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MEMORANDUM

TO: Lisa Ross, Ph.D., Chief
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FROM: Anna M. Fan, Ph.D., Chief *(Original Signed By Dr. Anna Fan)*
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DATE: July 25, 2013

SUBJECT: COMMENTS ON THE DRAFT EXPOSURE ASSESSMENT DOCUMENT FOR CARBARYL

The Office of Environmental Health Hazard Assessment (OEHHA) has reviewed the draft Exposure Assessment Document (EAD) for occupational and ambient air exposure to carbaryl, prepared by the Department of Pesticide Regulation (DPR), dated June 28, 2012. Our comments are provided in the attachment. OEHHA has provided comments in a separate memorandum on the Risk Characterization Document for Carbaryl. OEHHA reviews risk assessments prepared by DPR under the authority of Food and Agriculture Code section 11454.1.

OEHHA has provided a number of comments on the exposure assessment methodology and conclusions of the draft EAD. These comments and our recommendations, as well as suggested clarifications, additions and corrections, are contained in the attachment.

Thank you for providing this draft document for our review. If you have any questions regarding OEHHA's comments, please contact Dr. Charles Salocks at (916) 323-2605 or me at (510) 622-3200.

Attachment

cc: Charles B. Salocks, Ph.D., D.A.B.T.
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Office of Environmental Health Hazard Assessment

OEHHA's Comments on the Draft Exposure Assessment Document for Carbaryl

The Office of Environmental Health Hazard Assessment (OEHHA) is responding to a request from the Department of Pesticide Regulation (DPR) to comment on the draft Exposure Assessment Document (EAD) for carbaryl [*1*-naphthyl *N*-methylcarbamate]. OEHHA reviews risk assessments prepared by DPR under the authority of Food and Agricultural Code Section 11454.1, which requires OEHHA to conduct scientific peer reviews of risk assessments conducted by DPR.

SUMMARY

The EAD was comprehensive and assessed a wide range of exposure scenarios of workers in agricultural and non-agricultural settings, bystanders and residents. The uncertainties and calculations were well described.

OEHHA concurs with most of the approaches and factors used in the EAD, but have the following suggestions:

- Update exposure calculations using the current U.S. Environmental Protection Agency (US EPA) guidelines for dislodgeable foliar residues (DFR) and consider US EPA assumptions for clothing of residential handlers and resident reentry level. Update breathing rate defaults or consider OEHHA's breathing rates to calculate exposure.
- Consider providing exposure estimates from take-home residues and estimates of ingestion doses for children with pica.
- Provide more detailed descriptions of the monitoring studies, and provide justification for selecting certain surrogate chemical studies and rejecting others.
- Reconsider clothing assumptions used in the homeowners' exposure scenario, and calculate post-application exposure without re-entry interval for residential users.
- Identify representative activities within the high use season instead of establishing representative activities independently of the pesticide use.

In addition, we offer some suggestions to improve the readability of the document. These suggestions include revising the abstract to include key issues beyond risk assessment conclusions, expanding the introduction to orient the reader, and adding conclusion statements for each major section.

SPECIFIC COMMENTS

ABSTRACT (pages 7 and 8)

The abstract summarizes the key conclusions regarding risk and is not actually an abstract. Listed scenarios were identified as "having the highest level of concern" based on comparison of exposure to toxicity profile (as stated on page 88 in the RISK APPRAISAL section). OEHHA recommends that if the section continues to be named as an "abstract" it should be revised to reflect the key points from each of the sections in the EAD (environmental concentrations, pharmacokinetics, scenarios, exposure assessment...), not solely conclusions regarding risk.

INTRODUCTION (page 8)

The introduction contains only two sentences on carbaryl's use and a statement about its mode of action. OEHHA recommends this section be revised to provide the reader with information on the layout and content in the EAD.

EXPOSURE SCENARIOS (pages 17 to 27)

The EAD describes a wide range of occupational and non-occupational scenarios including application exposure of handlers, and post-application exposure of workers, bystanders, residents (including children at play on treated lawns), and swimmers. For the exposure of workers entering a treated area (reentry) after a certain time (i.e., the reentry interval or REI), DPR used a tiered approach to select work activities. Since carbaryl is used on many crops, some of the crops were grouped and portrayed by a representative crop. For each representative crop, work activities with the highest potential for exposure were selected as scenarios for exposure calculations.

OEHHA concurs with the choice of scenarios in the EAD. However, OEHHA recommends that the EAD includes exposure to carbaryl in take-home dust. There is evidence in recent studies showing that non-volatile pesticides can be found in significant amounts in homes of agricultural workers (Bradman et al. 2007, Curwin et al. 2007, Golla et al. 2012, Gunier et al. 2011) or homes neighboring agricultural fields (Gunier et al. 2011). Gunier et al. (2011) investigated the association between proximity to fields and pesticides residues in carpet dust. Significant associations were determined for simazine, phosmet, chlorpyrifos, iprodione and chlothal-dimethyl. While the study did not find a significant association for carbaryl, there were limitations to the study, including small sample size and lack of information about pesticide use patterns. In addition, the EAD should note the possibility that there are potentially multiple sources of carbaryl contributing to the levels detected in indoor dust and that an assessment of aggregate exposure may be warranted.

PHARMACOKINETICS (pages 24 to 31)

The dermal absorption was set at 70 percent (%) based on results from a dermal absorption study in rats following 12 hours of exposure to 4 microgram per square centimeter (μg/cm^2) of carbaryl. This value was based on the "best available data for the anticipated range of occupational and residential exposures" (page 89). DPR decided that the selected study, which used acetone as a solvent vehicle, was acceptable because comparison of two other studies showed that acetone did not alter (increase) the dermal absorption of carbaryl (page 26 and EXPOSURE APPRAISAL, *Estimated Dermal Absorption*, page 89). Other *in vivo* data from studies in rats were available but their doses were high (35.6 μg/cm^2) compared to anticipated human carbaryl exposures, and this may have resulted in underestimation of percutaneous absorption because high skin surface loading typically results in lower absorption efficiencies.

Human data were not used because the study was not well conducted (pages 30 and 31). All *in vitro* data available were derived from studies that used high doses (40 μg/cm^2), and consequently the percutaneous absorption rate may have been underestimated. Results from the *in vitro* studies (which showed 20-40% absorption) were within the range of the rates observed with the high-dose rat study. The RISK APPRAISAL section (pages 88-89) explained clearly how DPR used *in vitro* data in combination with other information as weight of evidence. The study selection was justified and the quality assurance was verified. The dermal absorption rate identified in the EAD was much higher than the rate determined by US EPA, in part because US EPA excluded bound skin residues in estimating penetration (US EPA 2008). OEHHA concurs with the choice of 70 percent for dermal absorption rate.

The EAD used a default value of 100 percent for inhalation intake and uptake since no experimental data were available, and suggested (page 94) that using this default value for the inhalation absorption rate might overestimate exposure. Nevertheless, OEHHA believes the default value is appropriate given the lack of data to support an alternative absorption rate.

Numerous biomonitoring studies were available for determining the pharmacokinetics of carbaryl but the data did not correlate specific metabolites with exposure levels. OEHHA agrees with the conclusion in the EAD that the results of these studies were not usable for the exposure assessment.

ENVIRONMENTAL CONCENTRATIONS (pages 31 to 46)

The EAD provided summaries and evaluations of numerous studies to determine the concentrations (on treated surfaces, water, and air) to be used for the calculation of exposure.

OEHHA suggests that, at the end of each subsection, the EAD include a brief statement of conclusion indicating which specific studies and environmental concentrations will be used to calculate exposures. For example, under ***Water*** (pages 42 to 46), the last paragraph in the section stated that "Reported concentrations of carbaryl in surface water were used in calculating swimmer exposure estimates" (page 43), but no specific study was cited. The water concentration that was used to estimate swimmer exposure appeared as a part of the study description for Walters et al. (2003) (page 45) under the subsection of "Surface Water Monitoring: Application Site."

Dislodgeable Foliar Residues **(pages 31 to 37)**

DPR followed the acceptability criteria set by US EPA (1996) to select the studies for estimating a worker's dermal exposure to DFR. The DFR studies conducted with carbaryl included dissipation studies on field crops, vegetables and fruits, and spot sampling studies. In the absence of carbaryl-specific DFRs for certain crops, DFRs from other chemicals or other crops were used as surrogates. Interpolation of DFR data for the days that were not sampled post-application was done by log-linear regression of data for sampled days; the rationale on the use of this regression was provided on page 91. The transfer coefficients (TC) were considered not chemical-specific but rather crop- and activity-specific. When data were not available, DPR used default TC values from similar cases (that is, a combination of similar activity and a similar crop).

OEHHA concurs with DPR's methodology and DFR and TC values, as summarized in Table 16 (page 36). However, the studies and values may need to be updated using the current version of the US EPA guidelines (2012).

Transferable Turf Residues (TTRs) were determined to estimate the dermal exposure to carbaryl on treated turf and sod (pages 35 to 37). Carbaryl residues were measured in two studies, one using a liquid formulation and one using a granular formulation. On page 35, the introductory sentence to this section stated "Available data do not appear to support a consistent relationship between TTR and exposure." It isn't clear whether this is a general statement that applies to all pesticides or a statement that applies specifically to the TTR data that are available for carbaryl. In the summaries of the two studies, there was no explanation why these results were rejected and surrogate exposure monitoring data were used instead (page 37, first paragraph). OEHHA recommends additional explanation for rejection of the TTR studies. Furthermore, this section of the EAD should indicate why surrogate exposure data were used.

***Air* (pages 37 to 42)**

Ambient Air
The EAD described two studies, conducted by the California Air Resources Board (ARB) and U.S. Geological Survey (USGS), to determine ambient air levels at both urban and rural sites (page 37). The USGS monitored ambient air concentrations of carbaryl in Sacramento County (Majewski and Baston 2002) and carbaryl was detected at both urban and rural sites. The highest concentration was 0.0306 microgram per cubic meters (µg/m^3). Results of this study suggested that the general population can be exposed to airborne carbaryl in areas that are distant from application sites.

Ambient air monitoring was conducted by ARB in three counties with relatively high carbaryl use (Fresno, Tulare, and Kings) during times when peak use was anticipated (ARB 2008). Carbaryl was not detected in any of the samples. The EAD did not use the results from these studies to estimate exposure to carbaryl in ambient air. Instead, a higher air concentration (estimated for bystanders at the application site) was selected to provide a "health-protective" estimate (page 88). These air concentrations ranged from 43.9 µg/m^3 for a one-hour exposure to 1.59 µg/m^3 for chronic and lifetime exposures, as shown in Table 35. OEHHA concurs with the selection of air concentrations for bystander exposure to calculate ambient air exposure.

Application Site Air Monitoring: Agricultural Applications
Data from two air monitoring studies for carbaryl associated with agricultural applications were available, but were determined not acceptable because of limited sampling and lack of information about application and monitoring conditions (page 37). Instead, data from a methyl parathion airblast application (Barry 2006) was used as a surrogate to determine the air concentration for bystander exposure (pages 37 to 40). The justification was that airborne concentrations and drift depend on the equipment, timing, and location of the application, and the vapor pressure of the active ingredient rather than the chemical structure of the active ingredient (page 38). OEHHA considers the justification reasonable. However, the potential impact of a 10-fold higher vapor pressure for methyl parathion (page 38, 2nd paragraph) compared to carbaryl on the inhalation exposure estimates for bystanders should be discussed in the EAD.

Application Site Air Monitoring: Applications in Urban Areas
Multiple studies were available that monitored on-site air in California (Table 18, page 41). The highest concentration detected in any of these studies was 12 µg/m^3 (Neher et al. 1982). Two studies were available that monitored off-site air in California (Table 19), one monitoring drift from an aerial application and one monitoring off-site air following a mist blower application. The conclusion of the study summaries provided no indication which one was selected as a basis for estimating bystander exposure from applications in urban areas. This information was provided much later on page 87 (Table 87). OEHHA suggests that the EAD include a discussion on the merits of the Neher et al.

(1982) study and provide justification why it was used as a basis for calculating these exposure estimates.

Water **(pages 42 to 46)**

Carbaryl has been detected in surface water and ground water as a result of rainwater, and runoff from application sites. Reported concentrations of carbaryl in surface water were used in calculating swimmer exposure estimates. Walters *et al.* (2003) measured the highest carbaryl concentration in a swimmable body of water at 6.94 microgram per liter (µg/liter) in a fishpond in Sacramento County; this concentration was used to estimate swimmer exposure. OEHHA agrees with the selection of the surface water data that were used to calculate swimmer exposure.

EXPOSURE ASSESSMENT (pages 46 to 88)

Exposures (as absorbed dosages) of workers, bystanders, residents, and swimmers were calculated using the selected environmental concentrations and other parameters such as exposure rates, protective clothing factors, body weights, skin surface area, absorption factors, and exposure durations. The durations included short-term, intermediate-term, and long-term (annual and lifetime) exposures.

Occupational Handler Exposure **(pages 47 to 66)**

The dermal and inhalation exposures of handlers (mixer, loader, and applicator, abbreviated M/L/A) under agricultural and non-agricultural settings (e.g., lawns, golf courses and rights of way) were determined for each application method (such as hand-held, airblast, groundbloom, aerial, and ground applications). They were calculated using environmental concentrations, exposure rates from carbaryl or surrogate monitoring studies or the US EPA Pesticide Handler Exposure Database (PHED), applicable protection factors, and various assumptions. Short-term exposure estimates were calculated using application sizes (acres treated) recommended by US EPA as realistic maxima. The application rate was the maximum allowed per the product label.

Seasonal, annual and lifetime exposures were also estimated for all handlers, except those applying carbaryl on rights-of-way because repeated exposures are not anticipated for this scenario. The application rate was based on the highest annual mean values in California during a 5-year interval. The application size used was the average from the Pesticide Use Report (PUR) data or the typical application size assumed by US EPA. To determine the high-use period, temporal patterns (percent of annual use based on pounds applied per month 2006-2010) were investigated using data from the county that had the highest application rate and seasonal application for a specific crop. OEHHA concurs with the values for application size and rate, and the high use period.

Monitoring studies and PHED were used to determine exposure rates (µg carbaryl exposure/pounds handled), as discussed under the following two subsections.

Exposure Monitoring Studies (pages 47 to 50, Tables 20-29)
Six studies monitored applicators using hand-held spray equipment. With the exception of Merricks (1997), these studies could not be used to estimate exposure because of problems with the protocol or analysis (page 47). Merricks (1997) monitored exposure of residential handlers applying multiple carbaryl products (page 47, Table 20): a dust product, and liquid products using three liquid application methods (ready-to-use trigger sprayer, hose-end sprayer, and hand-pump sprayer), each involving monitoring of 40 replicates. In this study, all handlers wore gloves, except those using dusters. A glove protection factor (90%) was added to the duster handler exposure since the current label requires the use of gloves for dust products. OEHHA concurs with the use of data from this chemical-specific study to estimate exposure for low pressure handwand M/L/A (page 62, Tables 26 and 27), trigger sprayer and hose-end sprayer M/L/A (page 63, Tables 26 and 27) and dust M/L/A (page 66; Tables 28 and 29). OEHHA also agrees with the glove protection factor and with DPR's statement that the protection factor might underestimate exposure (pages 90-91).

Three studies monitored applicators using airblast equipment. With the exception of Smith (2005), these studies could not be used to estimate exposure as explained on pages 47 to 48. Smith (2005) monitored dermal and inhalation exposure of airblast applicators driving open-cab tractors to carbaryl and wearing either Sou'wester rain hats (15 replicates) or hooded rain jackets (10 replicates). OEHHA concurs with the use of data from this chemical-specific study to estimate exposure for airblast applicator (pages 48-49, 55-58; Tables 21, 24, and 25).

No chemical-specific monitoring data were available for granular applications using a push-type lawn spreader (page 49). DPR used a "well-conducted" surrogate study by Klonne and Honeycutt (1999) with applicators using Dacthal® granular herbicide, containing 0.9 percent dimethyl tetrachloroterephthalate (the active ingredient). Dermal and inhalation exposures were estimated for push type-spreader loaders and applicators (pages 65-66, Tables 20, 28 and 29). OEHHA concurs with the use of a surrogate study to estimate exposure when no chemical specific data was available, but justification for the selection of the study conducted by Klonne and Honeycutt (1999) is needed.

Exposure Estimates Using the Pesticide Handler Exposure Database (page 50, Tables 22-29)

DPR used the PHED to determine exposure estimates for all other handlers (page 50) utilizing the following application methods: aerial (pages 50-53, Tables 22-23), airblast (mixer and loader; pages 48-49, 55-58; Tables 21, 24, and 25), groundboom (pages 58-59, Tables 24 and 25), chemigation (page 59), rights-of-way (page 60, Table 26), backpack sprayer (page 60, Tables 26 and 27), high pressure handwand (page 62, Tables 26 and 27) and broadcast spreader (page 63, Tables 28 and 29).

As discussed in the appraisal (page 89), the most recent studies cited in PHED were conducted in 1994. The measurements done using older equipment and practices tended to overestimate exposure (Beauvais et al. 2007). Because of the degree of uncertainty in the PHED data, DPR used the 90 percent upper confidence limit of the 95th percentile values for short term exposure, and the 90 percent upper confidence limit of the arithmetic mean for long term exposure estimates. Total exposure was assumed to be lognormally distributed with a coefficient of variation of 100% (Beauvais et al. 2007). PHED values were adjusted to sample size by using multipliers. Because no chemical specific data were available, OEHHA concurs with the use of PHED to estimate exposures for these groups of handlers.

***Occupational Post-Application Exposure* (pages 67 to 79)**

For post-application exposure estimates, DPR determined crops where carbaryl is used, as reported in DPR's Pesticide Use Report, selected work activities that represent typical fieldworker activities for a crop group, and identified the activities with highest potential exposures (page 20, Tables 7 and 8). The studies used to calculate the DFR and TC were discussed on pages 31 to 37.

OEHHA suggests that the identification of representative activities included consideration of the extent of carbaryl use. High exposure could occur during high use season. For example, pruning was identified as the representative activity for the use of carbaryl on olive trees (page 22), but according to PUR data (page 75) this activity does not occur during the months of high carbaryl use (July-August). This could have underestimated the exposure.

The EAD identified five studies (Tables 30-31) to estimate post-application exposure: (Klonne et al. 2001a) for olive pruning; (Klonne et al. 2001b) for cabbage scouting, cucumber scouting, and tobacco hand harvesting; (Klonne et al. 2001c) for apple hand thinning; (Klonne and Merricks 2000) for citrus pruning; and (Zweig et al. 1984) for strawberry scouting. Apple DFR data were used as a surrogate for asparagus hand harvesting, lettuce scouting, and corn detasseling. Strawberry DFR data were used as a surrogate for grape leaf pulling, bean scouting, blackberry pruning, potato scouting, and tomato staking/tying. Citrus DFR data were used as a surrogate for ornamental plant hand harvesting. OEHHA concurs with DPR's choice of selected studies and surrogate data.

Short term post-application exposure estimates were calculated for workers for use of carbaryl on asparagus, beans, blackberry, cabbage and tobacco. Short term and long term post-application occupational exposure estimates were calculated for use of carbaryl on citrus, corn, cucumber, grape, lettuce, olive, ornamental plants, potato, strawberry, and tomato. OEHHA supports the selection methodology of activities and durations of exposure.

Turf maintenance
For workers on turf or sod after application of carbaryl, dermal exposure was assumed to occur the same day as the application because the product label did not specify a post-harvest interval (PHI) for applications to golf courses, lawns, and other turf (page 78). Results from a study of adults doing exercise on oxadiazon-treated carpet (Rosenheck and Sanchez 1995) were used as surrogate data for carbaryl to determine the exposure rate (micrograms per kilogram per hour, μg/kg-hour). Dermal exposure was adjusted using a 90 percent protection factor for covered body regions provided by long sleeves, long pants and shoes. In this scenario, the EAD only determined short term exposure because carbaryl application on turf was infrequently reported (DPR 2012).

OEHHA concurs with these assumptions although the choice of oxadiazon as a surrogate needs to be justified. This study was briefly described, using the same text, on pages 79 and 82, but no details were provided on how the exposure rate was determined. Such explanation should be included as part of the presentation of studies under Transferable Turf Residues (TTR) on pages 35 to 36.

***Residential Handler Exposure* (pages 79 to 81)**

For residential handlers, a surrogate study with Dacthal® (Klonne and Honeycutt 1999) for push-type spreader application and PHED data for backpack sprayer application were used to determine the exposure rates. Data from carbaryl studies (Merricks 1997) were used for workers using handwand, trigger sprayer, hose-end sprayer, and dust can application. The exposure rate determinations assumed that all handlers (push type spreader included) wore protective clothing and chemical-resistant gloves (Table 32).

OEHHA is concerned that this assumption may not be valid based on the following information. On page 17, the EAD stated "In contrast [to liquid formulations], most labels on granular products and baits have user safety recommendations rather than requirements for residential users. As users can legally choose not to follow the recommendations, exposure estimates for residential handlers of these products do not assume that protective clothing or PPE are used." Page 92 of the RISK APPRAISAL section included the following statement: "Users of pesticides are legally required to follow use directions given on pesticide labels but non-occupational pesticide handlers are not inspected for safety. In recognition of this enforcement gap, exposure estimates were calculated for users not complying with product label requirements for PPE." Furthermore, there was a large difference when exposure estimates were calculated for users NOT complying with product label requirements for Personal Protective Equipment (PPE) (Table 38). When results were compared, exposures without PPE were estimated to be 3 to 80 times higher than those with PPE (page 93). Despite the acknowledgement of a low level of enforcement, DPR still assumed PPE use in the exposure estimate calculations. OEHHA suggests the EAD present only the exposure estimates that were calculated assuming no PPE, as shown in Table 38 (page 92), with handlers wearing loose-fitting shorts and no gloves. US EPA considered that residential applicators would wear short pants, T-shirts and shoes (US EPA 1992, 2012) as a "worse case but common scenario".

Carbaryl liquid applications were restricted to spot treatments of 1000 square feet and 2-4 applications/year at least 7 days apart. The maximum rate allowed was a function of the application type. Carbaryl granular/bait applications were restricted to treatments of 0.5 acre at 8.28 pounds of active ingredient per acre (lb AI/acre) with no minimum reapplication interval or applications/year. Seasonal, annual and lifetime uses were not anticipated. Only the short-term absorbed daily dose (STADD) was calculated (page 80, Table 32). OEHHA concurs with the assumptions and the calculation only for short-term exposure.

***Residential Post-Application Exposure* (pages 81 to 84)**

<u>Dermal Exposure from Reentry onto Treated Lawns (pages 81 to 83)</u>
The representative reentry scenario in residential settings is dermal exposure from contact with treated lawns. Dermal exposure rates for toddlers (3-year olds) and adults on treated lawns were calculated using data from a surrogate study with adults exposed to oxadiazon (Rosenheck and Sanchez, 1995). Adults and toddlers were expected to spend 2 hours per day on treated turf (US EPA 1997).

OEHHA concurs with the assumptions that were incorporated into these calculations as shown on Table 33 (page 82), but suggests that DPR clarifies the assumptions regarding the clothing worn by children and adults. Previous comments about the oxadiazon study also apply to this section.

On page 78, DPR stated that reentry was assumed to occur on the same day as the application without any reentry interval (REI). But the study used to estimate exposure (Beauvais 2012) followed the label requirement "until the spray has dried". Depending on the weather conditions at the time of application, the drying time could last several hours, particularly along coastal areas of California.

If the EAD used data from a study with REI without adjusting the result to account for a "no REI" assumption, it most likely underestimated exposure. Moreover, OEHHA notes that the assumption "until the spray has dried" is subjective and vague, adding uncertainties to the assessment. US EPA (2012) considered post-application exposure for residential users without re-entry interval. OEHHA suggests that DPR follow US EPA guidance and adjust the data so they are consistent with the EAD assumptions. In addition, the EAD should provide the data and calculations from the Beauvais (2012) study to show how the exposure rates were determined, instead of simply citing this internal report.

Incidental Non-Dietary Ingestion of Pesticides Applied to Turf

Incidental non-dietary ingestion by toddlers of pesticides applied on turf was included to account for hand-to-mouth transfer, object-to-mouth transfer and soil Ingestion (pages 83-84). A carbaryl-specific non-dietary ingestion exposure monitoring study was not available. Consequently, exposure estimates were determined based on TTR (Mester 1999). Overall, non-dietary ingestion exposures were considered insignificant compare to dermal exposure (page 83) from reentry to treated turf. OEHHA agrees with the approach to calculate the exposure dosages for children with normal behavior, but suggest that ingestion exposure of children with pica should also be considered.

***Swimmer Exposure* (pages 84 to 85)**

No monitoring data for swimmers exposed to carbaryl-contaminated water was available. The dermal and oral exposures were calculated by multiplying the concentration in surface water by the dermal and oral uptake rates in children (6 years old) and adults. The carbaryl water concentrations for short-term and long-term exposures were the highest post-application levels measured in a pond and the median concentration in surface water samples, respectively. Exposure times were assumed to be 5 hours per day for short-term exposure estimates, and shorter (2.3 hours per day for children and 1.3 hours per day for adults) for long-term exposures. Default values and equations from US EPA (US EPA 2003) were used to address swimmer exposure in pools. The relevance of this approach to an outdoor swimmer scenario is difficult to assess. No information was available on frequency and duration of outdoor swimming. The EAD suggested that the concentration in surface water likely overestimated the exposure for multiple reasons (page 94). Children's exposure was considered the worse-case scenario because children have greater surface area to body weight ratio than adults (page 94). Aggregate exposure was estimated for swimmers by summing the dermal and oral exposures, while inhalation exposure was considered negligible in the outdoor setting (pages 83-85). OEHHA concurs with the assumptions and calculations for swimmers' dermal and oral exposures to carbaryl. In California, the assumption that the weather is suitable for outdoor swimming for 100 days per year is reasonable.

Airborne Exposures Associated with Applications **(pages 85 to 87)**

Bystander exposures to airborne carbaryl from agricultural applications, as well as urban and suburban applications (public pest control) were calculated. The exposure rates were based on studies (Barry 2006, Wofford and Ando 2003) with a surrogate compound, methyl parathion. The use of surrogate data was justified by the observation that drift is less affected by the chemical structure of the active ingredient (AI) itself than by the application method and various physical factors (page 95). The EAD estimated exposure by multiplying the concentration in air by the uptake (page 85, Table 35) using default average breathing rates of 0.59 cubic meters per kilogram body weight per day (m^3/kg-day) for children and 0.28 m^3/kg-day for adults to calculate human exposure levels (in terms of mg/kg-day) from air concentrations.

OEHHA concurs with the use of the methyl parathion study but is concerned with the breathing rates used to calculate exposure. OEHHA recommends that DPR update its policy and consider citing the breathing rates developed for the *Air Toxics Hot Spots Program Risk Assessment Guidelines: Technical Support Document (TSD) for Exposure Assessment and Stochastic Analysis* (OEHHA 2012). In the TSD, the mean and 95^{th} percentile daily breathing rates for infants are 0.66 and 1.09 m^3/kg-day, respectively; for adults the corresponding values are 0.19 and 0.29 m^3/kg-day.

Ambient Inhalation Exposure **(page 88)**

The EAD considered bystander exposure estimates to be appropriate to address ambient inhalation exposure. Exposure to ambient air was anticipated to be equal or less than the estimated bystander exposure. OEHHA concurs with this position. The comment about breathing rates for bystander exposures is also applicable to this scenario.

EDITORIAL COMMENTS

The readability of the document would be improved if the headings (sections and sub-sections) were numbered.

The equations for the calculation of absorbed daily doses were presented in different formats in the EAD. They were in footnotes under the Occupational Handler Exposure section (for example, page 52, Table 22, footnote e). But they were in the text for the Occupational Post-Application Exposure section (for example, page 67, 4th paragraph). For clarity and consistency, OEHHA suggests a single format for all equations.

Page 35, 3rd paragraph, 4th line: Some words are missing in the sentence, "Following each application, the plots were irrigated; the with 0.3 to ..."

Page 35, last paragraph, first word: "IKrolski" should be "Krolski"

Page 44, third paragraph: "A report from the California Department of Fish and Game compared carbaryl concentrations measured during surface water monitoring to concentrations found to be toxic to aquatic organisms in laboratory studies, and determined that carbaryl concentrations in the Sacramento-San Joaquin River system can present acute and chronic hazards to aquatic life (Siepmann and Jones, 1998). An assessment by DPR staff concurred (Starner, 2007)". OEHHA suggests deleting this paragraph since it is not related to the exposure assessment.

Page 46-88 EXPOSURE ASSESSMENT: This section needs better organization with additional headings, especially since it is over 40 pages long.

- An overview, similar to that presented under the heading of Occupational Post-Application Exposure (page 67), would be helpful for other subsections.

- The second and third paragraphs on page 46 discuss the exposure calculation and assumptions for workers. There was no similar information about other exposed populations such as residents and swimmers. Also this discussion seemed to be out place as it was presented before the discussion of the carbaryl concentration data that was used for dose calculation.

- The discussion of granular applications (on page 49) should be presented before Table 20, where the data are provided.

- The heading "Aerial Applications" and subsequent headings (page 50 and on) should have their own subsections, instead of immediately following the discussion of Exposure Monitoring Studies and PHED (pages 46 to 50).

Table 26: The exposures from the use of low-pressure handwand, trigger spray, and hose-end sprayer were based on a study conducted by Merricks (1997). This was noted in Table 27, and should also be noted in Table 26.

Page 67: In the equation, "ADD" should be "STADD."

Page 68: In the oxadiazon study, the body weight used for residential for post-application exposure (Table 33) was 69.4 kg, whereas 70 kg was used in other parts of the EAD (Tables 30, 31) based on this same study. Mathematically this difference is trivial but perhaps the same values should be used for consistency.

Page 84: Under "Soil Ingestion," the units for bulk soil density should be g/cm^3, not cm^3/g, and the body weight for 6 year old child (15 kg) should be specified as an assumption in the text.

Page 86 (Table 35) and page 87 (Table 36): This table cited an OEHHA 2000 reference for the hourly breathing rate. DPR should update the value, if needed, and cite the latest version of OEHHA's guidelines (OEHHA 2012).

Pages 89-90: The text (pages 89-90) which relates to Table 37 (PHED data) does not give the chemical specific exposure rates for all scenarios described. In order to compare PHED data with chemical specific data, it would be helpful to have the rates from both sources in the text or the Table, even though the references are included.

Pages 96-118: Many of the web links associated with certain references are not working. For example, the links starting with http://www.cdpr.ca.gov/docs/empm should start with http://www.cdpr.ca.gov/docs/emon. Other links, such as http://www.cdpr.ca.gov/docs/sw/contracts/usgs024100.pdf and http://www.arb.ca.gov/research/abstracts/a6-177-33.htm did not work either.

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