SALT LAKE CITY MOSQUITO ABATEMENT DISTRICT

Executive Director's Report

November 2025

1. **Personnel:**

Personnel	
Staff	Seasonal
12	10

Type of Work	2025	3 - Year Average
Adulticiding	0.00	0.00
Wetlands / Rural	51.50	13.00
Fish Culture	153.00	43.00
Catch Basins / Gutters	0.00	0.00
Tree Holes	0.00	0.00
Prison	0.00	2.50
Service Request	3.00	.67
Traps	9.00	41.17
Laboratory	272.50	244.42
Office / Administration	791.50	703.25
Equipment Maintenance	271.50	214.58
Facility Maintenance	402.00	214.83
Training	244.00	181.42
Education	136.50	70.58
Unmanned Aerial System	0.00	8.50
CSU Grant	32.50	54.58
Aerial Operations	47.50	0.00
Other / Errands	59.50	72.67
Comp. Time Used	92.50	75.42
Vacation	118.75	190.08
Additional Hours	0	5.33
Holidays	92.00	208.67
Sick Leave	87.75	47.50
Total	**2,865.00**	**2,392.17**

2. Office/Lab/Shop Activities:

Ary Faraji, Executive Director

- Executive Director Faraji met with ESA MUVE Vice President Dr. Alex Ko on 3 November 2025.
- Executive Director Faraji presented at Dr. Scott Benson's Epidemiology call at the University of Utah on 5 November 2025.
- Executive Director Faraji and staff attended the monthly meetings of the Owner/Architect/Engineers on 5 November 2025.
- Executive Director Faraji attended the annual Utah Association of Special Districts conference on 5 November 2025.
- Executive Director Faraji attended and presented at the annual Entomological Society of America's annual conference on 10-14 November 2025. This was the final year of serving at the Medical, Urban, and Veterinary Entomology section president for Executive Director Faraji.
- Executive Director Faraji met with Ella Branham, former seasonal and current master's student at Southern Mississippi University on 17 November 2025.
- Executive Director Faraji met with Wayne Niederhauser regarding the new homeless shelter on 2200 West on 17 November 2025.
- Executive Director Faraji met with Dr. George Dimopoulos from Johns Hopkins University regarding collaborative projects on 18 November 2025.
- Executive Director Faraji and staff attended the monthly meetings of the Owner/Architect/Engineers on 19 November 2025.

Aleta Fairbanks, CFO

- 3 November 2025 – Attended seminar to obtain hours towards required 40 annual hours of continuing education for CPA license.
- 5 – 7 November 2025 – Attended Utah Association of Special Districts 36th Annual Convention.
- 18 November 2025 – Attended seminar to obtain more hours towards required 40 annual hours of continuing education for CPA license.

Greg White, Assistant Director

Weekly Construction Meetings plus other construction meetings
Conduct Annual Professional Development Form for USU PhD student Emily Calhoun - 11/10
Write recommendation letter for grant for USU PhD student Thad Allen – 11/10
Meet with Johns Hopkins professor George Dimopoulos about larvicide trials – 11/18
Create slide on District 3D printing for Mark Nakata at Delta Mosquito and Vector Control District in California – 11/3

UASD Conference – 11/5 to 11/7
Panelist for Urban Ecology Class at The University of Utah 11/12
Meet with Senator Niederhauser about homeless shelter – 11/17
Meet with Cameron Grundy of Vector Dx to provide mosquito samples for new PCR tests – 11/24

Chris Bibbs, Laboratory Director

Nov 3	Organizing mosquito colony diet testing collaboration w/ Brad Willenberg (UCF); Proofs/Copy editing on Exhale Manuscript for JME
Nov 4	Methoprene final report edits w/ CLS; teaching entomology class for Jack Longino (U of U); Natalie Hammond Honors Thesis review
Nov 5	Making presentation for EntSoc; final report edits for methoprene trials (CLS); graphing RBCLA and Intergenic extraction results from nectar meal analysis
Nov 6	Data analysis for anthrone/sugar; RBCLA summaries; project call w/ Nadia
Nov 7	Finishing EntSoc presentation; practice talks
Nov 9-13	EntSoc: Portland
Nov 14	Conference debrief; post-conference correspondence (Barker lab, Downs lab, Willenberg lab, Peach lab)
Nov 17	PacVec 2026 intern funding applications; scheduling Capgel call w/ IVCC and Brad Willenberg; Prep for L. Kothera erythrothorax samples; AMCA registration/hotel; VectorSurv w/ Ivy Hurwitz; Tox stats analysis w/ Ilia; MS Thesis review for Amy; Honors Thesis review w/ Natalie Hammond; Reviewing formatting guidelines for American Entomolgist re: dragonfly manuscript
Nov 18	Meeting with G. Dimopolous (JHU); reviewing treehole manuscript for Amy; Amy project mentorship; Dirofilaria manuscript edits w/ Nate
Nov 19	Meeting w/ IVCC and Brad Willenberg on Capgel tech; finishing treehole manuscript edits
Nov 20	Lit review, introduction, and methods for nectar-meal analysis manuscript; rotator trap data executive summaries w/ Avery
Nov 21	Methods writeup for nectar-meal analysis manuscript; lab meeting w/ Ryan Stolley on spectrophotometry assays in Toxorhynchites; meeting with Irvane Nelson (SRI) on 2023 anthrone data for nectar-meal analysis manuscript
Nov 24	SRI TA'ship forms/applications (Clara Morris); stats call w/ Ilia (Tox manuscript); Anthrone data entry/analysis for 2023
Nov 25	Reviewing bioassay protocols for Saarman lab; SRI new student meeting; Anthrone data entry/analysis for 2023
Nov 26	Saarman lab conference call; Stats call w/ Ilia

Michele Rehbein, Education Specialist

- Dr. Rehbein was invited to participate in the AMCA Young Professionals Symposium and Round Table Discussion for AMCA 2026 and accepted on 6 November.
- Dr. Rehbein went to the Hartland Partnership Center for the first week of several for a weekly education programming with students on 12 November. The youth center there has mostly African refugee students currently, ages 5-14.
- Dr. Rehbein did maintenance in the pollinator habitat and mulched on 12 and 13 November.
- Dr. Rehbein created and sent out issue 12 of the SLCMAD newsletter on 14 November.
- Dr. Rehbein wrote a letter of recommendation for Annabeth Mathews (previous intern) for public health graduate programs on 18 November.
- Dr. Rehbein was interviewed by Shelby Lofton KSL about the proposed homeless shelter on 2200 W on 18 November. Link: https://ksltv.com/environment/faith-leaders-environmental-groups-push-back-on-proposed-homeless-campus/847897/.
- Dr. Rehbein went to the Hartland Partnership Center for the second week of several for a weekly education programming with students on 19 November.

- Dr. Rehbein presented to two 7th grade classes at Rowland Hall Middle School on 24 November.
- Dr. Rehbein completed and published the SLCMAD newsletter, issue 13, on 26 November.

- Dr. Rehbein met with Dr. Tim Burton for a monthly meeting about RaHP VEC social media on 5 November.
- Dr. Rehbein attended an AMCA National Campaign committee meeting on 6 November.
- Dr. Rehbein and Dr. White met with Craig Wallentine on 13 November.
- Dr. Rehbein presented to and conducted a tour for one of the lab sections of Dr. Emmanuel Santa-Martinez's environmental science class from Salt Lake Community College on 17 November.
- Dr. Rehbein presented to and conducted a tour for the second lab section of Dr. Emmanuel Santa-Martinez's environmental science class from Salt Lake Community College on 19 November.
- Dr. Rehbein met with Andrew Dewsnup, Dr Faraji, and Amanda Barth to discuss website proposals on 20 November.

Nate Byers, Molecular Biologist

Reviewed a paper on siRNA during arbovirus infection of *Culex* cells for Parasites & Vectors

Presented our *Dirofilaria immitis* surveillance paper at Entomology 2025. I also moderated one of the MUVE sessions; 9-12 Nov

Participated in conversation with George Dimopoulos about his Chromobacterium larvicide project; 17 Nov

Talked with Dan Peach (and Chris) about plant DNA detection; 24 Nov

Brad Sorensen, Aerial Operations Supervisor

Continued to attend OAC Meetings and monitor progress

Issue with Hangar footings

Asphalt Completed

Cleaned out Door 4 of pesticide shed to store furniture from CCG

Coordinated and picked up SLCMAD's New Helicopter from Airbus with Nick McCoy from Lee County and Brad Correa from Utah DPS

Worked on helicopter maintenance contracting

Worked on helicopter warranty items

11/5 – OAC Meeting

11/12 – OAC Meeting

11/17 through 11/19 Picked up Helicopter from Airbus Helicopters in Colombus MS

11/20 Moved helicopter to DSLASA Hangar for temporary storage

Quinten Salt, Urban Field Supervisor

Complete #26 winter detail work 11/23

Winterize outside fish tank and put cover on 11/4

Deep clean all fry skimmers and shelter material for hatchery 11

Yearly fish inspection from department of natural resources 11/19

Gus last day 11/25

Jason Hardman, Rural Field Supervisor

Winter clean up and equipment maintenance
Inventory

3. Field Data:

Service Requests:

MOSQUITO SERVICE OPPORTUNITIES RECEIVED BY MONTH

	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Total
2025	5	11	40	44	22	25	23	3	2	175
3-Year Avg.	4.00	11.33	26.33	40.00	34.00	19.33	9.67	20.33	0.00	164.99

4. Weather:

November's weather was warmer (by 6.7º) and drier (by .71") than normal.

Temperature:

	Monthly Avg.	Normal	High	Low
October	54.6º	54.6º	85º	30 º
November	48.4º	41.7º	73º	28 º

https://www.weather.gov/wrh/Climate?wfo=slc

Precipitation:

	Total for Month	Normal	Most in 24 hours
October	5.12"	1.26"	2.47" on 4th
November	0.61"	1.32"	0.24" on 30th

https://www.weather.gov/wrh/Climate?wfo=slc

Great Salt Lake (elevation in feet above sea level):

	Oct 1	Nov 1	Dec 1
2024	4,192.5	4,192.2	4,192.2
2025	4,191.0	4,191.2	4,191.3

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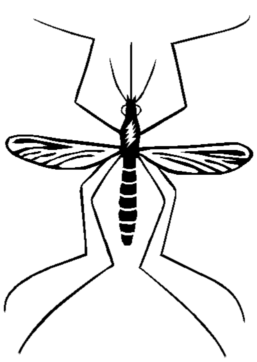

American Mosquito Control Association
Re: Separation of Industry and Presidency

20 November 2025

Dear AMCA Board of Directors,

In June of 1935, twenty-six mosquito workers from non-profit organizations assembled and voted to combat spurious allegations against mosquito control from the public, environmental proponents, and advocacy groups. They created a new organization called the Eastern Association of Mosquito Control Workers (EAMCW) to lead the counter attack against individuals and organizations spreading falsehoods that "mosquito control operations have been an important factor in the depletion of wildlife". This organization would go on to become the American Mosquito Control Association (AMCA) in 1944.

The AMCA has since become a global leader for the enhancement of quality of life and public health through suppression of vector-transmitted diseases by providing leadership information, collaboration, tools, and education to public health stewards everywhere. Our membership has grown and includes individuals of many professions from public and private sectors, in addition to academia and beyond. However, our public perception issues have not subsided and with increasing chemophobia concerns, advocacy and environmental groups continue their ill-advised rhetoric. We are often mistakenly blamed for being in cahoots and colluding with the private sector and that the more we "spray", the more money we make. These accusations could not be further from the truth; however, the perception from the general public continues to linger.

The membership of AMCA includes many individuals and many of us, particularly our program at the Salt Lake City Mosquito Abatement District (SLCMAD), take pride in working collaboratively with private industry to evaluate products and tools, enhance existing methods, and assist with bringing new active ingredients to our profession. We value industry as a true partner in mosquito control and fully understand that our public health mission is served best collaboratively.

However, having an individual from a private for-profit company serve as the president of the largest non-profit mosquito control organization is bad optics for the profession. This sends the wrong message to the general public and advocacy/environmental groups that routinely scrutinize our profession. The AMCA Board of Directors (BOD) already includes a position for Industry Director, which is filled by a member from our for-profit vendors. This allows our commercial partners to have a voice with the Association and has served all of us well in the past. But there is a significant difference between an Industry Representative on a board of directors, versus having an individual from private for-profit industry serve as the president and face of the AMCA. This is comparable to the American Medical Association having a pharmaceutical representative serve as the president. That would cause major alarm nationally and reduce the legitimacy of that organization. Our situation is no different.

The purpose of this letter is not an attack on the currently-elected individual; however, we are asking that this issue be formally evaluated by the Bylaws Committee and recommended changes brought back to the membership. This issue has been discussed with past AMCA President Dr. Ruide Xue, but a formal appraisal has still not been conducted.

Most governmental non-profit organizations are required to review their bylaws annually. It may be good practice for the AMCA to also undergo this process every few years. The current Bylaws Chair, is also the current Industry Representative and VP-Elect; hence, this can also pose a conflict of interest. Furthermore, with the recent elections, the AMCA BOD will be composed of three individuals in the coming years with industry representation. This may also be of concern and an issue that the Bylaws Committee should investigate.

Presently, SLCMAD is asking that these issues be thoroughly considered and that appropriate measures are taken in the future to prevent such conflicts of interest. Our district is formally expressing our apprehensions about these issues and we believe that this may be a misstep for the association that should be corrected. Please examine these issues and address the concerns.

Sincerely,

Ary Faraji, PhD
Executive Director – SLCMAD
Past President – American Mosquito Control Association

Subject: FW: Confidential: Moody's Draft Press Release For Your Review - Salt Lake City Mosquito Abatement District, Utah - Moody's ID: 903653976
From: "Aleta Fairbanks" <aleta@slcmad.org>
Sent: 12/9/2025 9:32:55 AM
To: "Ary Faraji" <ary@slcmad.org>
Attachments: CONFIDENTIAL_Draft_Press_Release_SpecialPurposeDistrict_12-09-2025.pdf

I am fine with this rating change. Aa2 and Aa3 are both good ratings. Aa3 indicates fairly high-quality debt with very low credit risk. Here is what I found online:
Moody's Aa3 rating signifies
high-quality debt with very low credit risk, placing it just below the top-tier Aaa rating, indicating a very strong capacity to meet financial commitments, with only minor differences from the highest-rated entities, reflecting solid financial health and stability. Issuers with this rating, like some states or large corporations, benefit from favorable borrowing terms, as it signals strong management and robust financial reserves, as seen with New Jersey's upgrade to Aa3 for its strong fiscal position.

Aleta Fairbanks, MPrA, CPA
Chief Financial Officer
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From: MIS_SPD_Issuer_Communications <SPD_Issuer_Communications@moodys.com>
Sent: Tuesday, December 09, 2025 9:07 AM
To: aleta@slcmad.org
Cc: Yunie Chang (Ratings - Analytical) <Yunie.Chang@moodys.com>
Subject: Confidential: Moody's Draft Press Release For Your Review - Salt Lake City Mosquito Abatement District, Utah - Moody's ID: 903653976

Hello,

This communication is part of the implementation and application of a new US Special Purpose Districts methodology published by Moody's Ratings (Moody's) on December 9, 2025. This methodology includes a new analytical framework and instrument rating notching guidance for special purpose districts which differ from those used previously to determine the ratings for these districts. The attached draft press release announces rating actions we are taking on certain special purpose districts now that this new methodology has been released.

You have been identified by the rated entity **Salt Lake City Mosquito Abatement District, Utah** or its agent as the contact to receive draft communications of credit rating actions regarding the rated entity prior to the public dissemination of the credit rating action.

Attached is the draft press release for your review, to give you the opportunity to draw attention to any factual errors and/or inadvertent disclosure of confidential information. However, please note that under our policies, Moody's retains ultimate editorial control over the form and content of all its publications. Moody’s will not accept other changes that would alter the meaning or tone of its opinions or credit rating announcements.

Please note that this draft press release is strictly confidential and you may not disclose it to any other person except: (i) to your legal counsel acting in their capacity as such; (ii) to your other authorized agents who are subject to confidentiality obligations and acting in their capacity as such; and (iii) as required by law or regulation.

You also may not post it to any SEC Rule 17g-5(a)(3) website, if applicable.

You have two working hours from the time of this email to tell us if the draft press release contains any factual errors or inadvertent disclosures of confidential information, after which we may publish the press release whether we have heard from you or not.

However, if you respond to us in writing (including by email) in the form specified below, we may publish the press release before the two working hours have elapsed.

Form of response to enable Moody’s to publish the press release before the full stated time period has elapsed:

"I confirm that we have reviewed the draft press release and that, to the best of our knowledge, it does not contain any factual errors or inadvertent disclosures of confidential information."

Please note: if the draft press release relates to the assignment of a new credit rating and the rated entity wishes to delay the public dissemination of such credit rating action pending an event that has not yet occurred, such as an announcement by the rated entity, you are responsible for providing this information to Moody’s within the time period stated above.

The below table lists the action(s) being taken with regard to **Salt Lake City Mosquito Abatement District, Utah** and any of its rated components. Please note that the below table lists only your entity's name, issuer rating, instrument rating(s), and outlook, as applicable.

State	Issuer or Obligor	Affected sale / Issuer Rating	Sale ID	Prior Rating	Prior Review Status	Current Rating	Current Review Status
UT	Salt Lake City Mosquito	ISSUER RATING	N/A	Aa2		Aa2	

	Abatement District, Utah						
UT	Salt Lake City Mosquito Abatement District, Utah	Lease Revenue Refunding Bonds, Series 2020	906482970	Aa3		Aa3	
UT	Salt Lake City Mosquito Abatement District, Utah	Lease Revenue Bonds, Series 2017	903844531	Aa3		Aa3	

Please refer to Moody's Rating Symbols and Definitions for definitions of Moody's credit rating terminology.

Thank you,

Yunie Chang

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Evaluating Human Health Risk of Aerial Ultra-Low Volume Insecticide Applications for Adult Mosquito Management

Daniel L. Mendoza[1,2,*], Christopher S. Bibbs[3], M. Andrew Dewsnup[3], Ilia Rochlin[3], Gregory S. White[3], Jane A. S. Bonds[4], Robert K. D. Peterson[5], Ary Faraji[3]

[1] Department of Atmospheric Sciences, University of Utah, Salt Lake City, Utah, USA.
[2] Department of Internal Medicine, Pulmonary Division, University of Utah Health, Salt Lake City, Utah, USA.
[3] Salt Lake City Mosquito Abatement District, Salt Lake City, Utah, USA.
[4] Bonds Consulting Group, Panama City, Florida, USA.
[5] Department of Land Resources and Environmental Sciences, Montana State University, Bozeman, Montana, USA.
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HIGHLIGHTS

- Two models estimated potential exposure to naled, an organophosphate insecticide, during ultra-low volume adult mosquito control applications.
- The estimated maximum exposure was well below EPA reference dose values.
- When naled is used for mosquito control following label guidelines, human health risk is negligible.

ABSTRACT. *Risk characterization for insecticides used in mosquito management requires assessment of exposure amount, frequency, timing, and likelihood of contact. Naled (Dibrom, AMVAC Chemical Corporation, Commerce, CA), the insecticide used for this study, is an organophosphate employed for adult mosquito management because of predicted low environmental effects in wetland habitats, high relative density of droplets, and excellent efficacy against mosquitoes. Our study used the current United States Environmental Protection Agency reference dose (RfD) of naled, 0.01 mg/kg body weight per day, and human data were configured for a 78 kg (172 lb) adult and 10 kg (22 lb) child located at the highest concentration in the deposition models for a continuous naled contact of 2 hrs. Two dispersion models, AERMOD and AGDISP, were used to estimate potential ground-level exposure following an ultra-low volume naled application for adult mosquito control. The models were run under stable and high-wind conditions, as well as using 5-year meteorological conditions for the application season in Salt Lake City, Utah. Resulting exposure estimates were 2.5% for adults and 14.7% for children using the adjusted naled RfD at 0.01 mg/kg per day. Our findings support prior research suggesting very low potential exposures to naled under realistic field conditions. Thus, routine naled aerial applications applied in accordance with pesticide label parameters pose negligible human health risks when used for adult mosquito management.*

Keywords. *Adulticide, AERMOD, AGDISP, DDPV, Mosquitoes, Naled, Organophosphates, Risk assessment, ULV, Vector management.*

Risk characterization for insecticides used in mosquito management requires assessment of exposure amount, frequency, timing, and likelihood of contact (Covello and Merkhoher, 1993). Pyrethroids and organophosphates are by far the two insecticide classes most used for adult mosquito management in the United States (Davis et al., 2007; Milam et al., 2000; Mount, 1998), with organophosphates accounting for as much as one-third of the insecticides used by weight (Atwood and Paisley-Jones, 2017). Naled (dimethyl 1,2-dibromo-2,2-dichloroethylphosphate, Dibrom, AMVAC Chemical Corporation, Commerce, CA), the insecticide used for this study, is an organophosphate employed in mosquito management because of negligible environmental effects in wetland habitats, high relative mass density of droplets, and excellent efficacy against mosquitoes (AMVAC, 2021; Davis et al., 2007; USEPA, 2020). However, the negative perception of naled with respect to human health and non-target risks as a result of mosquito management may interfere with public health operations (Philip et al., 2019), leading to delayed or cancelled interventions and exacerbating outbreaks of vector-borne diseases (Rigau-Pérez, 2018).

Exposure assessments are crucial to translate the dose-response data established by the United States Environmental

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Citation: Mendoza, D. L., Bibbs, C. S., Dewsnup, M. A., Rochlin, I., White, G. S., Bonds, J. A. S., Peterson, R. K. D., & Faraji, A. (2025). Evaluating human health risk of aerial ultra-low volume insecticide applications for adult mosquito management. *J. ASABE, 68*(5), 753-760. https://doi.org/10.13031/ja.16225

Protection Agency (EPA) to the actual human health risks (USEPA, 2020). Under ideal circumstances, directly sampling the air or ground during naled applications should furnish the required parameters. Unfortunately, there are many pitfalls involved in such field operations, including low stability of naled in the environment, sampling biases, instrument sensitivity, and the highly specialized technical expertise required (Bonds, 2012). Conservative estimates can, however, be more productively modeled to represent worst-case scenarios under different conditions, such as low winds or perpendicular wind directions (Qiu et al., 2021).

We used two pesticide dispersion modeling approaches combined with actual application data for aerial naled ultra-low volume (ULV) adult mosquito control to assess potential human risk under real-life operational scenarios. The aim of a ULV application is to deliver the most efficacious droplet size using the least amount of insecticide that will control the target mosquitoes (Faraji et al., 2016). Generally, ULV applications are conducted in the evening or early morning when a neutral atmospheric stability has occurred and light winds are present to promote droplet movement through the air column. These applications are universally carried out while moving rapidly; the emission source is not stationary. There is no single model that covers all the variables with this scenario. Therefore, we selected both the Agricultural Dispersal (AGDISP) software designed for aerial pesticide applications and The American Meteorological Society/Environmental Protection Agency Regulatory Model (USEPA, 2018) because of their established utility and complementary purposes under different exposure scenarios (Schleier III and Peterson, 2014; Schleier III et al., 2009; Schleier III and Peterson, 2010).

The AGDISP model is capable of differentiating between fixed-wing and rotary aircraft (Bilanin et al., 1989), wet and dry deposition estimates (Teske et al., 2003), and evaporative stress on the longevity of insecticide deposits (Teske et al., 2019). When used in conjunction with the Agricultural Drift (AgDRIFT) sub-model, AGDISP/AgDRIFT can characterize proximate and distant linear depositions (Teske et al., 2019). The AGDISP model was developed specifically to model fast-moving emitters and the subsequent drift of particles that settle across a varied terrain (El Afandi et al., 2023; Schleier III and Peterson, 2014; Teske et al., 2003, 2019). The AGDISP model has the most appropriate assumptions for ULV applications. However, the rendering tends to overestimate deposition with points of exposure that are farther from the source (Bird et al., 2002) and can be inferior for ground-level analysis (Macedo et al., 2007; Schleier III and Peterson, 2014; Schleier III and Peterson, 2010). Thus, AGDISP/AgDRIFT may not be as reliable for calculating deposition interactions near and at the ground level for ULV applications for adult mosquito management (Schleier III and Peterson, 2010).

In contrast to AGDISP/AgDRIFT, two-dimensional spatial analysis methods or hybrid models (El Afandi et al., 2023), such as AERMOD, are considered more dependable for the ground-level estimates of various mosquito management products (Schleier III et al., 2009). AERMOD has been used for comparative risk assessments of naled exposure in humans when used for mosquito control during outbreaks of vector-borne diseases (Peterson et al., 2006).

AERMOD estimates longer-range transport of pollutants emitted as a dispersing cloud up to 50 km from the source (Perry et al., 2005). This cohort-derived model assumes a stationary point source (Cimorelli et al., 2004), while the model output results in a two-dimensional analysis that should be informative at and near-ground level deposition, thus being more applicable to human exposure, especially further away from the source (El Afandi et al., 2023; Schleier III et al., 2009).

The prior studies employed simulated data or forecasting developed specifically for agricultural applications that differed considerably from adult mosquito management methodology. The toxicology profile and dose-responses of naled may be well documented, but modeling with empirical data inputs from actual mosquito management operations to estimate human risk has not been conducted thus far. To address this knowledge gap, we calibrated both AGDISP/AgDRIFT and AERMOD models with real-world aerially applied ULV treatment data, including droplet size, droplet density, and meteorological data, collected over a 5-year period (2016–2020) during routine mosquito control operations at the Salt Lake City Mosquito Abatement District (SLCMAD) near the Great Salt Lake in Utah. This approach allowed us to better estimate potential naled exposure during real-life mosquito control operations. The focus of this study was on human risk; ecological or non-target impacts of naled mosquito control applications have been described in the literature (Bonds, 2012; Breidenbaugh and De Szalay, 2010; Rochlin et al., 2022).

METHODS

Our study used the current reference dose (RfD) of naled, 0.01 mg/kg BW per day, as these are the default EPA values from the Exposure Factors Handbook (Mendoza et al., 2023; USEPA, 1994, 2020). In all outputs, human data were configured for a 78 kg (172 lb) adult and 10 kg (22 lb) child located at the highest concentration in the deposition models for a continuous naled contact of 2 hrs. Exposure to both adults and children was deliberately overestimated by assuming a high respiration rate, consistent with moderate physical activity, using values from the EPA Exposure Factors Handbook (USEPA, 2011) of 1.6 m^3/hr (56.5 ft^3/hr) and 1.2 m^3/hr (42.4 ft^3/hr) for adult and child, respectively, also used in prior studies (Peterson et al., 2006). Estimates assumed all droplets were inhaled by the hypothetical person with no reduction in exposure due to half-life or environmental factors, thus emulating a worst-case scenario.

The SLCMAD conducted aerial ULV naled (Dibrom; 87.4% active ingredient) applications using a Piper PA-23-250 Aztec airplane (Reg# 203DM) or a Piper PA-31-350 Navajo Chieftain (Reg# N27989) equipped with Micronair AU4000 rotary atomizers on the wings (fig. 1A). Atomizers were adjusted to 10,000 revolutions per minute (RPM) to create a droplet spectrum with a volume median diameter ($Dv_{0.5}$) of 34 μm. $Dv_{0.5}$ is a term used to represent a statistic where 50% of the spray volume or mass is contained in

Figure 1. (A) Piper PA-23-250 Aztec airplane (Reg# 203DM) used by the Salt Lake City Mosquito Abatement District, Utah, USA, for aerial ULV adulticide applications. (B) Equipped with Micronair AU4000 rotary atomizers.

droplets smaller than this value. Droplet measurements for mosquito control are often provided as a mass median diameter or $Dv_{0.5}$ (Farajollahi et al., 2012). Droplet size and distribution are two of the most important factors affecting the success of a ULV application (Bonds, 2012). Additionally, USEPA-approved labels, which are used to enforce federal law, require that given equipment adhere explicitly to required $Dv_{0.5}$ values so that the most efficacious droplet size is likely to impinge on a mosquito to deliver a toxic dose, while reducing non-target impact (Bonds, 2012; Farajollahi et al., 2012; Mount, 1998). Aerial applications were performed at a release height of 30.5 – 91.5 m (100–300 ft) with a swath width of 305 m (1,000 ft) at the rate of 55 ml/ha (0.75 oz/acre) of total product per label. Naled applications were initiated at sunset in remote and rural habitats with few physical obstructions to drift (fig. 2). Applications were conducted from June to September, coinciding with the typical adult mosquito activity season in the area. Applications were only initiated when temperatures were above 10°C (50°F) with wind speeds between 0.447 m/s (1 mph) and 4.471 m/s (10 mph) with flight paths corrected to be ± 30° perpendicular to the active wind direction. All meteorological data was downloaded from the MesoWest database, and winds are measured at 10 m, as it is the standard height (Horel et al., 2002).

AERMOD Parameters

The AERMOD model for this study employed a 2.4 km x 2.4 km spatial grid derived from a typical spray block—approximately 2,303 ha (5,693 acres) for SLCMAD operations. In this spray block, the application was simulated using 16 spray paths (8 N-S and 8 S-N) at 150-m distance from each other. The application height was 45.72 m (150 ft). The AERMOD receptor grid consisted of receptors separated at 150 m in the longitudinal and latitudinal directions in a 21.6 km x 21.6 km grid sharing the same center as the spray block. The AERMOD receptor grid was fixed, defining the exact distance and orientation (N-S and E-W) between the spray line and the receptors, irrespective of wind direction and speed. The AERMOD model was run to yield ground level deposition ($\mu g/m^2$) and 1 m above-ground concentrations ($\mu g/m^3$). The distribution for particle diameter mass fraction is shown in table 1; for this study, the particle density was fixed at 1.96 g/cm^3 (O'Neil, 2013). An ensemble consisting of 241 possible meteorological conditions based on those typically experienced during actual aerial applications were included in this model. For AERMOD, we used the totality of possible spray lines from the source data (SLCMAD) creating a heatmap to visualize cumulative data.

AGDISP Parameters

The AGDISP modeling follows the path of the droplet dispersion dependent on wind direction and yields the result for just one spray line per output. The AGDISP model was run for both the Piper Navajo and Piper Aztec aircraft using either average or windy conditions scenarios. The aircraft settings were imported directly from AGDISP's library (table 2). Table 3 lists the model settings and table 4 compares the two scenarios for average and windy conditions. Both typical and extreme weather conditions, derived from the real-life data, were used to create two snapshots from AGDISP that compare normal and windy weather condition outcomes.

Historical data from SLCMAD identified an average of 17 aerial applications of naled per year using the above parameters, with no more than 10 applications per year being conducted within the same land geometry (fig. 2). The individual treatment polygons typically span anywhere from 2,072 to 4,144 ha (5,120 to 10,240 acres), being inherently limited by the respective acreage feasible for one or two payloads of naled as 113.5 L (30 gal) drums.

Results

Since AERMOD is a stationary model that favors deposition as static, vertical descent, an output was generated for ground-level (fig. 3A) and for 1 m above ground level depositions, the latter to better account for human height (fig. 3B), with maximum values observed to be 6.12 $\mu g/m^2$ and 5263 $\mu g/m^3$, respectively. The AGDISP model factors in movement and crosswinds at the emission source, so data from SLCMAD were filtered to generate an output for typical ambient conditions (fig. 4A) and again for high wind conditions based on the 5-year study window (fig. 4B). The high wind output allowed estimation for drift to evaluate the general risk that aerosolized droplets could reach human population centers despite the remoteness of the application sites.

The AGDISP model (fig. 4) yielded deposition results ranging from 0 to 1, 100 $\mu g/m^2$ and 0 to 700 $\mu g/m^2$ for typical and windy conditions, respectively. The highest deposition was observed to be 1,095 $\mu g/m^2$ in the peak drift zones

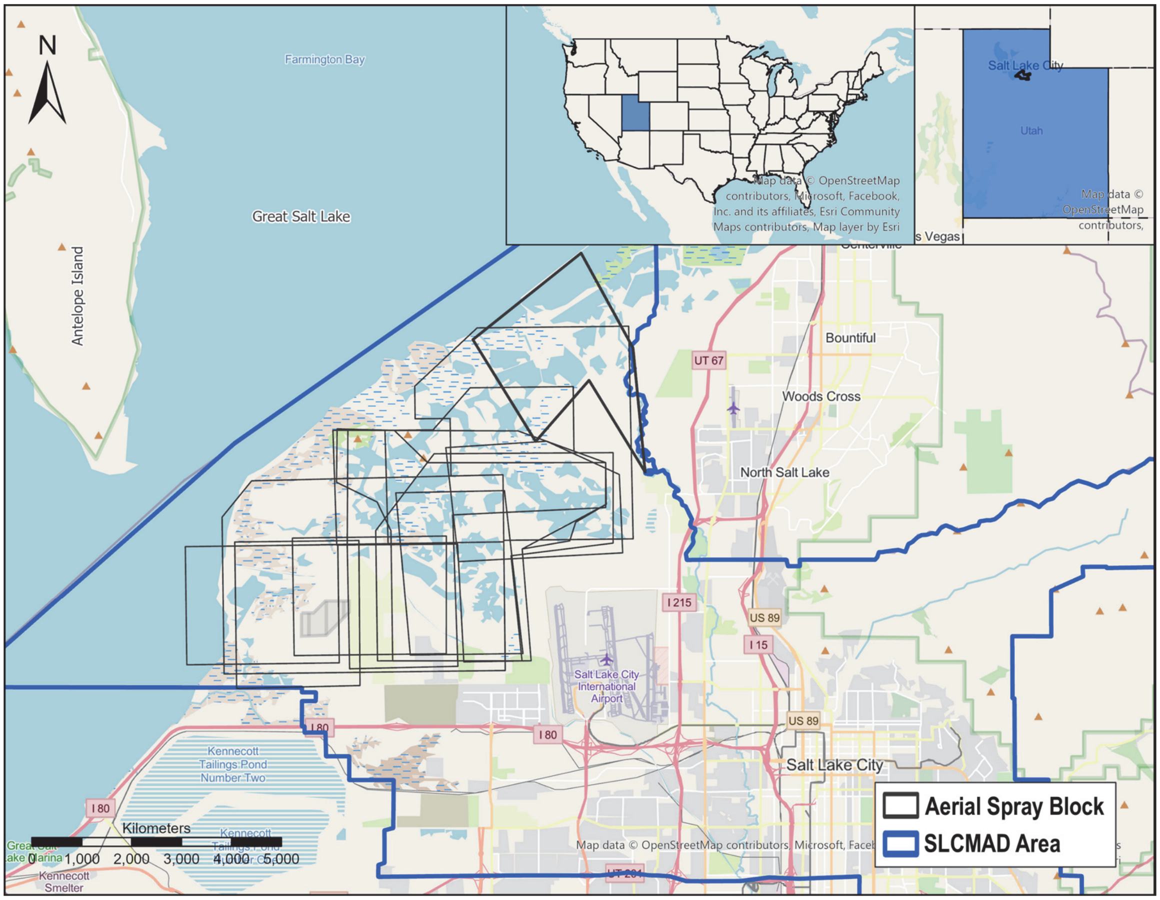

Figure 2. Map of aerial treatment areas, aka 'Aerial Spray Blocks,' used for naled treatments in uninhabited natural areas outside of Salt Lake City, Utah, USA.

Table 1. Particle diameter mass fraction distribution. The particle density was fixed at 1.96 g/cm^3.

Particle Diameter (µm)	Mass Fraction
10.77	0.028
16.73	0.035
19.39	0.030
22.49	0.020
26.05	0.021
30.21	0.046
35.01	0.078
40.57	0.106
47.03	0.125
54.50	0.124
63.16	0.086
73.23	0.061
84.85	0.070
98.12	0.071
113.71	0.054
131.73	0.027
152.79	0.006
177.84	0.002
205.84	0.010

Table 2. Aircraft model settings imported from the default included in the AGDISP library (Bilanin et al., 1989).

	Piper Navajo	Piper Aztec
Type	Fixed Wing	Fixed Wing
Semispan (m)	6.22	5.67
Weight (kg)	2,381.32	1,912.02
Typ. Speed (m/s)	101.02	53.64
Propeller RPM	2,575	2,575
Prop. Radius (m)	1.1	1.1
Biplane Sep. (m)	0	0
Planform Area (m^2)	19.97	32.89
Engines	2	2
Engine Vert. (m)	0	0
Engine Fwd. (m)	3.6	3.6
Engine Horiz. (m)	1.8, 0	1.65, 0
Wing Vert. (m)	0.3048	0.3048
Boom Vert. (m)	-0.3048	-0.3048
Boom Fwd. (m)	-0.1524	-0.1524
Nozzle (m)	-4.14, 4.14	-2.49, 2.49

within the first 500 m of drift (fig. 4). Up to a 1 km drift was estimated from the point of emission when evaluating with typical ambient conditions (fig. 4A), whereas drift reached ~2.7 km from the point of emission in the windy conditions, but with correspondingly lower concentrations within the first 500 m (fig. 4B). To visualize this drift range, a canonical spray block within SLCMAD with proximity to populated centers was labeled for context (fig. 3A).

In contrast to AERMOD, AGDISP does not estimate aerial concentrations. The linear output of AGDISP is not directly translatable to the 2-D output of AERMOD and underpins the importance of comparing both models. The outputs from the typical versus the extreme weather conditions for AGDISP had a similar dispersal pattern of deposited naled droplets. Both sets of conditions generally observed a steep decline in naled concentration 1.5 km from the outer

Table 3. AGDISP model settings for all runs based on 5-year averages recorded from the Salt Lake City Mosquito Abatement District.

Application Method	
Method	Aerial
Release Height	45.72 m
Spray Lines	1
Application Technique	
Technique	Liquid
Nozzles	2 nozzles
Spray Material	
Spray Material Evaporates	Yes
Spray Volume Rate	0.0548 L/ha
Active Fraction	0.874
Nonvol. Fraction	0.874
Carrier% of Tank Mix	12.6
Atmospheric Stability	
Night Cloud Cover	Overcast
Surface	
Upslope Angle	0˚
Sideslope Angle	0˚
Surface Roughness	0.0075 m
Transport	
Distance	0 m
Swath	
Swath Width	152.4 m
Swath Displacement	150 m
Advanced	
Height for Wind Speed Measurement	2 m
Maximum Computational Time	600 sec
Maximum Downwind Distance	5,000 m
Vortex Decay Rate OGE	0.1500 m/s
Vortex Decay Rate IGE	0.5588 m/s
Aircraft Drag Coefficient	0.1
Propeller Efficiency	0.8
Ambient Pressure	1,012.87 mb
Ground Reference	0 m
Default Swath Offset	½ Swath
Specific Gravity (Carrier)	1.96
Specific Gravity (Active and Additive)	1.96
Evaporation Rate	84.76 $\mu m^2/^{\circ}C/sec$

Table 4. Meteorological conditions – the wind is defined at a single height (10 m) based on 5-year averages recorded from the Salt Lake City Mosquito Abatement District.

	Average Day	Windy Day
Wind Speed (m/s)	1.70	3.39
Wind Direction (˚)	-60	-90
Temperature (˚C)	29.35	27.00
Rel. Humidity (%)	25	20

edges of treated areas, a zone that in this case is largely unpopulated (fig. 3A, fig. 4). However, AGDISP consistently returned lower deposition values compared to AERMOD. Therefore, we used the AERMOD value to estimate human exposure to account for the worst-case scenario.

After correlating the exposure parameters to the AERMOD outputs, the highest concentrated area for inhalation risk yielded a potential 6.12 $\mu g/m^3$ (0.00612 mg/m^3) exposure. Adult risk estimates used 1.6 m^3/hr respiration for 2 hrs in a 0.00612 mg/m^3 air concentration, divided by the 78 kg body weight, resulting in a 0.00025 mg/kg BW daily intake. For the child risk, inhalation exposure [(1.2 m^3 × 2 hr × 0.00612 mg/m^3)/10 kg BW] resulted in 0.00147 mg/kg BW daily intake. Resulting daily intake estimates were 2.5% for adults and 14.7% for children relative to the adjusted naled RfD of 0.01 mg/kg per day (USEPA, 2020).

DISCUSSION

Naled has been registered in the United States since 1959 and has undergone numerous reviews as technology and regulations advance (USEPA, 2020). Dose-response assessments are among the metrics used to assess the risk of naled (Covello and Merkhoher, 1993) and are adjusted as new research becomes available (USEPA, 2020). Quantification by the EPA has established an acceptable daily intake (ADI), also known as the reference dose (RfD). The RfD is derived from the experimentally determined No Observed Adverse Effect Level (NOAEL) and a Safety Factor (SF) that occurs in multiples of 10 (Peterson et al., 2006; USEPA, 1994). The NOAEL is based on inhibition of blood and brain enzymes in a 28-day rat study (USEPA, 2002). The NOAEL categories set by the EPA are expressed as separate sensitivities per category of risk; as an example, for naled and dichlorvos (naled degradation product, DDVP), these values are 198 mg/kg body weight (BW) (inhalation), 56 mg/kg BW (ingestion), and 2.3 mg/kg BW (chronic/reproductive) (USEPA, 2020). However, adjusting for a 10× safety factor for interspecific variability to account for differences between human and animal responses multiplied by an additional 10× safety factor for intraspecific variability to account for susceptibility differences among individuals in the human population, including vulnerable populations such as pregnant women or individuals with underlying health conditions, places the current regulated RfD by the EPA at 0.01 mg/kg BW/day based on cholinesterase inhibition in rats (Mendoza et al., 2023; USEPA, 1994, 2020).

The highly conservative exposure estimates in our study resulted in deposition values ranging from approximately 3% (adults) to 15% (children) of EPA's approved RfD levels for naled when applied following labeled guidelines. Our exposure estimates were purposely conservative, a reasonable worst-case scenario containing such reasonable worst-case assumptions as (1) a person present within the area of highest naled deposition, (2) breathing at a high ventilatory rate throughout the whole period of application, and (3) using the AERMOD model that overestimates deposition (Schleier III and Peterson, 2014). In addition, airborne naled is intercepted by buildings and free-standing vegetation (Bonds, 2012) and decays as rapidly as 15 minutes (Tietze et al., 1996). Due to these factors, the actual exposures to naled are likely much lower than this study's estimates.

In human biomonitoring studies, the use of aerial applications of naled in Miami-Dade, FL (U.S.) during the Zika outbreak (Philip et al., 2019) was not associated with a single human poisoning (Mulay, 2018). Other studies employing urinalysis to detect naled or its metabolites (Duprey et al., 2008) found that naled application for public health did not lead to increased levels in humans (CDC, 2005; Duprey et al., 2008). Thus, there is no scientific evidence to suggest that naled compromises human health, especially compared to the risk of mosquito-borne infections (Mendoza et al., 2023; Peterson et al., 2006) when used following label guidelines.

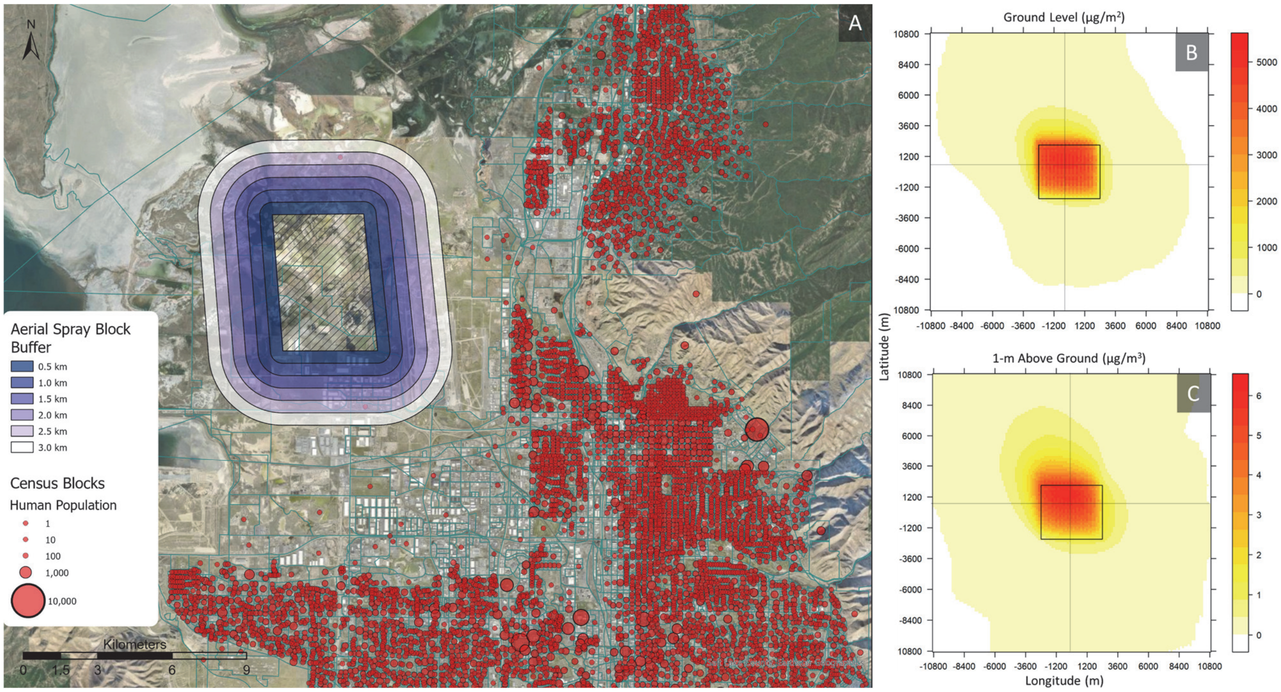

Figure 3. (A) Naled treatment block (hatched area) from Salt Lake City Mosquito Abatement District (SLCMAD): aerial spray block represents a 2,072 ha (113.5 L naled drum) spray zone that is the closest to the human population of the SLCMAD blocks. Buffer rings around the spray block from 0.5 to 3.0 km width are shown. The black-bordered interior square represents the treated spray block or area. (B-C) AERMOD outputs were rendered for naled deposition using 5 years of study data from Salt Lake City Mosquito Abatement District. Heat scales are depicted with color relative to maximum values, displayed as µg of naled. (B) Heatmap of deposition at ground level, where accumulation is greatest by surface area (m²). (C) Heatmap of deposition at 1-m above ground, where a human is most likely to inhale droplets volumetrically (m³).

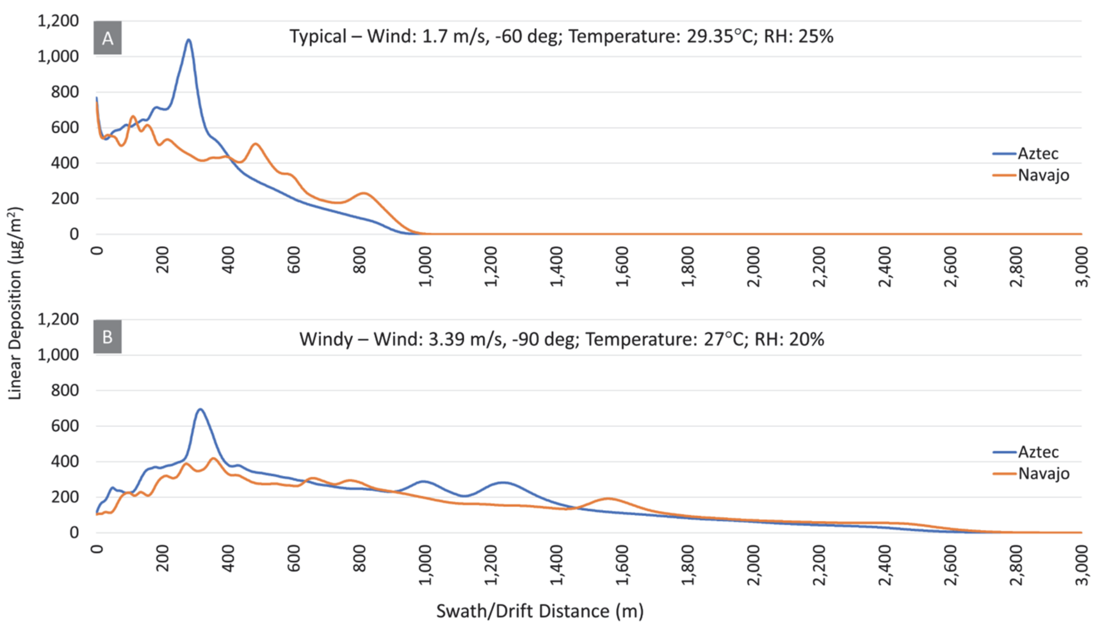

Figure 4. AGDISP outputs for naled deposition using 5 years of study data from Salt Lake City Mosquito Abatement District using Piper Navajo and Piper Aztec aircraft. (A) Accumulated linear deposition using average ambient weather conditions based on the 5-yr data; 1.7 m/s wind speed, 29°C air temperature, and 25% relative humidity. (B) Accumulated linear deposition using high wind conditions based on the 5-yr data; 3.39 m/s wind speed, 27°C air temperature, and 20% relative humidity. X-axis shows the drift distances in meters. Y-axis shows deposition is measured in µg of naled. Both graphs depict the values of two different Piper series aircraft that conducted real-life aerial naled applications.

Conclusion

Our findings support prior research suggesting negligible health risks from routine naled aerial applications due to very low potential exposure levels to naled under realistic field conditions (Mendoza et al., 2023). This modeling study corroborates extensive scientific literature and regulatory evaluations, confirming that naled presents minimal risk to human health when used according to label guidelines for adult mosquito control (Duprey et al., 2008; Mendoza et al., 2023; Tai et al., 2024).

This study does not evaluate the ecological impacts of naled application, such as its effects on non-target organisms, pollinators, aquatic systems, or the broader environment. Ecological or non-target impacts of naled mosquito control applications have been described in the previous studies (Bonds, 2012; Breidenbaugh and De Szalay, 2010; Rochlin et al., 2022). An important point of consideration is the potential public resistance to aerial pesticide use. Such resistance is often rooted in perceived risks, which may differ from the actual risks identified by scientific studies. Public perception can be influenced by misinformation or a lack of trust in regulatory processes, leading to challenges in implementing aerial spraying programs even when the health benefits outweigh the risks. Addressing these concerns requires effective communication strategies to bridge the gap between scientific findings and public understanding.

Despite these limitations, studies like the current one play a critical role in supporting the decision-making process and strengthening evidence-based policies. By providing a framework to assess the costs and benefits of aerial mosquito control, this research contributes to a more balanced and scientifically informed approach for managing public health threats posed by mosquito-borne diseases. Future efforts should aim to incorporate field data validation, address ecological impacts, and engage in community outreach to enhance the utility and public acceptance of such interventions.

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