario Number)	Data Source	Standard Assumption[a] (8-hr work day)	Comments[b]
			Mixer/Loader/Applicator Exposure
Mixing/loading/applying liquids with a low pressure handwand (9)	PHED V1.1	1 acre or 40 gallons spray	**Baseline:** Hand data are All grades, dermal are ABC grades, and inhalation data are ABC grades. Hand = 70 replicates; dermal = 9 to 80 replicates; and inhalation = 80 replicates. Low confidence in hand/dermal data, and medium confidence in inhalation data. No protection factor was needed to define the unit exposure value. **PPE:** The same dermal and inhalation data are used as for the baseline coupled with a 50% protection factor to account for an additional layer of clothing, and an 80% protection factor to account for the use of a dust/mist respirator, respectively. Hand data are ABC grades, with 10 replicates. Low confidence in hand/dermal data. **Engineering Controls:** Not feasible for this scenario.
Mixing/loading/applying wettable powders with a low pressure handwand (10)	PHED V1.1	1 acre or 40 gallons spray	**Baseline:** Hand data are AB grades, dermal are ABC grades, and inhalation data are ABC grades. Hand = 15 replicates; dermal = 16 replicates; and inhalation = 16 replicates. Medium confidence in hand/dermal data, and medium confidence in inhalation data. No protection factor was needed to define the unit exposure value. **PPE:** The same dermal and inhalation data are used as for the baseline coupled with a 50% protection factor to account for an additional layer of clothing, and an 80% protection factor to account for the use of a dust/mist respirator, respectively. Hand data are AB grades, with 15 replicates. Medium confidence in hand/dermal data. **Engineering Controls:** Not feasible for this scenario.
Mixing/loading/applying liquids with a backpack sprayer (11)	PHED V1.1	1 acre or 40 gallons spray	**Baseline:** Hand data are C grade, dermal are AB grades, and inhalation data are A grades. Hand = 11 replicates; dermal = 9 to 11 replicates; and inhalation = 11 replicates. Low confidence in hand/dermal and inhalation data. A 90% protection factor was needed to "back calculate" the no glove exposure value. **PPE:** The same dermal and inhalation data are used as for the baseline coupled with a 50% protection factor to account for an additional layer of clothing, and an 80% protection factor to account for the use of a dust/mist respirator, respectively. Hand data are C grade, with 11 replicates. Low confidence in hand/dermal data. **Engineering Controls:** Not feasible for this scenario.
Loading/Applying Granular with a Push-type Spreader (12)	PHED V1.1	5 acres	**Baseline:** Hand and dermal data are C grade, and inhalation data are B grade. Hand = 15 replicates; dermal = 0 to 15 replicates; and inhalation = 15 replicates. Low confidence in hand/dermal data, and high confidence in inhalation data. No protection factor was needed to define the unit exposure value. **PPE:** The same hand and dermal data are used as for the baseline coupled with a 90% protection factor to account for chemical resistant gloves, and a 50% protection factor to account for an additional layer of clothing, respectively. The same inhalation data are used as for the baseline coupled with an 80% protection factor to account for the use of a dust/mist respirator. **Engineering Controls:** Not feasible for this scenario.
Loading/Applying Granular with a Belly Grinder(13)	PHED V1.1	1 acre	**Baseline:** Hand and dermal data are ABC grades, and inhalation data are AB grades. Hand = 23 replicates; dermal = 29 to 45 replicates; and inhalation = 40 replicates. Medium confidence in hand/dermal data, and high confidence in inhalation data. No protection factor was needed to define the unit exposure value. **PPE:** The same hand and dermal data are used as for the baseline coupled with a 90% protection factor to account for chemical resistant gloves, and a 50% protection factor to account for an additional layer of clothing, respectively. The same inhalation data are used as for the baseline coupled with an 80% protection factor to account for the use of a dust/mist respirator. **Engineering Controls:** Not feasible for this scenario.

Exposure Scenario (Scenario Number)	Data Source	Standard Assumption[a] (8-hr work day)	Comments[b]
Flagger Exposure			
Flagging Spray Applications (14)	PHED V1.1	350 acres on cotton	**Baseline:** Hand data is AB grades, dermal data is AB grade,, and inhalation data are AB grade. Hand = 30 replicates; dermal = 18 to 28 replicates; and inhalation = 28 replicates. High confidence in hand/dermal data, and high confidence in inhalation data. No protection factor was needed to define the unit exposure value. **PPE:** The same hand and dermal data are used as for the baseline coupled with a 50% protection factor to account for an additional layer of clothing. The same inhalation data are used as for the baseline coupled with an 80% protection factor to account for the use of a dust/mist respirator. **Engineering Controls:** The same hand, inhalation, and dermal data are used as for the baseline coupled with a 98% protection factor to account for the engineering control of a closed truck.

[a] Standard Assumptions based on an 8-hour work day as estimated by HED. BEAD data were not available.

[b] All handler exposure assessments in this document are based on the "Best Available" data as defined by OREB SOP for meeting Subdivision U Guidelines. Best available grades are assigned to data as follows: matrices with grades A and B data and a minimum of 15 replicates; if not available, then grades A, B and C data and a minimum of 15 replicates; if not available, then all data regardless of the quality (i.e., All Grade Data) and number of replicates. High quality data with a protection factor take precedence over low quality data with no protection factor. Generic data confidence categories are assigned as follows:

High = grades A and B and 15 or more replicates per body part
Medium = grades A, B, and C and 15 or more replicates per body part
Low = grades A, B, C, D and E or any combination of grades with less than 15 replicates

Summary of Non-Cancer Risk Concerns for Occupational Handlers

For the dermal and inhalation, short and intermediate term exposure, the target MOE is 100. The calculated MOE values were not aggregated for short term and intermediate term because the dermal and inhalation endpoints were different.

Baseline Level

The calculations of short- and intermediate-term inhalation risk indicate that inhalation MOEs are **more** than 100 at the **baseline** level for the all the assessed exposure scenarios **except** the following:

- (1a) Mixing/loading liquids for aerial application at 1200 acres per day on cotton.
- (2a) Mixing/loading wettable powders for aerial application.
- (2b) Mixing/loading wettable powders for groundboom application.
- (8) Applying Sprays with a High Pressure Handwand.
- (10) Mixing/loading/applying wettable powders with a low pressure handwand at 0.076 lbs ai/gallon of spray application rate.

The calculations of short- and intermediate term dermal risk indicate that the dermal MOEs are **less** than 100 for short-term at the **baseline** level for all assessed exposure scenarios **except** the following:

- (1a) Mixing/loading liquids for aerial application.
- (1b) Mixing/loading liquids for groundboom application.
- (2a) Mixing/loading wettable powders for aerial application.
- (2b) Mixing/loading wettable powders for groundboom application at 200 acres per day on cotton and 40 acres per day on golf course turf.

Additional PPE

All calculated short- and intermediate-term dermal MOEs were **more** than 100 at the **additional PPE** level.

The calculations of short- and intermediate term inhalation risk indicate that the inhalation MOEs are **more** than 100 at the **additional PPE** level for all assessed exposure scenarios **except** the following:

- (2a) Mixing/loading wettable powders for aerial application.
- (2b) Mixing/loading wettable powders for groundboom application at 200 acres per day on cotton.

Engineering Controls

All calculated short- and intermediate-term inhalation MOEs for the feasible exposure scenarios were **more** than 100 at the **engineering control** level.

All calculated short- and intermediate-term dermal MOEs for the feasible exposure scenarios were **more** than 100 at the **engineering control** level.

Occupational Handler Exposure and Risk Estimates for Cancer

MSMA and DSMA cancer classification is "not likely" human carcinogens; therefore a occupational handler cancer assessment was not conducted.

Occupational Post Application Exposures and Non-Cancer Risk Estimates

A restricted entry interval (REI) or early-entry PPE requirements are not mentioned on many current MSMA/DSMA labels. Some labels specify a 12 hour REI and the following early entry PPE: coveralls, waterproof gloves, shoes, socks, protective eye wear, and chemical resistant headgear for overhead exposure. A few labels also specify chemical resistant footwear.

The registrant has submitted one turf transferable residue study in support of the reregistration of MSMA/DSMA, titled *Determination of Transferable Residues from Turf Treated with Monosodium Methanearsonate* (MRID No. 449589-01).[13] This study will be used to assess post-application exposure and risk from treated turfgrass. Chemical-specific post application exposure and/or environmental fate data have not yet been submitted by the registrant in support of reregistration of all formulation types of MSMA/DSMA. In lieu of these data, a surrogate post-application assessment was conducted to determine potential risks for cotton. The results of these assessments in Table 9 are based on the application rates of 3.6 lb ai/A for cotton and 7.56 lbs ai/A for turfgrass. MSMA and DSMA are also used under trees, vines and shrubs. Occupational post-application exposures resulting from this type of application are assumed to be less than the exposures from the three assessed post-application exposure scenarios.

The transfer coefficients used in this assessment for the use on cotton are from the Agricultural Re-entry Task Force (ARTF) database. An interim transfer coefficient policy was

developed by HED's Science Advisory Council for Exposure using the ARTF database (policy # 3.1).[14] It is the intention of HED's Science Advisory Council for Exposure that this policy will be periodically updated to incorporate additional information about agricultural practices in crops and new data on transfer coefficients. Much of this information will originate from exposure studies currently being conducted by the ARTF, from the further analysis of studies already submitted to the Agency, and from the studies in the published scientific literature.

The golf course turfgrass assessment uses a transfer coefficient of 500 cm^2/hr, for activities such as mowing and maintaining golf course turfgrass. The sod farm assessment uses a transfer coefficient of 16,500 cm^2/hr, far activities such as hand and mechanical harvesting, hand weeding and transplanting of sod. Actual turf transferable residue (TTR) data from the MSMA turfgrass study was used since some of the natural log transformed regressed data was found to not be linear. Also, TTR data was not needed for a time period beyond what was tested for. The average TTR values for the New York site, the North Carolina site and the California site on the day of application were 0.0752, 0.0360, 0.368 $\mu g/cm^2$ respectively. The highest residue value of 0.368 $\mu g/cm^2$ from the CA site was used as a screening level assessment. The study was conducted at an application rate of 2.25 lbs ai/acre, but the maximum application rate on turfgrass is 7.56 lbs ai/acre (reg #42519-6). So, the TTR value was adjusted by a factor of 3.3 to compensate for the higher application rate. The duration of post-application exposure is assumed to be intermediate term.

The cotton surrogate assessment uses a medium transfer coefficient of 1,500 cm^2/hr, for activities such as irrigating and scouting and a high transfer coefficient of 2,500 cm^2/hr for activities such as hand harvesting .[14] The DFR is derived from using an estimated 20 percent of the rate applied as initial dislodgeable residues for cotton and an estimated 10 percent dissipation rate per day. The duration of post-application exposure is assumed to be intermediate term.

The equations used to calculate the post-application in Table 8 are presented below:

Surrogate DFR calculation (cotton only)

$$DFR\left(\frac{\mu g}{cm^2}\right) = AR\left(\frac{lb\ ai}{A}\right) \times CF\left(\frac{\mu g/cm^2}{lb\ ai/A}\right) \times F \times (1\text{-}DR)^t$$

Where:

AR	=	Application rate is 3.6 lbs ai/A for cotton
DR	=	Daily dissipation rate (10 percent / day)
t	=	Days after treatment
CF	=	Conversion factor (11.2 μg per cm^2/ lb ai per A)
F	=	Fraction retained on foliage (20 percent for cotton)

Dose calculation:

$$Dose\ (mg/kg/d) = \frac{(DFR\ (\mu g/cm^2)\ x\ Tc\ (cm^2/hr)\ x\ CF\left(\frac{1\ mg}{1{,}000\ \mu g}\right)\ x\ ED\ (hrs)}{BW\ (kg)}$$

Where:

DFR = Initial DFR or daily DFR ($\mu g/cm^2$)

Tc = Transfer coefficient (1,500 cm^2/hr and 2,500 cm^2/hr for cotton, 500 cm^2/hr and 16,500 cm^2/hr for turfgrass)

CF = Conversion factor (1 mg/1,000 μg)

ED = Exposure duration (8 hours per day)

BW = Body weight (70 kg)

$$MOE = \frac{NOEL\ (mg/kg/d)}{Dose\ (mg/kg/d)}$$

Where:

NOAEL = 1,000 mg/kg/day

Dose = Calculated dose (mg/kg/day)

Table 8. MSMA/DSMA Non-Cancer Post application Assessment.

DAT[a]	DFR or TTR ($\mu g/cm^2$)[b]		Dermal Dose (mg/kg/day)[c]				MOE[d]			
			cotton		turfgrass		cotton		turfgrass	
	cotton	turfgrass	medium	high	golf course	sod farm	medium	high	golf course	sod farm
0 (12 hours)	8.0	1.2	1.4	2.3	0.0034	0.13	720	430	290,000	8,800

Footnotes:

NA = Not applicable

[a] DAT is "days after treatment"

Initial DFR ($\mu g/cm^2$) = Application rate (cotton 3 lbs ai/A) x Conversion factor (1 lb ai/acre= 11.209 $\mu g/cm2$) x Fraction of initial ai retained on foliage (20%) (cotton only, study data used for turfgrass)

Initial DFR ($\mu g/cm^2$) = 0.368 $\mu g/cm^2$ * (7.56 lbs ai/acre / 2.25 lbs ai/acre) (study data used for turfgrass)

[c] Dose = DFR ($\mu g/cm^2$) x Transfer coefficient (cotton 1,500 cm^2/hr and 2,500 cm^2/hr, turfgrass 500 cm^2/hr and 16,500 cm^2/hr) x Conversion factor (1mg/1000 μg) x Hrs worked per day (8 hrs) / Body weight (70 kg)

[d] MOE = NOAEL (mg/kg/day) / Dermal dose (mg/kg/day). Where: intermediate NOAEL is 1000 mg/kg/day for cotton

Occupational Post-application Non-cancer Risk Summary

For non-cancer risks, the number of days after application that the calculated MOE exceeds the target MOE is 0 (12 hours) for cotton for activities such as irrigating, scouting, and hand harvesting and for turfgrass for activities such as mowing and maintaining golf course turfgrass and hand and mechanical harvesting, hand weeding, and transplanting of sod.

Occupational Post-application Exposure and Risk Estimates for Cancer

MSMA and DSMA cancer classification is "not likely" human carcinogens; therefore a occupational post-application cancer assessment was not conducted.

Residential Exposures and Risks

Residential Handler Exposures and Non-Cancer Risk Estimates

Residential Handler Scenarios

HED has determined that there are potential exposure to residential mixer, loader, and applicators during the usual use-patterns associated with MSMA/DSMA[7]. Based on the use patterns, 6 major residential exposures were identified for MSMA/DSMA: (1) mixing/loading/ applying liquids with a low pressure hand wand; (2) mixing/ loading/applying liquids with a back pack sprayer; (3) mixing/loading/applying liquids with a sprinkler can or ready-to-use liquid, (4) loading/applying granulars with a belly grinder, (5) loading/applying granulars with a push-type spreader, and (6) applying granular with hand/spoon. Hose-end sprayer use is prohibited on MSMA and DSMA labels.

The duration of exposure for residential populations is assumed to be short-term only, weed control occurs about once a month during the weed growing season of 3 months. Table 9 presents the risk assessment for short term dermal and inhalation exposures at baseline. Table 10 summarizes the caveats and parameters specific to the surrogate data used for each scenario and corresponding exposure/risk assessment.

Residential Handler Exposure Scenarios' Data and Assumptions

The following assumptions were made in the exposure calculations:

- Average body weight of an adult handler is 70 kg.
- The area treated per day: ½ acre for belly grinder and push-type spreader, 10 gallons of spray for low pressure handwand and backpack sprayer, 1,000 square feet for hand/spoon and 100 square feet for a sprinkler can and a ready-to-use liquid.
- If the amount of dilution, not application rate is stated on the label, then it was assumed that the volume of diluted spray used per day was 10 gallons for a backpack sprayer or a low pressure handwand. For ready-to-use formulations, the entire container is assumed to be used in one day.
- The hose-end sprayer PHED data was used to assess exposure from the use of a sprinkler can and ready-to-use liquid, since no PHED data are available for these

exposure scenarios. The hose-end sprayer PHED data is assumed to over estimate the exposure from the sprinkler can and ready-to-use liquid.

- Generally, the use of PPE and engineering controls are not considered acceptable options for products sold for use by homeowners, because they are not available and/or are inappropriate for the exposure scenario.

- Calculations are completed at the maximum application rates for crops as stated on the available MSMA/DSMA labels.

Residential Handler Exposure and Non-Cancer Risk Assessment

Equations to Calculate Handler Exposure

Potential daily dermal exposure is calculated using the following formula:

$$\text{Daily Dermal Exposure}\left(\frac{mg\ ai}{day}\right) = \text{Unit Exposure}\left(\frac{mg\ ai}{lb\ ai}\right) \times \text{Use Rate}\left(\frac{lb\ ai}{A}\right) \times \text{Daily Acres Treated}\left(\frac{A}{day}\right)$$

Potential daily inhalation exposure is calculated using the following formula:

$$\text{Daily Inhalation Exposure}\left(\frac{mg\ ai}{day}\right) =$$
$$\text{Unit Exposure}\left(\frac{\mu g\ ai}{lb\ ai}\right) \times \text{Conversion Factor}\left(\frac{1mg}{1{,}000\ \mu g}\right) \times \text{Use Rate}\left(\frac{lb\ ai}{A}\right) \times \text{Daily Acres Treated}\left(\frac{A}{day}\right)$$

The daily dermal and inhalation dose is calculated as follows using a 70 kg body weight

$$\text{Daily Inhalation Dose}\left(\frac{mg\ ai}{kg/day}\right) = \text{Daily Inhalation Exposure}\left(\frac{mg\ ai}{day}\right) \times \left(\frac{1}{\text{Body Weight (kg)}}\right)$$

$$\text{Daily Dermal Dose}\left(\frac{mg\ ai}{Kg/Day}\right) = \text{Daily Dermal Exposure}\left(\frac{mg\ ai}{Day}\right) \times \left(\frac{1}{\text{Body Weight (Kg)}}\right)$$

The inhalation and dermal MOEs were calculated using the following formulas:

$$\text{Dermal MOE} = \frac{\text{NOAEL}\left(\frac{mg}{kg/day}\right)}{\text{Dermal Daily Dose}\left(\frac{mg}{kg/day}\right)}$$

$$\text{Inhalation MOE} = \frac{\text{NOAEL}\left(\frac{mg}{kg/day}\right)}{\text{Inhalation Daily Dose}\left(\frac{mg}{kg/day}\right)}$$

Based on the available toxicity data, it is not appropriate to combine dermal and inhalation MOEs because the effects observed for the dermal and inhalation studies were different. The short-term MOEs for dermal exposure were calculated using a NOAEL of 1000 mg/kg/day. The short- term MOEs for inhalation exposure were calculated using a NOAEL of 4.38 mg/kg/day.[1]

Table 9. Residential Handler Short-term Dermal and Inhalation Exposure to MSMA/DSMA at Baseline.

Exposure Scenario (Scenario #)	Dermal Unit Exposure (mg/lb ai)[a]	Inhalation Unit Exposure (μg/lb ai)[b]	Application Rate (lbs ai/acre)[c]	Amount Used or Area Treated per Day[d]	Daily Dermal Dose (mg/day/kg)[e]	Daily Inhalation Dose (mg/day/day)[f]	Dermal MOE[g]	Inhalation MOE[h]
MIXER/LOADER/APPLICATOR EXPOSURE								
lixing/Loading/Applying Liquids ith Low Pressure Hand Wand (1)	100	30	0.094 (per gallon)	10 gallons	1.34	0.0004	740	11,000
lixing/Loading/Applying Liquids ith Backpack Sprayer (2)	5.1	30	0.094 (per gallon)	10 gallons	0.07	0.0004	15,000	11,000
lixing/Loading/Applying Liquids ith a Sprinkler Can or Ready-to-se liquid (3)	30	9.5	6.1	100 sq. ft.	0.01	0.000002	170,000	2,300,000
oading/Applying Granulars ith Belly Grinder (4)	110	62	3.9	½ acre	3.06	0.00176	330	2,500
oading/Applying Granulars ith a Push-Type Spreader (5)	3	6.3	3.9	½ acre	0.08	0.000176	11,000	25,000
pplying Granulars with land/Spoon (6)	430	470	3.9	1,000 sq. ft.	0.55	0.00060	1,800	7,300

Footnotes:

a Baseline dermal unit exposure represents short pants, short-sleeved shirt, no gloves, open mixing/loading.

b Baseline inhalation unit exposure represents no respirator.

c Application Rates are based on the maximum application rates listed on the MSMA/DSMA labels.

d Amount handled per day are from EPA estimates of acres treated, or square feet treated, in a single day based on the application method. For ready to use formulations, the whole container is assumed to be used in one day.

e Daily Dermal Dose (mg/kg/day) = (Dermal Unit Exposure (mg/lb ai) x Application Rates (lb ai/A and lb ai/sq. ft.) x Area Treated per day (acres and square feet))/ body weight (70 kg).

f Daily Inhalation dose (mg/kg/day) = (Inhalation Unit Exposure (μg/lb ai) x (1mg/1000 μg) Conversion Factor x Application Rate (lb ai/A) x Area Treated per day (acres and square feet))/ body weight (70 kg).

g Short-term Dermal MOE = Dermal NOAEL (1000 mg/kg/day)/ Daily Dermal Dose (mg/kg/day).

h Short-term Inhalation MOE = Inhalation NOAEL (4.38 mg/kg/day) / Daily Inhalation Dose (mg/kg/day).

Table 10. Residential Handler Exposure Scenario Descriptions for the Use of MSMA/DSMA

Exposure Scenario (Number)	Data Source	Standard Assumption[a]	Comments[b]
Mixer/Loader/Applicator Descriptors			
Mixing/Loading/Applying Liquids with a Low Pressure Handwand (1)	PHED V1.1	10 gallons/day	**Baseline:** Dermal and inhalation data = ABC grades, and hands data = All grade. Dermal = 9-80 replicates; hands = 70 replicates; and inhalation = 80 replicates. Low confidence in hands, dermal data. Medium confidence in inhalation data. **PPE and Engineering Controls:** Not required for assessment.
Mixing/Loading/Applying Using a Backpack Sprayer (2)	PHED V1.1	10 gallons/day	**Baseline:** Dermal = AB grade; inhalation = A grade; and hands = C grade. Dermal = 9 to 11 replicates; hands = 11 replicates; and inhalation = 11 replicates. Low confidence in dermal, and inhalation data. A 90% protection factor was used to back calculate "no glove" hand data from the gloved scenario. **PPE and Engineering Controls:** Not required for assessment.
Mixing/Loading/Applying Using a Sprinkler Can or Ready-to-Use Liquid (used the unit exposures for hose-end sprayer for sprinkler can/ready-to-use liquid) (3)	PHED V1.1	100 square feet/day for sprinkler can and ready-to-use liquid	**Baseline:** Dermal and inhalation = C grade; and hands = E grade. Dermal, inhalation, and hands = 8 replicates each. Low confidence in all data. **PPE and Engineering Controls:** Not required for assessment.
Loading/Applying Granulars with a Belly Grinder (4)	PHED V1.1	½ acre/day	**Baseline:** Dermal and hands data = ABC grades, inhalation = AB grade. Dermal 20-45 replicates; hands = 15 replicates; and inhalation = 40 replicates. Medium confidence for hands, dermal and high confidence for inhalation. **PPE and Engineering Controls:** Not required for assessment.
Loading/Applying Granulars with a Push-Type Spreader (5)	PHED V1.1	½ acre/day	**Baseline:** Hands = C grade, and inhalation data = B grade. Hand = 15 replicates; dermal = 0-15 replicates; and inhalation = 15 replicates. Low confidence in hands, dermal data, and high confidence in inhalation data.. A 50% protection factor was used to "back calculate" a short sleeved shirt value from long sleeve shirt data. **PPE and Engineering Controls:** Not required for assessment.
Applying Granulars by Hand/Spoon (6)	PHED V1.1	1,000 square feet/day	**Baseline:** Dermal, hands and inhalation data = ABC grade. Hands, dermal and inhalation = 16 replicates. Medium confidence in all data. A 90% PF was applied to gloved hands data to back calculate "no glove" hand exposure. **PPE and Engineering Controls:** Not required for assessment

[a] Standard Assumptions based on HED estimates.

[b] "Best Available" grades are defined by HED SOP for meeting Subdivision U Guidelines. Best available grades are assigned as follows: matrices with grades A and B data and a minimum of 15 replicates; if not available, then grades A, B and C data and a minimum of 15 replicates; if not available, then all data regardless of the quality and number of replicates. Data confidence are assigned as follows:

High = grades A and B and 15 or more replicates per body part
Medium = grades A, B, and C and 15 or more replicates per body part
Low = grades A, B, C, D and E or any combination of grades with less than 15 replicates

Summary of Non-Cancer Risk Concerns for Residential Handlers

The short term dermal NOAEL of 1000 mg/kg/day was used for all handler exposures. The 10x FQPA factor for MSMA/DSMA was reduced to 3x for all populations. The target MOE for the dermal short-term exposure is 300.

The calculations of short-term dermal risk indicate that dermal MOEs are more than 300 at the **baseline** level for the all the assessed exposure scenarios.

The calculations of short-term inhalation risk indicate that inhalation MOEs are more than 300 at the **baseline** level for the all the assessed exposure scenarios.

Residential Handler Exposure and Risk Estimates for Cancer

MSMA and DSMA cancer classification is "not likely" human carcinogens; therefore a residential handler cancer assessment was not conducted.

Residential Post-Application Exposures and Assumptions

HED has determined that there are potential post-application exposures to residents entering the areas where MSMA or DSMA has been applied. The scenarios likely to result in post-application exposures are listed in Table 14 and are as follows:

- Dermal exposure from residue on lawns (adult and toddler);
- Hand-to-mouth transfer of residues on lawns (toddler);
- Ingestion of pesticide treated grass (toddler).
- Ingestion of pesticide granules (toddler).
- Incidental ingestion of soil from pesticide-treated residential areas (toddler);
- Dermal exposure from residue on golf course turfgrass (youth and adult);

MSMA/DSMA can be used on athletic fields, parks and other recreational areas. The residential post-application exposure scenario, dermal exposure from residue on lawns (adult and toddler), addresses these exposure concerns since the time spent on grass and transfer coefficients are assumed to be similar. The transfer coefficients are based on the Jazzercise method, which is assumed to be a similar exposure as playing sports on athletic fields. MSMA/DSMA can also be used as a spot treatment under ornamental trees, shrubs and plants and around sidewalks, fences and patios. Post-application residential exposures from these uses are assumed to be less than post-application exposure from a MSMA/DSMA broadcast use on

lawns. Thus, the post-application assessments done on lawn use addresses these exposure concerns.

The half lives calculated from the study data are as follows with the correlation coefficient in parentheses: 0.74 days (0.84), 9.44 days (0.21) and 5.48 days (0.37). Since the correlation coefficients are so low, the data may not be linear. Thus, the calculated half lives that used linear assumptions may not be accurate. Most of the TTR values were very low compared to the initial residues or not detectable after day seven at the three sites tested. Therefore, residential post-application exposure is assumed to be short-term.

The equations and assumptions used for each of the scenarios were taken from the Draft Standard Operating Procedures (SOPs) for Residential Exposure Assessments guidance document[15], and are given below. The following general assumptions were made for all scenarios:

- Residential post application exposure was assessed on the same day the pesticide is applied because it was assumed that the homeowner could enter the lawn immediately after application. Therefore, residential post application exposures were based on day 0.

- Adults were assumed to weigh 70. The 1 to 6 year old toddler is assumed to weigh 15 kg.

- The registrant has submitted one turf transferable residue study in support of the reregistration of MSMA/DSMA, titled *Determination of Transferable Residues from Turf Treated with Monosodium Methanearsonate* (MRID No. 449589-01).[13] This study will be used to assess post-application exposure and risk from treated turfgrass. Actual turf transferable residue (TTR) data from the MSMA turfgrass study was used since some of the natural log transformed regressed data was found to not be linear. Also, TTR data was not needed for a time period beyond what was tested for. The average TTR values for the New York site, the North Carolina site and the California site on the day of application were 0.0752, 0.0360, 0.368 $\mu g/cm^2$ respectively. The highest residue value of 0.368 $\mu g/cm^2$ from the CA site was used as a screening level assessment. If there are risks of concern (MOEs < 300) then the TTR values from each site were assessed. The study was conducted at an application rate of 2.25 lbs ai/acre, but the maximum application rate on turfgrass is 7.56 lbs ai/acre (reg #42519-6). So, the TTR values was adjusted by a factor of 3.3 to compensate for the higher application rate.

Dermal Exposure to Residues on Lawns (adult and toddler)

$$ADD = (TTR_t * CF1 * Tc * ET) / BW$$

where:

ADD	=	average daily dose (mg/kg/day)
TTR_t	=	turf transfer residue on day "t" ($\mu g/cm^2$)
CF1	=	weight unit conversion factor to convert μg units in the DFR value to mg for the daily dose (0.001 mg/μg)
Tc	=	transfer coefficient (cm^2/hr)
ET	=	exposure time (hr/day)
BW	=	body weight (kg)

- The mean dermal transfer coefficient used for turfgrass was 14,500 cm^2/hr for adults and 5,200 cm^2/hr for toddlers.

- The exposure time for adults and toddlers to turfgrass was assumed to be 2 hours per day for both age groups (1-4 years and 18-64 years), based on the 95th percentile values for playing on grass.

Hand-to-mouth Transfer of Pesticide Residues on Lawns (toddler).

$$ADD = (TTR_t * SA * FQ * ET * SE * CF1) / BW$$

where:

ADD	=	average daily dose (mg/kg/day)
TTR_t	=	turf transferable residue on day "t" ($\mu g/cm^2$ turf)
SA	=	surface area of the hands (cm^2/event)
FQ	=	frequency of hand-to-mouth activity (events/hr)
ET	=	exposure time (hr/day)
SE	=	extraction by saliva (50%)
CF1	=	weight unit conversion factor to convert μg units in the DFR value to mg for the daily exposure (0.001 mg/μg)
BW	=	body weight (kg)

- The palmer surface area of three fingers was assumed to be 20 cm^2 for a toddler (age 3 years).

- Replenishment of the hands with pesticide residues was assumed to be an implicit factor in this assessment.

- It was assumed that there is a one-to-one relationship between the dislodgeable residues on the turf and on the surface area of the skin after contact (i.e., if the dislodgeable residue on the turf is 1 mg/cm^2, then the residue on the human skin is also 1 mg/cm^2 after contacting the turf).

- The mean rate of hand-to-mouth activity is 20 events/hr for toddlers (3 to 5 years old).

- The duration of exposure for toddlers was assumed to be 2 hours per day.

Ingestion of Pesticide Treated Grass (toddler).

$$ADD = (TTR_t * IgR * CF1) / BW$$

where:

ADD	=	average daily dose (mg/kg/day)
TTR_t	=	turf transferable residue on day "t" (μg/cm^2)
IgR	=	ingestion rate of grass (cm^2/day)
CF1	=	weight unit conversion factor to convert the μg of residues on the grass to mg to provide units of mg/day (1E-3 mg/μg)
BW	=	body weight (kg)

- The assumed ingestion rate for grass for toddlers (age 3 years) was 25 cm^2/day (i.e., 2 x 2 inches or 4 in^2). This value was intended to represent the approximate area from which a child may grasp a handful of grass.

Ingestion of Granules in Treated Areas (toddler):

$$ADD = (IgR * F * CF1)/Bw$$

where:

ADD	=	Average Daily Dose (mg/kg/day)
IgR	=	ingestion rate of dry pesticide formulation (g/day)
F	=	fraction of ai in dry formulation (unitless)
CF1	=	weight unit conversion factor to convert g units in the ingestion rate value to mg for the daily exposure (1,000 mg/g).
Bw	=	body weight (kg)

- The assumed ingestion rate for dry pesticide formulations at the typical rate for ornamentals is 0.091 grams/day for toddlers age 3 years. This is based on the assumption that if 20.0 pounds of product were applied to a 10,000 square

feet of land, the amount of product per square foot would be 0.91 g/ft^2. The toddler would consume one-tenth of the product available in a square foot.

Incidental Ingestion of Soil from Pesticide-Treated Residential Areas (toddler):

$$ADD = (SR_t * IgR * CF1) / BW$$

where:

ADD	=	average daily dose (mg/kg/day)
SR_t	=	soil residue on day "t" (μg/g)
IgR	=	ingestion rate of soil (mg/day)
CF1	=	weight unit conversion factor to convert the μg of residues on the soil to grams to provide units of mg/day (1E-6 g/μg)
BW	=	body weight (kg)

and

$$SR_t = AR * F * (1-D)^t * CF2 * CF3 * CF4$$

where:

AR	=	application rate (lb ai/acre)
F	=	fraction of ai available in uppermost cm of soil (fraction/cm)
D	=	fraction of residue that dissipates daily (unitless)
t	=	post application day on which exposure is being assessed
CF2	=	weight unit conversion factor to convert the lbs ai in the application rate to μg for the soil residue value (4.54E8 μg/lb)
CF3	=	area unit conversion factor to convert the surface area units (ft^2) in the application rate to cm^2 for the SR value (2.47E-8 acre/cm^2 if the application rate is per acre)
CF4	=	volume to weight unit conversion factor to convert the volume units (cm^3) to weight units for the SR value (U.S. EPA, 1992) (0.67 cm^3/g soil)

- On the day of application, it was assumed that 100 percent of the application rate are located within the soil's uppermost 1 cm.

- The assumed soil ingestion rate for children (ages 1-6 years) was assumed to be 100 mg/day.

Dermal Exposure to Golf Course Turfgrass

The Agency has decided to address the exposures of golfers because it is an obvious potential source of exposure for a large percentage of the population. In fact, according to a 1992 report from *The Center For Golf Course Management*, 12.2 percent of the population are golfers (i.e., 28.5 million people). Golfing is considered a lifetime sport so individuals of all ages,

excluding very small children, routinely play. As a result, risk assessments must address exposures to golfers across applicable age groups. Children who are 12 years of age or older are likely to represent the vast majority of the youth that play golf on any sort of routine basis. However, the popularity of golf as a recreational pastime has increased steadily over the last few years which has resulted in more and more young children (i.e., less than 12 years old for this discussion) becoming involved in the sport. Risk assessments for these age children are more difficult to complete because of the increased uncertainties associated with any extrapolations using adult dermal exposure data and because of the increased likelihood that other behaviors that might contribute to exposure such as mouthing contaminated hands or golf balls.

Given the current state-of-the-art, the Agency cannot definitively complete an extrapolation from adults to children to calculate dermal exposures nor can it accurately predict how mouthing behaviors contribute to the overall exposure of youth golfers for several reasons (e.g., frequency of events is unavailable, chemical transfer processes not well understood). The Agency does believe, however, that these exposures should be addressed and has decided to address them by adjusting adult exposure levels using a surface area to body weight ratio (SA/BW) for 5 year old male children (i.e., the difference is larger for males compared to female making the value more protective). The SA/BW ratio was calculated using the 95th percentile body surface area coupled with the 50th percentile body weight for the 5 year old male child. Use of these factors significantly increased the per unit dose, when compared to an adult, by a factor of approximately 70 percent. The Agency believes that this additional factor should adequately address any uncertainties associated with extrapolating to child golfers due to differences in the SA/BW ratio or due to mouthing behaviors. Five year olds were selected as the target group because younger children are not believed to be a viable population for risk assessment purposes.

$$ADD_{(t)}\ (mg/kg/day) = ((TTR_{(t)}\ (\mu g/cm^2) \times TC\ (cm^2/hr) \times ET(hr/day) \times (1\ mg/1000\ \mu g))/(BW\ (kg))$$

Where:

ADD = average daily dose (mg/kg/day) at time (t) attributable to golfing on previously treated turf (mg/kg/day);
$TTR_{(t)}$ = turf transferable residue at time (t) ($\mu g/cm^2$);
TC = transfer coefficient (cm^2/hour);
ET = exposure duration (hours); and
BW = body weight (kg).

- Transfer coefficient = 500 cm^2/hour based on exposure data for two chemicals that quantified exposures to golfers. This transfer coefficient represents golfers wearing short pants and short-sleeved shirts.

- Duration is 4 hours for a chemical that can be used on all parts of a course (greens, tees, and fairways). This estimate of the average time it takes to play a round of golf which is based on the report completed by the Center For Golf Course Management *[1992 Golf*

Course Operations: Cost of Doing Business/Profitability. Library of Congress GV975.G56 1992].

- **Adult dose levels are adjusted (i.e., multiplied) by a factor of 1.7** in order to calculate dose levels for child golfers. This value represents a skewed surface area to body weight ratio calculated by the Agency using the 95th percentile value for body surface area for 5 year old male children and comparing that to the 50th percentile value for body weight for 5 year old children. The values are purposely skewed to account for the uncertainties that would be expected with calculating dose levels with children if more definitive data were available. The values used in these calculations were excerpted from tables 6-2, 6-6, 7-4, and 7-6 of the EPA Exposure Factors Handbook (1997).

- The dose levels calculated for adult golfers can be considered upper level estimates of exposure because of several reasons including the clothing scenario considered (i.e., shorts and short-sleeved shirts are not worn by all golfers), combining average values across several input parameters mathematically results in an upper percentile calculated product.

- The dose levels calculated for child golfers can be considered upper level estimates of exposure in addition to those presented above for adult golfers because of several reasons including the duration for child golfers may be lower because of developmental issues and the amount of skew introduced into the calculation through the direct comparison of the 95th and 50th percentile values for surface area and body weight, respectively.

Residential Exposure and Non-Cancer Risk Estimates

Risk Calculations

Short-term MOEs were calculated as follows:

$$MOE = \frac{NOAEL}{ADD}$$

The dermal NOAEL of 1000 mg/kg/day was used for the dermal exposure to lawns scenarios. The acute oral endpoint of 2 mg/kg/day for the hand-to-mouth, turfgrass ingestion and soil ingestion scenarios, since these are oral exposures. Table 11 summarizes the post-application exposures and non-cancer risks to residential populations.

Table 11. MSMA/DSMA Short-term Residential Post-Application Scenarios and Estimated Risks.

nario	Receptor	Application Rate Per Treatment (AR) (lbs ai/A)	TTR (μg/cm^2)[a]	Site	SRt (μg/g)[b]	Transfer Coefficient (Tc) (cm^2/hr)	Exposure Time (ET) (hrs/day)	Surface Area (SA) (cm^2/ event)	Freq. (FQ) (events/ hr)	IgR (cm^2/day), (mg/day), or (g/day)[c]	F (ai)	BW (kg)	ADD (mg/kg/day)[d]	MOE[e]
mal osure to wns	Adult	7.56	1.2	CA	-	14,500	2	-	-	-	-	70	0.50	2,000
	Toddler					5,200						15	0.83	1,200
id-to-uth	Toddler	7.56	1.2	CA	-	-	2	20	20	-	-	15	0.032	63
			0.248	NY									0.0066	300
			0.112	NC									0.0030	670
fgrass estion	Toddler	7.56	1.2	CA	-	-	-	-	-	25	-	15	0.002	1,000
idental l Ingestion	Toddler	7.56	-	-	57	-	-	-	-	100	-	15	0.00038	5,300
estion of inulars in ated as	Toddler	-	-	-	-	-	-	-	-	0.091	0.045	15	0.27	7.3
mal osure to lf Course fgrass	Adult	7.56	1.2	CA	-	500	4	-	-	-	-	70	0.034	29,000
	Child											-	0.058	17,000

Footnotes

[a] Turf Transferable Residue (μg/cm^2) from *Determination of Transferable Residues from Turf Treated with Monosodium Methanearsonate* (MRID No. 449589-01). Actual TTR data from the MSMA/DSMA turfgrass study was used since the regression from the natural log transformed data produced low R squared values. The average TTR values for the NY site, the NC site and the CA site on the day of application were 0.0752, 0.0360, 0.368 μg/cm^2 respectively. The highest residue value of 0.368 μg/cm^2 from the CA site was used as a screening level assessment. If there are risks of concern (MOEs < 300) then the TTR values from each site were assessed. The study was conducted at an application rate of 2.25 lbs ai/acre, but the maximum application rate on turfgrass is 7.56 lbs ai/acre (reg #42519-6). So, the TTR values was adjusted by a factor of 3.3 to adjust for the higher application rate.

[b] Soil residue (μg/g) = [AR (lbs ai/A) * fraction ai retained on soil (100%/cm) * 4.54E+8 μg/lb * 2.47E-8 A/cm^2 * 0.67 cm^3/g soil]

[c] Ingestion rate: cm^2/day for grass ingestion, mg/day for incidental soil ingestion, and g/day for granular ingestion.

[d] Average daily dose (ADD) (mg/kg/day)

Dermal exposure (lawns): = [TTR (μg/cm^2) * Tc (cm^2/hr) * mg/1,000 μg * ET (hrs/day)] / [BW (kg)];
Hand-to-mouth: = [TTR (μg/cm^2) * SA (cm^2/event) * FQ (events/hr) * mg/1,000 μg * ET (2 hrs/day) * SE (%)] / [BW (kg)];
Turfgrass ingestion: = [TTR (μg/cm^2) * IgR (cm^2/day) * mg/1,000 μg] / [BW (kg)];
Granular ingestion: = [F * IgR (g/day) * 1,000 mg/g] / [BW (kg)];
Incidental soil ingestion: = [SRt (μg/g) * IgR (mg/day) * g/1,000,000 μg] / [BW (kg)]; and
Dermal exposure (golf courses) = [(TTR (μg/cm^2) * Tc (cm^2/hr) * mg/1,000 μg * ET (hrs/day)] / [BW (kg))*1.7 (child dose level adjustment factor)]

[e] MOE = NOAEL (1000 mg/kg/day or 2 mg/kg/day) / ADD.

Summary of Risk Concerns for Non-Cancer Residential Post Application Exposure

The dermal NOAEL of 1000 mg/kg/day was used for the dermal exposure to turfgrass scenarios. The acute oral endpoint of 2 mg/kg/day for the hand-to-mouth, turfgrass ingestion and soil ingestion scenarios, since these are oral exposures. The FQPA safety factor was reduced to 3x for all other populations[2]. The target MOE for the dermal short-term exposure is 300 for adults, which includes the 3x FQPA safety factor for the general population.

- Hand-to-mouth transfer of residues on lawns (toddler) using the TTR data from the CA site;

- Ingestion of pesticide granulars in treated area (toddler).

It is HED's policy to routinely conduct screening level assessments (based on standard values in the Residential SOPs) for children's incidental ingestion of granules when a granular pesticide may be applied in residential settings. The screening-level assessment for MSMA/DSMA resulted in an MOE of 7.3 and is a risk of concern. Information on particle density (number of particles per pound or gram), carrier type (corn cob, clay), granular color, and average granular size is requested from the MAA Task Force in order to refine this screening level assessment.

For the residential post-application scenarios, ingestion of turfgrass and hand-to-mouth transfer of residues from lawns, the TTR value obtained in the study is thought to under estimate exposure to the toddler from these behaviors, because the TTR value was obtained by using a dry California Cloth Roller. Residue transfer from mouthing usually takes place under wet not dry conditions, which would cause the transfer to occur at a greater rate. TTR values in the turfgrass study range form 0.13 to 1.4 percent of the application rate, as opposed to the standard TTR value of 5 percent of the application rate.

Residential Post application Exposures and Risk Estimates for Cancer

MSMA and DSMA cancer classification is "not likely" human carcinogens; therefore a residential post-application cancer assessment was not conducted.

Data Gaps and Confidence in Risk Estimates

- A MSMA post-application dislodgeable residue decline study on plants and turfgrass that tests for both MSMA and cacodylic acid residues.

- Low confidence data were used to calculate the risks to handlers from the use of the following equipment: turf handgun sprayer, rights-of-way sprayer, push-type spreader, low pressure hand wand, and a backpack sprayer.

- No exposure data exists for mixing/loading/applying dry flowables with a backpack sprayer and low pressure handwand, mixing/loading/applying wettable powders with a backpack sprayer and mixing/loading/applying liquids with a "Hypo-Hatchet" injector.

- Information on particle density (number of particles per pound or gram), carrier type (corn cob, clay), granular color, and average granular size of the MSMA and DSMA granular products.

Any possible data requirements will be discussed during the risk mitigation phase of the reregistration process.

Study Review

Turf Transferable Residue Study

A turf transferable residue study titled *Determination of Transferable Residues from Turf Treated with Monosodium Methanearsonate"* MRID No. 449589-01 was conducted on MSMA. The data collected reflecting the dissipation of monosodium methanearsonate (MSMA) from treated turf meet most of the criteria specified by the U.S. Environmental Protection Agency's (US-EPA) OPPTS Series 875, Occupational and Residential Exposure Test Guidelines, Group B: Post application Exposure Monitoring Test Guidelines, 875.2100, Transferable Residue Dissipation: Lawn and Turf. The data are of sufficient scientific quality to be used to determine dislodgeable foliar residue (DFR) dissipation.

In this study, a 50:50 blend of two 51 percent MSMA liquid formulations was applied twice at the maximum application rate and the minimum application volume to several varieties of growing turf. This study was conducted under very different environmental conditions, i.e., during the hot summer in New York, the cool fall in North Carolina and the late fall to winter in California. Triplicate transferable turf residue (TTR) samples were collected using the modified California Cloth Roller technique developed by the Outdoor Residential Exposure Task Force (ORETF). Samples were collected at intervals from 0 to 28 days after treatment in NY, and sampling was extended to 49 days after treatment in North Carolina and 44 days after treatment in California. Samples were analyzed for MSMA only.

Maximum MSMA levels attained in TTR field samples collected after the second application varied widely between test sites, with the California site having a 2,120 μg/sample; the New York site having a 615 μg/sample; and the North Carolina site having a 279 μg/sample. After the second application, MSMA TTR levels dissipated to below the limit of quantification (LOQ) by the fifth day after treatment in New York, by seventh day after treatment in North Carolina and by forty fourth day after treatment in California. In North Carolina and especially in California, there was a distinct two-phase dissipation pattern after the second application. TTR values in California increased from the initial treatment to 6 hours after treatment.

The data was analyzed, using all individual data replicates after the second application as follows: from the day of application to day 7 for NY, from the day of application to day 28 for NC, and from 6 hours after treatment to day 25 for CA collected after Application #2. Since the majority of the field recoveries were above 90% for the fortification level, 2 μg/sample, closest to the amount of residue found on the grass, field fortified recoveries were not corrected for. In accordance with EPA guidance, first order dissipation kinetics were assumed. A linear regression was performed to natural log (ln) transform data. The following dissipation half-life values were obtained: 0.74 days (R^2=0.78) for NY; 9.4 days (R^2=0.21) for NC; and 5.48 days (R^2=0.36) for CA. Since the regression from the natural log transformed data produced low R squared values, actual turf transferable residue (TTR) data from the MSMA turfgrass study was used in the RED chapter. Also, TTR data was not needed for a time period beyond what was tested for.

The turf transferable residue study completed in support of the regulatory requirements contained the following omissions and flaws with respect to Series 875 Group B Post application Exposure Monitoring Test Guidelines. The most important discrepancies and issues of concern include: (1) MSMA levels in the tank mixes were about 30 percent higher than target at the New York site, and about 20% lower than target at the California site; (2) ambient temperatures were significantly cooler than the label specified temperature (between 80° and 90° F) on application days at all three sites (i.e. in NY: 78° F and 71° F.; in NC: 80° and 68° F.; in CA: 63° and 72° F.); (3) a number of rain events occurred which coincided with either application or sampling days at all three of the test sites; (4) there were major seasonal differences between the data-sets presented for the three sites, with snow falling on two occasions at one site; concurrent laboratory fortification samples were variable with up to 20 percent variability between replicates; (5) since field fortified samples contained either 2.0 μg/ sample or 2,000 μg/ sample and most of the field sample data-points were well below 700 μg/ sample, an intermediate fortification level should therefore have been chosen to better reflect the sample data; (6) the field fortified sample recoveries were extremely variable, with the highest fortification level (2,000 μg/sample) having recoveries ranging between 60.8 percent and 116.7 percent and the lowest fortification level (2 μg/sample) having recoveries ranged between 75 percent and 180 percent; (7) a metabolite of MSMA, cacodylic acid, was not tested for; and (7) The study was conducted at an application rate of 2.25 lbs ai/acre, but the maximum application rate on turfgrass is 7.56 lbs ai/acre (reg #42519-6). However, the data collected in this study are of sufficient scientific quality and HED will use the results in the RED.

Assessment of Handler Exposure to MSMA

The registrant submitted an assessment of handler exposure to MSMA titled "Assessment of Exposure for MSMA and DSMA" (MRID 437204-01). The registrant conducted an analysis of dermal and inhalation handler exposure to MSMA and DSMA based on specified application rates, cacodylic acid's dermal absorption, and exposure data available in the Pesticide Handler's Exposure Database (PHED), (version not stated, before May 1995). The six scenarios identified in the study were mixer/loader (liquid formulation), mixer/loader (wettable powder

formulation), ground rig applicator, occupational hand spray application, residential hand spray application, pilot application, and flaggers.[16]

The registrant's suggested unit exposure values were compared to the unit exposures in PHED Surrogate Exposure Guide, version 1.1, August 1998. The following registrant suggested unit exposure values are relatively similar to unit exposures to PHED: mixer/loader (wettable powder formulation) for dermal exposure, ground rig application for dermal exposure, and flagger for both dermal and inhalation exposure. The following registrant suggested unit exposure values are within a ten fold margin of PHED unit exposure values: mixer/loader (liquid formulation) for inhalation exposure, ground rig application for inhalation exposure, occupational hand spray application for both dermal and inhalation exposure, residential back pack sprayer application for dermal exposure, and pilot for both dermal and inhalation exposure. The rest of the unit exposure values differed from PHED by more than a 10 fold factor.

Annual dose and daily amortized dose were calculated for both MSMA and DSMA. HED dose not calculate annual and daily amortized doses. For MSMA used on cotton, a small grower's annual dose is 20 μg/kg/year and a large grower's annual dose is 49 μg/kg/year. A small grower's daily amortized dose is 0.056 μg/kg/day and a large grower's daily amortized does is 0.14 μg/kg/day. A mixer/loader's annual dose is 183 μg/kg/year and daily amortized dose is 0.5 μg/kg/day. A pilot's annual dose is 342 μg/kg/year and daily amortized dose is 0.94 μg/kg/day. A flagger's annual dose is 3400 μg/kg/year and daily amortized does is 9.4 μg/kg/day.

For liquid DSMA used on cotton, a small grower's annual dose is 24 μg/kg/year and a large grower's annual dose is 58 μg/kg/year. A small grower's daily amortized dose is 0.066 μg/kg/day and a large grower's daily amortized does is 0.16 μg/kg/day. A mixer/loader's annual dose is 141 μg/kg/year and daily amortized dose is 0.32 μg/kg/day. For the wettable powder formulation of DSMA, a small grower's annual dose is 141 μg/kg/year and a large grower's annual dose is 338 μg/kg/year. A small grower's daily amortized dose is 0.38 μg/kg/day and a large grower's daily amortized does is 0.93 μg/kg/day. A mixer/loader's annual dose is 218 μg/kg/year and daily amortized dose is 0.6 μg/kg/day. A pilot's annual dose is 22 μg/kg/year and daily amortized dose is 0.060 μg/kg/day. A flagger's annual dose is 41 μg/kg/year and daily amortized does is 0.11 μg/kg/day.

For the remaining occupational uses of MSMA and DSMA, such as orchards, non-crop, and lawn application, the annual dose of MSMA liquid ranges from 141 to 52 μg/kg/year and the daily amortized dose ranges from 0.38 to 0.14 μg/kg/day. The annual dose of DSMA liquid ranges from 151 to 52 μg/kg/year and the daily amortized dose ranges from 0.42 to 0.14 μg/kg/day. The annual dose of DSMA wettable powder ranges from 885 to 78 μg/kg/year and the daily amortized dose ranges from 2.5 to 0.21 μg/kg/day.

For residential lawn application, the annual dose of MSMA and DSMA liquid is 3.5 μg/kg/year and daily amortized dose is 0.0095 μg/kg/day. The annual dose of DSMA wettable powder is 3.8 μg/kg/year and daily amortized does is 0.011 μg/kg/day.

It is HED's policy to use the PHED Surrogate Exposure Guide, Version 1.1, August 1998 when assessing handler exposure. Use of the Surrogate Exposure Guide offers certain advantages over attempting to subset PHED for each individual exposure assessment. For example, use of the Guide results in consistency among exposure assessments for similar pesticide exposure scenarios, and use of the Guide is relatively easy and, therefore, saves resources by reducing the time spent on analyzing individual data sets. Moreover, restrictive subsets (e.g., one exposure study) may not encompass the variety of agricultural equipment in use throughout the country and the inter-variability of exposures among handlers. Therefore, the unit exposures from the PHED Surrogate Exposure Guide, Version 1.1, August 1998 will be used in the MSMA and DSMA Occupational and Residential Exposure Assessment.

Assessment on Post application Exposure to MSMA

An assessment on post application exposure titled "Assessment of Post application Exposure Potential for MSMA and DSMA" (MRID 437205-01) was submitted by the registrant. The assessment calculated average daily doses of occupational and residential populations exposed to turf after the application of MSMA and DSMA. HED conducted an assessment using the study parameters and HED policy.[17]

For occupational exposures, the registrant submitted assessment's daily dermal dose is 10 times higher than HED's assessment of daily dermal dose using the registrant's stated parameters. For residential exposure, the registrant submitted assessment's daily dermal dose is approximately 4 times less for adults and two times greater for children than HED's assessment of daily dermal dose.

This submission does not satisfy Series 875 - Group B guideline data requirements for residential lawn uses because the studies used in the assessment were not MSMA or DSMA and the properties of these chemicals such as dissipation rate and transferability were not shown to be the same as MSMA or DSMA. Also, the background laboratory information was not provided for the studies to determine if the comply with EPA guidelines.

A waiver for non-crop land and agricultural post application exposure data was requested at the end of the study. The registrant's's rationale for this is that non-crop land and agricultural uses of MSMA and DSMA provide no opportunity for contact with the residues that would likely produce measurable human dermal residues. The post application activities associated with non-crop land and agricultural uses would involve limited contact with treated surfaces.

HED has reviewed this data waiver requests and recommends waiving the data requirement for non-crop land uses. The non-crop land data waiver does **NOT** include turf/lawn data requirements, since there is a high potential for residential exposure. HED recommends denying the data waiver request for agriculture uses, because this request is not specific as to which agricultural uses they wish to have the data requirements waived for.

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7) MSMA and DSMA Labels

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14) U.S. EPA 2000. HED Science Advisory Council for Exposure, Policy 003.1. *Agricultural Default Transfer Coefficients*. Health Effects Division, Office of Pesticide Programs, August 7, 2000.

15) U.S. EPA 1997. *Draft Standard Operating Procedures (SOPs) for Residential Exposure Assessments*. December 1997 with revisions stated in *Overview of Issues Related to The Standard Operating Procedures for Residential Exposure Assessments.* Presented to the FIFRA Scientific Advisory Panel on September 21, 1999.

16) U.S. EPA 2000. *Review of "Assessment of Exposure for MSMA and DSMA.* MRID 437204-01. DP Barcode D217733. September 5, 2000

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