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Allan M. Strong, Chair June 24, 2020
Endangered Species Committee
University of Vermont
312 Aiken Center
Burlington, VT 05405

Re: Arrowwood Environmental's Revised Report – The BLSG District's Use of the Adulticides Malathion and Permethrin: Impacts on Five Threatened and Endangered Bat Species

Dear Chairman Strong,

This letter accompanies a revised version of my report "**The BLSG District's Use of the Adulticides Malathion and Permethrin: Impacts on Five Threatened and Endangered Bat Species."** After the first version of this report was submitted on August 23, 2019, I attended two meetings of the Vermont Endangered Species Committee (October 2019 and April 2020). At those meetings many useful comments were made and some questions were raised about the ways in which the specific methods of pesticide application in the BLSG Insect Control District, which are unique in Vermont, might impact threatened and endangered bats. To address and help clarify those comments and questions, I completed additional research and added two new sections to the report. I have also added additional explanations and citations of scientific literature throughout the report (see list below of 25 new references cited).

New sections in the report include Section II(c), which describes the Lemon Fair Insect Control District (LFICD). The LFICD is the only other insect control district in Vermont, is adjacent to the BLSG District, and differs from the BLSG District in not using any chemical adulticides to control mosquitoes. To me, this new information helps put into context the difference between controlling mosquito larvae with non-harmful bacterial treatments (done exclusively in the Lemon Fair District) and controlling adult mosquitoes with chemical pesticides (within Vermont done only in the BLSG District).

Section IV(e) is a new section which describes the potential for BLSG's operations to reduce the population of insects sufficiently to harm bats by depriving them of prey, an issue which was raised at the April meeting of the Endangered Species Committee. I conclude that this is unlikely to happen in the BLSG District due to the ways in which pesticide application is limited spatially and temporally, and is targeted at small insects (no larger than mosquitoes). This new section highlights that the most critical risk of injury to the endangered and threatened bats in the BLSG District is the plume of chemical pesticides suspended for an hour or more over hundreds of acres whenever BLSG applies adulticides by roadside spraying.

I thank Dave Yates, Mammal Program Director and Wildlife Research Biologist at the Biodiversity Research Institute in Maine, for reviewing the first version of the report and offering comments. Dave has performed research on bats within the BLSG District and has in-depth knowledge of the biology and ecology of the five listed bat species mentioned in the report. It is an understatement that the reasoning and conclusions I make in the report have been greatly improved by Dave's thoughtful input and analysis.

The current report, attached here, provides evidence that bats are uniquely vulnerable to airborne pesticides, and that repeated nighttime application of a long-lasting plume of chemical adulticides during the summer months puts the five listed bats at a high risk of injury.

Respectfully submitted,

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June 25, 2020

Re: Revised Report from Arrowwood Environmental – The BLSG District's Use of the Adulticides Malathion and Permethrin: Impacts on Five Threatened and Endangered Bat Species

Dear Chairman Strong:

National Wildlife Federation, Biodiversity Research Institute, Toxics Action Center, Colrain Center for Conservation and Wildlife, Vermont Natural Resources Council, Center for Biological Diversity, and Moosalamoo Woods & Waters (the Coalition) appreciate the opportunity to submit the attached revised Report by Arrowwood Environmental LLC (Arrowwood) regarding the Brandon-Leicester-Salisbury-Goshen-Pittsford Insect Control District's (BLSG, or District) adulticide program, and its impact on the following five threatened and endangered Vermont bat species – the Indiana bat, northern long-eared bat, little brown bat, eastern small-footed bat, and tri-colored bat.

<u>Background</u>

Arrowwood recently revised and updated the initial August 20, 2019 Report, to clarify certain comments and questions that arose during the October 2019 and April 2020 Endangered Species Committee meetings. For the Committee's review, the revised Report is attached along with a summary of the updated and clarified substantive changes by Arrowwood. Jeff Parsons, author of the Report, is available upon the Committee's request to answer questions about its data, analysis, and the updating and clarifying revisions.

The revised Report's conclusions and available evidence demonstrate that the District's plume of chemical pesticides sprayed at night during the summer months is highly likely to result in exposure, injury, and consequently, unauthorized takes under Vermont law of the five listed bat species. As a result, the Coalition respectfully requests the Committee to exercise its advisory role under 10 V.S.A. § 5404(b) by recommending actions necessary to protect the listed bats, including the requirement of an incidental takings permit.

A. The Protection of Endangered Species Act

Vermont's Protection of Endangered Species Act, 10 V.S.A. Ch. 123, prohibits any person from "taking" any endangered or threatened species listed under the Act. 10 V.S.A. § 5403(a)(1). The term "take" is defined broadly, explicitly incorporating acts that create "*a risk of injury* to wildlife, *whether or not the injury occurs*." 10 V.S.A. §5401(18)(A)(ii) (emphasis added).
Section 5408 of the law provides a limited exception to the otherwise strict prohibition against the "taking" of a listed species. Specifically, the Agency may—after obtaining advice from the Committee—issue a permit allowing the taking of a listed species if the "taking is *necessary* to conduct an otherwise lawful activity." 10 V.S.A. § 5408(b)(1) (emphasis added).

The Arrowwood Report's findings underscore our legal conclusion that the District's spraying of chemical pesticides directly fit the statutory definition's terms for identifying an illegal take, and under the law the District therefore is in violation of the statute if it proceeds without an incidental takings permit. To that end, regarding incidental takings, substantial evidence exists supporting the notion that the District's chemical pesticide program is *not necessary* to perform its duty of combating nuisance mosquitoes. Indeed, directly adjacent to the District is a separate insect control district, the Lemon Fair Insect Control District, which successfully combats nuisance mosquitos through the sole usage of non-harmful bacterial larvicide application (discussed in the revised Report).

B. The Pesticide General Permit

During the April 23, 2020 Endangered Species Committee meeting, there appeared to be a considerable amount of confusion regarding Vermont's National Pollutant Discharge Elimination System (NPDES) Pesticide General Permit's (PGP) relevance to the District, its activities, and the listed bats. To clarify, the PGP is administered by Vermont's Agency of Natural Resources' Department of Environmental Conservation under the cooperative-federalism delegation of federal Clean Water Act authority and the NPDES program. The PGP regulates point source discharges of biological and chemical pesticides that leave a residue, to waters of the State. Insect control districts, like the District here, that perform mosquito control activities which result in a point source discharge of pesticides to waters of the United States, including indirectly through pesticide residuals, must comply with the requirements of the PGP.

Particularly relevant here, is that the PGP *only* permits insect control districts to discharge chemical pesticide that are "not *likely* to result in a take" of any state-listed species. VT PGP § 1.6 (emphasis added). Thus, given that the District's chemical pesticide spraying program *is likely* to result in a take under Vermont law, the District *cannot* lawfully be allowed to discharge pesticides until it applies, and receives approval, for an incidental takings permit.

The PGP's relevance is twofold. First and importantly, the PGP does not preempt or relieve the District from complying with Vermont's Protection of Endangered Species Act. *See* 33 U.S.C. § 1365(e). Second, the combined mandates of Vermont's Endangered Species Act and the PGP arguably form an even broader threshold standard, which prohibits the District from spraying chemical pesticides until it receives proper permit coverage. Based on the Report's findings, the District's chemical pesticide spraying clearly meets that threshold.

Conclusion

Moving forward, when reviewing the Report and considering Vermont's legal threshold for an illegal take, we strongly urge the Committee and the Department to apply the terms of the law and the canonic precautionary principle. The District's use of chemical pesticides does not occur in a vacuum. It is made even more ecologically harmful to these species because it is injected into a context of compounded cumulative impacts from other threats, making the risk impacts of the District's pesticide practices on these vulnerable species especially threatening.

We will be pleased to be of service to you and the Committee during the review process, and ask that you forward to us any particular questions that may arise where further information or legal analysis would be helpful.

Thank you again for your concern for wildlife and your prompt attention to this matter.

Respectfully submitted, Dated: June 25, 2020

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/s/ Zach Cockrum
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June 24, 2020

Re: The BLSG District's Use of the Adulticides Malathion and Permethrin: Impacts on Five Threatened and Endangered Bat Species

Dear Chairman Strong,

Arrowwood Environmental (Arrowwood) was asked to provide a review of the Brandon, Leicester, Salisbury, Goshen, Pittsford Insect Control District's (BLSG or District) mosquito control activities on five state and federally endangered and threatened bat species that reside within the District. These species include the Indiana bat, northern long-eared bat, eastern small-footed bat, little brown bat, and tri-colored bat. I begin this report with a brief summary of my scientific qualifications followed by my analysis of the issues.[1]

SUMMARY OF EXPERTISE

For nearly four decades, I have worked professionally as a biologist, ecologist, researcher, environmental consultant, and instructor. Between 1977 and 1982, I studied wildlife biology at Michigan State University. In 1985, I received my bachelor's degree in zoological anthropology from the University of Michigan. I received my master's degree in Natural Resource Planning from the University of Vermont in 1992, where my soil physics professor adopted my presentation on pesticide movement in soils for use in future classes.

I am currently the principal Wildlife Biologist, Wetlands Ecologist, and a Partner with Arrowwood. At Arrowwood I am responsible for a wide variety of studies including single-species and habitat assessments, wildlife impact assessments, field inventories, wildlife tracking and wildlife sign assessments, and grassland and high elevation avian assessments. My areas of

[1] This report would not have been possible without the help and counsel of David Yates, Mammal Program Director at the Biodiversity Research Institute. Throughout the research and writing process, Dave served as an independent peer-review for the project.

expertise include hydric soils and wetland delineation, wetland function and value assessment, wildlife and wildlife habitat assessments, recreational impacts on wildlife, lake and reservoir ecology and management, pesticide impact assessment, conservation biology, and geographic information systems.

Throughout my professional career as an environmental consultant, I have worked with various clients to obtain permits in order to ensure compliance with federal and state laws and regulations. I have worked with threatened and endangered species and am familiar with the five bat species that this report focuses on, along with the chemicals used by the BLSG for mosquito control. In addition, for nearly a decade I served on the Vermont Pesticide Advisory Council and have significant experience with pesticides and their impacts on wildlife. I have authored Vermont's Golf Course Risk Assessment addressing pesticide toxicity, half-life, and chemical mobility; the Adirondack Wetlands Pesticide Buffer Project; and two assessments of impacts of aquatic herbicide use in Vermont Lakes.

Outside of my work as an environmental consultant, I have taught at the University of Vermont, Northern Vermont University, Sterling College, and Vermont Law School. More detailed information about my background and work can be found in my curriculum vitae, which is attached to the end of this report.

EXPERT OPINION AND COMMENTS

I. Preliminary Background

Recent federal-level malathion determinations provide relevant and helpful background. Specifically, in 2014, the Environmental Protection Agency (EPA) began preparing a Biological Evaluation pursuant to the federal Endangered Species Act to determine the effects of approximately 96 actively-registered pesticide products containing malathion (one of the adulticide chemicals used by the BLSG) (EPA 2016b). In the EPA's evaluation, it determined that malathion is "likely to adversely affect 1,778 of the total species analyzed (97% of species) and 784 of the total critical habitats analyzed" (EPA 2016b). Relevant here is EPA's determination that malathion is "likely to adversely affect" the Indiana and the northern long eared bats—both of which are found in the District (EPA 2016b).

II. Bats in the BLSG District

a. Introduction

Since 2001, biologists from Vermont Fish and Wildlife Department, U.S. Fish and Wildlife Service, and Green Mountain National Forest have studied bat populations in the Champlain Valley (Vermont Fish and Wildlife 2009). In Vermont, there are nine bat species (Vermont Fish and Wildlife 2019a). Five of the species that have been found in the BLSG District are state and/or federally listed as threatened or endangered (Vermont Fish and Wildlife 2019b). The federally endangered Indiana bat has been recorded in three District towns and the federally threatened northern long-eared bat has been recorded in four District towns. All of the state and federally listed bats hibernate in caves or mine cavities where they can be exposed to white-nose syndrome.[2] Multiple aspects of bat ecology, behavior, and physiology described below are likely to put bats at high risk of injury when BLSG applies pesticides in the District.

b. Federal and state listed bat species located in the BLSG District (VT F&W 2019b)

Indiana bat (*Myotis sodalist*): The Indiana bat is listed as both federally and state endangered in Vermont. The Indiana bat population has declined dramatically due to white-nose syndrome. Within Vermont, the Indiana bat has been located primarily in Addison, Rutland, and Bennington counties and has been observed in the BLSG towns Brandon, Salisbury, and Leicester. The Indiana bat forages in riparian forests, floodplain forests, wetlands, and forests near roosting habitat (Watrous et al. 2006). The bat's diet consists of moths, butterflies, beetles, flies, midges, wasps, and aquatic stoneflies and caddisflies among other prey items (Murray and Kurta 2002).

Northern long-eared bat (*Myotis septentrionalis*): The northern long-eared bat is federally threatened and state endangered in Vermont.[3] This species suffered dramatic declines due to white-nose syndrome.[4] Prior to these declines, the bat's range was statewide and it had known maternity roosts in Brandon. There was documented presence of the northern long-eared bat in the BLSG towns of Brandon, Leicester, Salisbury, and Pittsford. The northern long-eared bat forages in upland forests and is often found along roads and occasionally aquatic habitats. The bat's diet consists of moths, butterflies, beetles, flies, mosquitoes, and other insects (Caceres and Barcaly 2000). The northern long-eared bat captures flying insects and also gleans insects off plant leaves (Foster and Kurta 1999).

Eastern small-footed bat (*Myotis leibii*): The eastern small-footed bat is a threatened species in Vermont. The bat lives statewide; there has been documented presence in the BLSG towns of Brandon, Leicester, and Salisbury. The species has declined as a result of white-nose syndrome.[5] The bat forages over calm water and wetlands and its diet consists of moths, flies, beetles, and mosquitoes among other insects (Moosman et al. 2007).

Tri-colored bat (*Perimyotis subflavus*): The tri-colored bat is listed as endangered in Vermont. The tri-colored bat occurs statewide in Vermont, including the towns in the BLSG spray district. The bat forages in orchards, woodlots, and old fields and its diet consists of moths, butterflies,

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[2] Please refer to Section II(e) for further detail about white-nose syndrome.

[3] In 2015, U.S. Fish and Wildlife Service (USFWS) listed the Northern Long-eared Bat as Federally Threatened. The final USFWS 4(d) Rule for the Northern Long-Eared Bat does not include a prohibition on the incidental take of northern long-eared bats by pesticide application from mosquito control operations (Dep't of Interior, U.S. Fish and Wildlife 2016), provided that the activity is lawful and complies with all applicable State laws. The Service based its decision on historic evidence involving environmental contaminants (insecticides, pesticides, and inorganic contaminants) effects on the northern long-eared bat, as well as its assertion in the draft 4(d) rule that chemicals used in mosquito control (malathion and others of comparable risk to mammals) pose risks to northern long-eared bats (Dep't of Interior, U.S. Fish and Wildlife 2016).

[4] Personal Communications with Dave Yates, Mammal Program Director, Biodiversity Research Institute (Apr. 28, 2020).

[5] Id.

leaf and tree hoppers, beetles, midges and flies, and caddisflies (among other insects) (Ceballos 2014).

Little brown bat (*Myotis lucifugus*): The little brown bat is listed as endangered in Vermont. The little brown bat is found in several locations across the state. There has been documented presence of the little brown bat in the BLSG towns of Brandon, Leicester, Salisbury, Pittsford, and Proctor. The little brown bat forages in beaver meadows, other wetlands, over ponds, and vernal pools that have forest cover. The bat generally prefers still water habitats. The bat's diet consists of moths, flies, mosquitoes, mayflies, and beetles and other insects (Clare et al. 2011, Wray et al. 2018).

c. Summer habitat for bats in the BLSG District

In the spring and summer, the five bat species listed above forage after dusk in the BLSG District. The diet of these species consists primarily of flying insects which are captured on the wing. Bats typically forage as low as 10 to 30 feet above the ground over fields and wetlands and also fly through forests often following corridors including woodland roads. Some of Vermont's listed bat species forage preferentially along forest edges (Jantzen and Fenton 2013; Hein et al. 2009). While travelling from daytime roosting sites to night-time foraging areas, bats often navigate along forest edges (Grindal et al. 1999; Zimmerman and Glanz 2000; Jantzen and Fenton 2013). Bats fly along the surface of quiet waterbodies to drink water.

In the summer, females and young bat pups spend their daylight hours in maternal roosts under tree bark, within tree crevices and cavities, or under or inside built structures (Agosta, 2002, Butchkoski and Hassinger, 2002). While clustered at the daytime roosting sites, some bats groom themselves and each other by licking fur (Carter and Wilkinson 2013). Bat pups are born and nursed at these roosting sites.

Maternal roosting colonies of the endangered Indiana bat have been located by Vermont Fish and Wildlife biologists in Salisbury and Leicester (Vermont Fish and Wildlife 2009). These colony sites are less than two miles from designated roadside spray routes in the BLSG District, well within the night-time foraging range of the bats.[6] Other maternal colonies of Indiana bats might also be present within the District (Vermont Fish and Wildlife 2009) and roosting sites of other species are documented throughout the District. At dusk, bats leave the roosting trees to forage for insects up to a few miles from the roosting site. The bats return to the roosting sites before sunrise.

d. Winter hibernacula

In late summer, all of Vermont's federally and state listed bats leave their foraging and roosting areas and migrate to caves or mines where they spend the winter in aggregations usually with many individuals of multiple species. Some listed bat species are known to have spent the winter at a hibernaculum site in Brandon, within the BLSG District, although many migrate to southern Vermont (near Dorset), New York, or even farther away. The endangered Indiana bat has been

[6] Id.

documented hibernating at the Brandon hibernaculum site (Vermont Fish and Wildlife 2009), which is a half mile from a designated pesticide spray route in the District and less than five miles from 10 other designated spray routes in four District towns. The habitat near hibernacula is critical for male Indiana bats which can spend the summer months roosting and foraging within a few miles of the cave or mine (Vermont Fish and Wildlife 2009). Most Indiana bats swarm near the hibernaculum site in the weeks before entering it in autumn and during this period can travel up to 10 miles to forage (US Fish and Wildlife 2019).

e. Bat physiology

While flying, bats burn 8–15 times more energy than while resting (Voigt and Lewanzik 2011). Due to their high metabolism and rapid use of energy in flight, bats must consume large amounts of food for their size. Some insectivorous bats may eat 30% - 120% of their body weight per day (Wilson 1997, Fenton and Simmons 2014). Lactating female bats can consume 67% more food daily than non-lactating bats (McLean and Speakman 1999). The little brown bat can consume as many as 500 mosquitoes in an hour and over 5,000 in a night (Wray et al. 2018).

The high rate of metabolism in bats increases oxygen demand. In addition to using their lungs for respiration, there is some evidence that bats exchange gas through their wing membrane. Makanya and Mortola (2007) report that up to 10% of oxygen consumption in fruit bats was through their wings. The surface area of the wings is about 85% of a bat's total body surface area and supplements respiratory gas exchange (Thompson and Speakman 1999). The subcutaneous vessels in the mostly hairless membrane lie very close to the surface (only a thin epidermis is present) and allow for the diffusion of oxygen and carbon dioxide (Voigt and Lewanzik 2011). Hernandez-Jerez et al. (2019) discuss pesticide absorption through the wing membrane of bats and state that "permeability of the wing membrane must be considered to be high, and it is assumed that any dermal exposure to pesticides will result in 100% penetration (page 24). The authors go on to state that current pesticide risk assessment protocols may not adequately address this exposure route and that it may constitute the highest route of pesticide exposure in bats (page 30).

Bats in the BLSG District must accumulate fat reserves to fuel their fall migration and winter hibernation. Fat is amassed by eating insects throughout the summer in the BLSG District. These reserves are gradually metabolized throughout the winter when the bats might be many miles from their summer foraging areas (see Section IV(d), page 11 of this report for a discussion of pesticides and the fat cycle in bats).

Gathering by the thousands to spend the winter hibernating in caves and mines, many of Vermont's bats are exposed to white-nose syndrome, a recently introduced disease that has killed millions of bats since 2006 (Alves et al. 2014, Wibbelt 2018). White-nose syndrome is caused by a fungus that infects the skin of bats and can be transferred from bat to bat or from infected caves to healthy bats. All of the federally and state listed bat species found in the BLSG District have been affected by white-nose syndrome (Vermont Fish and Wildlife 2019a).

III. Brandon-Leicester-Salisbury-Goshen-Pittsford Insect Control District (BLSG)

a. General background

The BLSG is a municipal district formed in 1978. It provides mosquito control services to the towns of Brandon, Leicester, Salisbury, Goshen, and Pittsford (Addison and Rutland counties). Funding for the BLSG comes from the five townships within the district and the Vermont Agency of Agriculture, Food, and Markets. The BLSG operates by a volunteer Board of Trustees with two representatives from each town, along with seasonal employees.

b. Pesticides used by BLSG

BLSG administers two pesticide programs—larvicide and adulticide—to control mosquitoes from April through October of each year. The Vermont Agency of Agriculture, Food, and Markets issues permits to BLSG for its use of larvicides for mosquito control in waters of the State. The Vermont Agency of Natural Resources' Department of Environmental Conservation regulates BLSG's discharges of pesticides (including larvicides and adulticides) via Vermont's National Pollutant Discharge Elimination System (NPDES) Pesticide General Permit (PGP), in compliance with the federal Clean Water Act.

i. Larvicide program

Larvicides help reduce mosquito populations by targeting immature stages of mosquitoes in breeding habitats. Larvae are killed before they can mature into adult mosquitoes and disperse to nearby communities. To cover the 6000 acres of potential mosquito breeding habitat in the District (primarily along Otter Creek), larvicide is typically applied by a helicopter dropping dry granules. Larvicide granules, pellets, or briquets are also applied by hand to smaller areas of breeding habitat (EPA 2016a; BLSG 2019a).

The BLSG uses two types of larvicide: bacterial (*Bacillus thuringiensis* subsp. *israelensis* or *B. sphaericus*), and methoprene. Bacterial larvicides are naturally occurring microbes that make proteins which are toxic to mosquito larvae. When applied to standing water, *B. thuringiensis* subsp. *israelensis* and *B. sphaericus* kill the larvae of mosquitoes and other small flies that have aquatic larvae. These larvicides are highly specific because the toxins are activated only after the bacteria are ingested by the target larvae (National Pesticide Information Center 2015; BLSG 2019b).

The other larvicide used is methoprene, which is an insect growth regulator. Methoprene is sometimes applied by hand by BLSG to vernal pools, catch basins, drainage ditches, and other small problem areas. Unlike bacterial larvicide, methoprene is lethal to a wide variety of insects, other invertebrates, and vertebrates (EPA 2001; Lawler 2017; BLSG 2019a; BLSG 2019b).

ii. Adulticides

Adulticides are insecticides used to kill adult mosquitoes. BLSG applies these insecticides via truck mounted ultra-low volume (ULV) sprayers or backpack sprayers (BLSG 2019a). BLSG's

ULV sprayers produce a mist of small droplets (generally less than 50 microns diameter) of concentrated chemical insecticide (Bonds 2012, BLSG 2019b). To increase the likelihood of contact with flying insects, the aerosol mist is engineered to stay suspended in the air for one to two hours and to drift laterally at least 150 feet (Mount 1998, Bonds 2012). This application strategy differs from typical agricultural pesticide treatments which are designed to coat plant surfaces and minimize lateral aerial drift (Frankel 1986).

c. Neighboring mosquito control district

Adjacent to the BLSG is the only other insect control district in Vermont. The Lemon Fair Insect Control District (LFICD 2020) includes the Addison County towns of Bridport, Cornwall, and Weybridge. The Lemon Fair District includes 59,000 acres compared to the 100,000 acres of the BLSG. As in the BLSG, the prime mosquito breeding areas in the Lemon Fair District are agricultural fields and wetlands in the floodplain of Otter Creek (BLSG is mostly east of Otter Creek and the Lemon Fair District is mostly to the west). In addition, the floodplain of the Lemon Fair River itself has extensive breeding areas. The Lemon Fair District was established in 2006.

The Lemon Fair District controls mosquitoes using bacterial larvicides. As in the BLSG, larvicides are applied by helicopter and from the ground. Methoprene, applied by hand to small bodies of water in the BLSG, is not used in the Lemon Fair District.

No adulticides are applied by the Lemon Fair District. An integrated pest management approach includes modifying vegetation or hydrology to eliminate breeding areas, removing water-holding containers, monitoring for larval and adult mosquitoes, and treatment with larvicides. A program of well-timed and repeated application of bacterial larvicides has been successful since 2006.

d. Roadside spraying of adulticides by BLSG

The BLSG's spray routes follow both public and private roadways in the towns of Brandon, Leicester, Salisbury, Goshen, Pittsford, and Proctor. There are 15 spray routes listed and mapped at the BLSG website (BLSG 2019a). Each of these spray routes covers approximately six to nine miles. The BLSG District has five spray trucks equipped with ULV sprayers. With multiple trucks operating, the District can cover four to six routes in one evening. During the summers of 2018 and 2019, roadside spraying occurred on 20 to 22 different evenings. An average of four separate routes were sprayed on each evening (BLSG 2019a).

Roadside insecticide spraying is done after dark. The spray is broadcast in tiny droplets of pesticide that stay airborne for one to two hours (Mount 1998, Bonds 2012). The insecticidal mist covers an area approximately 300 feet in width (150 feet on either side of the road) with an aerosol concentration sufficient to kill mosquitoes (BLSG 2019a). Assuming that pesticide does not drift farther from the road and that the mean route length is 7.5 miles, the 15 regularly sprayed routes in the District cover more than 4000 acres. This estimate does not include the road sections and many private driveways that are regularly sprayed but are not part of mapped spray routes. Therefore, on an average summer evening of adulticide spraying in the BLSG

District, a mist of concentrated pesticide is suspended over about 1000 acres for one or two hours.

i. Malathion

Malathion is an organophosphate insecticide. The mode of action of malathion and its primary metabolite malaoxon, like other organophosphate insecticides, is to inhibit acetyl cholinesterase (an enzyme critical to the proper functioning of the central nervous system) (USFS 2008). This inhibition results in continual nerve firing and a loss of both controlled movement and breathing by an organism. Any organism that depends on the normal functioning of this enzyme will be affected by malathion and its metabolite. Affected organisms include mammals, birds, reptiles, amphibians, and invertebrates including arthropods (including many insects). Malathion does not greatly accumulate in the fat tissues of most organisms (it has a log KOC[7] of 2.84) (Faria et al. 2010).

ii. Permethrin

Permethrin is classified as a pyrethroid insecticide. Permethrin acts on nerve function, essentially inducing tremors and eventually paralysis in affected organisms (EPA 2007a). It affects vertebrates and invertebrates, including insects. Permethrin bioconcentrates[8] in media and bioaccumulates in organisms. Permethrin has a strong tendency to adsorb to bottom sediments once in solution where it is stable and long-lasting. Permethrin bioaccumulates in aquatic insects at a rate of up to 570 times (Anderson 1982, insects can have 570 times higher concentration than the water they live in) and in zooplankton up to 1,000 times (Bhatnagar et al. 1988). The insecticide has low solubility and bioaccumulates in the fatty tissue of organisms (Geluso et al. 1976). (See Section IV(d) below "Bioaccumulation of permethrin in bats and immunosuppression"). Permethrin is stable, and its rate of breakdown is long with a half-life[9] in water of 113–175 days (EPA 2007b).

IV. Impacts of mosquito adulticides on bats

EPA concluded that malathion is "likely to adversely affect" the Indiana bat and the northern long eared bat (EPA 2016b). This analysis was only the first step in the Endangered Species Act's consultation requirement process. To date, the U.S. Fish and Wildlife's (FWS) biological opinion involving malathion has not been formally released. However, Freedom of Information Act requests reveal that the FWS team concluded that malathion places 1,284 federally endangered and threatened species in jeopardy (The New York Times 2019). The potential harm to bats from malathion might be even more serious because the FWS preliminary analysis failed to consider several important aspects of bat biology and ecology. The following modes of

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[7] ***KOC*** refers to the octanol-water coefficient of a substance. This is a measure of a substance's tendency to be adsorbed within soils and living organisms. Generally, the logarithmic value of KOC is stated, and a value of less than a log KOC of 4.5 signifies that the compounds is likely to bioaccumulate in organisms.
[8] The ***bioconcentration*** of a substance refers to the degree that some substances concentrate in the bodies of organisms above that of the medium (in this report the medium referred to is water) in which they are exposed.
[9] ***Half-life*** is a measure of the time required for the concentration of a substance to decrease by half.

exposure to pesticides suggest that the pesticide application procedures followed in the BLSG District create a high likelihood of a "take"[10] of one or more individuals of the five bat species addressed in this report.

a. Exposure to air-borne pesticides

Roadside spraying of malathion and permethrin in the BLSG District occurs after dusk between 8:00 p.m. and 6:00 a.m. (BLSG 2019a). This time overlaps with the foraging activities of the five listed bat species. During this time, the bats travel between daytime roosting areas and feeding sites where they forage for insects.

Navigating along forest edges or road corridors can bring bats close to roads and into direct contact with the plume of chemical adulticides from roadside spraying. The typical foraging activity of bats can also expose them to the chemical plume which nominally extends about 150 feet from roads. Air turbulence created by the spray truck, subsequent traffic, and light breezes will disperse the plume upwards. Experiments with caged mosquitoes demonstrated that ULV applied malathion can kill >80% of mosquitoes 50-100 feet above the ground (Mount 1998). The height above the ground at which most bats forage and travel in the District is well within this vertical spread of the chemical plume.[11] For example, successful mist netting of bats for research purposes is typically done less than 30 feet, and often less than 20 feet, above the ground (Robbins et al. 2008).

Bats flying through a pesticide spray cloud can be exposed by breathing fine droplets of concentrated pesticide or by contacting the pesticide with their wing membranes or fur. Both inhalation and contact with the highly vascularized wing membrane may allow pesticides to quickly enter the bat's blood stream. Pesticides contaminating the fur of bats can later be ingested when bats groom themselves, or by social grooming (Hernández-Jerez et al. 2019). Grooming is a major avenue of exposure of bats to contaminants, for example, from mine pollution (King et al. 2001, Kunz et al. 1977). In fact, the spreading of contaminants through grooming in bats has been exploited to cull "nuisance" bat populations in the past (Linhart et al. 1972, Johnson et al. 2014). Pesticides can also be transferred through a mother's milk in lactating female bats (Hofman and Heise 1991).

The plume of pesticides released by BLSG's spray trucks slowly disperses until it is capable of killing small flying insects about 150 feet on either side of the road. Before that time, the plume is more concentrated and poses a greater risk to larger insects and also to bats. Bats flying

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[10] I am familiar with both the state and federal laws and regulations involving endangered species and the associated "take" standards. For this report, I based my evaluation on Vermont's Protection of Endangered Species Law, 10 V.S.A. Ch. 123, and the definitions, standards, and prohibitions therein. Under the Act, "take" is broadly defined to include "an act that creates a risk of injury to wildlife, whether or not the injury occurs." 10 V.S.A. § 5401 (18)(A)(ii). I also familiarized myself with Vermont's National Pollutant Discharge Elimination System (NPDES) Pesticide General Permit (PGP) and its express prohibition of pesticide discharges that are likely to result in the take of a threatened or endangered species listed under 10 V.S.A. Ch. 123.

[11] Personal Communications with Dave Yates, Mammal Program Director, Biodiversity Research Institute (Apr. 28, 2020).

through the undispersed chemical plume close to the road would likely receive a higher dose of pesticide.

b. Ingesting contaminated insects

The protocol for ULV roadside spraying in the BLSG District produces a plume of small droplets of concentrated pesticide which kills small flying insects when they contact droplets. When the sprayer is calibrated correctly and the plume is well dispersed, insects much larger than a mosquito can survive typical contact with droplets (Boyce et al. 2007). Although they may contact hundreds of droplets, these larger insects continue to fly and can become prey for bats. Bats catching and eating these contaminated insects will also ingest pesticide on the insect. Individual insects which have not been killed by pesticide contact may not carry heavy loads of pesticide, but many hundreds or thousands of insects are eaten nightly by bats. The cumulative pesticide ingested by eating these contaminated insects throughout the summer may be substantial.

c. Sub-lethal symptoms of pesticide exposure

As discussed below, if the exposure of bats to pesticides is not immediately lethal, it can nonetheless put bats at substantial risk. In a study of the toxicity of an organophosphate insecticide, big brown bats lost motor control and could not right themselves at a dose about one-third the lethal dose (Clark 1986). Because the bats did not die, this affect did not contribute to the statistics of lethality. In the same study, mice exposed to sub-lethal amounts of organophosphate pesticides recovered in two hours, but the condition lasted for 24-hours in bats (Clark 1986). In nature, this toxic response would likely result in death of the bat due to exposure to predators, extremes in temperature, inclement weather, or drowning (Clark 1986; Eidels et al. 2016). A separate study (Plumb and Budde 2011) also reports that bats lose motor control for over 24-hours when they come in direct contact with organophosphate insecticides. Such exposures in nature could potentially create a high risk of injury for individual bats.

The same pattern has been shown with permethrin. The little brown bat's ability to fly was impaired at a median effective dose of permethrin that was at one-sixth the LD_{50}[12] lethal dose (O'Shea and Clark 2002). Such laboratory tests concluding that low doses of pesticides may affect motor control but are not lethal illustrate the danger that sub-lethal doses of these pesticides pose to natural bat populations.

Investigations of the sub-lethal exposures to organophosphate insecticides found negative impacts on reproductive behavior, normal endocrine function, and caused hypothermia in birds and mammals (Grue et al. 1997; Choudhary et al. 2008). Any negative effect on the ability of bats to reproduce could have serious consequences. Many bat species produce only one litter of pups per year, and often only a single pup. This places bats in a vulnerable position because of their limited ability to reproductively respond to population declines. The sub-lethal effects of

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[12] ***LD_{50}*** is the lethal dose of a substance (typically per body mass) that kills 50% of the test organisms in a designated time period.

pesticides on bat reproduction were not considered in the process by which the EPA determines the safety of a pesticide.

Wilkinson (1976) reports that respiratory failure and asphyxia can result from exposure to organophosphates. In addition, the negative effects of organophosphate exposures have been shown to be additive when combined with other pesticides including herbicides, carbamates, and pyrethroids (Costa and Murphy 1983; Ahmad 2007; and Trimble and Lydy 2006).

d. Bioaccumulation of permethrin in bats and immunosuppression

Because of permethrin's persistence in the environment and its tendency to bioaccumulate in the tissues of organisms, aquatic insects can have concentrations of permethrin many hundreds of times greater than that of the water they live in (Anderson 1982). Application of permethrin at rates similar to those used in the BLSG District resulted in contaminated aquatic sediments as long as 10 months after treatment (Rawn et al. 1999). Many of the flying insects eaten by bats in the District (e.g., flies, stoneflies, mayflies, caddisflies) have aquatic larval stages where they can be exposed to environmental permethrin and are vulnerable to its bioaccumulation.[13] Bats can be contaminated with permethrin by eating insects which have accumulated permethrin in this way or insects that have just flown through an aerial plume of permethrin.

When hibernating in communal caves or mine cavities, all five of the listed bat species mentioned herein survive on fat reserves acquired while eating insects during the warmer months. As these fat reserves are metabolized, any accumulated contaminants are released and can have toxic effects on the bats (Geluso et al. 1976; Clark and Shore, 2001). Bayat et al. (2014) state that the fat accumulation/depletion cycles associated with bat hibernation and migration can concentrate pesticides in bat brains where the maximum negative effect of the presence of toxicants is expressed.

One symptom of pesticide exposure in bats is suppression of the immune system and increased susceptibility to diseases including white-nose syndrome (Kannan et al. 2010). Permethrin reduces the ability of immune system cells, called T-lymphocytes, to recognize and respond to foreign proteins, and doses equivalent to 1/100 of the LD_{50} lethal dose inhibited T-lymphocytes in over 40% in test mammals (World Health Organization 1990). Permethrin also reduced the activity of a second type of immune system cell, natural killer cells, by about 40% (Blaylock et al. 1995).

Although malathion does not accumulate in fat reserves and therefore will not be released during hibernation, immunosuppression could be a direct effect of malathion exposure in bats. Malathion has been shown to lower the immunological responses in other mammals and birds. The sub-lethal exposure of malathion to rats (Popeskovic et al. 1974), rabbits (Banerjee et al. 1999), and mice (Rogers and Xiong 1997) produced lowered immunological responses.

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[13]***Bioaccumulation*** occurs when a substance accumulates in an organism quicker than it can be removed by excretion and catabolism. Bioaccumulation can become a serious concern when contaminants transfer up the trophic level of a food chain.

Currently, EPA has no guideline or standard within their risk assessment protocol for determining when a pesticide decreases an organism's immunological response. The potential immunological impacts of malathion and permethrin are not considered as part of the pesticide registration process, and therefore that process may understate the dangers of these pesticides for bats.

e. Impacts of pesticides on the insect prey of bats

Killing mosquitoes and other flying insects could harm bats by depriving them of their prey. Modelling efforts have included this assumption (EPA 2016b), but no field studies have confirmed this outcome. This outcome is unlikely to happen in the BLSG District due to the ways in which pesticide application there is limited spatially and temporally, and targeted at small insects.

In the BLSG District, roadside adulticide spraying happens only along designated spray routes which nominally reach 4,000 of the 100,000 acres in the District (see Section III(d) above). The application of adulticides is permitted only when "action thresholds" of high mosquito populations are met (BLSG. 2019b). Most designated roadside spray routes in the BLSG District are sprayed, on average, once or twice per month in the summer (typically May through September). This treatment involves spraying a plume of chemical adulticide into the air after dark when bats are actively foraging for flying insects and can expose bats to chemical contamination whenever it happens during the summer. Although this presents an obvious exposure risk to bats, the intermittent and spatially limited nature of BLSG's adulticide program is unlikely to reduce the populations of small prey insects sufficiently to cause stress for bats. Insects larger than mosquitoes are typically not killed even when they fly through the pesticide plume (Boyce et al. 2007). Bats may be more likely to be put at risk of exposure to pesticides by eating these contaminated insects than by lack of food because of reduced populations of smaller prey insects.

The application of larvicides in the BLSG District is also spatially and temporally limited and is highly targeted taxonomically. Helicopter application of bacterial larvicides happens only in the 6,000 acres of uninhabited lowlands along Otter Creek, Leicester River, and a few other swampy tracts. These aerial larvicide treatments do not happen every year (it has not happened since 2017). They happen only when and where monitoring indicates high mosquito larva density (usually in May or June), and only when the Vermont Agency of Agriculture, Food and Markets makes sufficient funds available. The treatment kills only the larvae of mosquitoes and a few other dipterans, and only those at a particular stage of development (the larvae must be feeding to ingest the bacteria), and is effective for only about two weeks after application (Lawler 2017). Due to the great expense of the helicopter procedure, it has never been repeated at the same site in one year. Although these treatments can temporarily depress populations of certain mosquito species near lowland wetlands, other insect species and nearby untreated areas will likely provide sufficient prey for bats during the short period of floodplain mosquito depression.

f. The inadequacy of pesticide risk assessment for bats

The EPA's registration of pesticides addresses some of the potential routes of pesticide exposure and the possible risks that are posed to animals. The Agency has never completed an Endangered Species Act consultation for these pesticides. Furthermore, the Agency has also not adequately assessed pesticide impacts on these bats nor instituted pesticide label changes to protect them. A recent June 2019 assessment by scientists within the European Food Safety Authority concludes that current risk assessment practices do not provide adequate protection for bats (Hernández-Jerez et al. 2019). Specifically, Hernández-Jerez et al. (2019) found that using other 'surrogate' mammals and birds in lieu of bats (within the risk assessment process) likely underestimates the risks of exposure and harm to bats. Hernández-Jerez et al. (2019) conclude that the risk of respiratory and dermal exposure (including through the wing membrane), transmittance through grooming activities, and the potential transfer of pesticides through a mother's milk pose substantial risks currently unaccounted for in present risk assessment processes. Such risks increase when considering life history traits of bats (e.g. long-lived, low fecundity, etc.) (Hernández-Jerez et al. 2019).

An example of misapplying information about surrogate species to bats involves the standard measure of acute toxicity of pesticides. This measure of how much pesticide was required to kill half of the test animals (LD_{50}) applies only crudely to bats. The acute toxicity of malathion and permethrin to bats was not measured as part of the protocol for registering pesticides. Tests on surrogate mammals such as rabbits determined that the toxicity of malathion and permethrin to mammals was "low." However, other laboratory measures of sub-lethal toxicity (at much lower doses) show dramatic negative effects on bats, for example loss of motor control (see Section IV(c) above), that would likely be lethal to bats in nature (Hernández-Jerez et al. 2019). It is likely that EPA's risk assessment protocol underestimates the degree of exposure—including the risk of injury—that these pesticides pose to bats.

V. Conclusions

The information presented above describes the potential impacts of BLSG's mosquito control activities on the five listed bats. The direct impacts to the bats are the acute toxic impacts resulting from bats flying through the pesticide plume and sub-lethal potentially debilitating effects on bat physiology (muscle control and coordination), reproduction, and immunology. Bat exposure within a pesticide plume can occur through both dermal and respiratory pathways and by ingestion of contaminated prey insects. Other potential pathways of pesticide exposure for bats include transfer through mother's milk and grooming activities.

Bat and mammal exposure to insecticides, and the resulting lethal and sub-lethal effects of both long-term chronic and short-term acute exposure has been well documented with organophosphates and pyrethroids (Kunz et al. 1977, Bayat et al. 2014, O'Shea and Clark, 2002). The specifics of BLSG's chemical pesticide spraying activities described above suggest a high risk that listed bats will be exposed to these chemical insecticides. The risk that the five listed bats will be injured by this exposure is increased by the unique life history, behavioral, and physiological characteristics of these bats (Hernández-Jerez et al. 2019, Secord et al. 2015).

On a typical evening of roadside spraying, BLSG produces a concentrated mist of chemical pesticide which remains suspended over about 1000 acres for one or two hours. This is likely to present a high risk of exposure and injury to one or more individuals of the listed bat species referred to in this report.

Respectfully submitted,

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JEFF PARSONS

PARTNER – WILDLIFE BIOLOGIST – WETLAND ECOLOGIST

Areas of Expertise

- Hydric Soils & Wetland Delineation
- Wetland Function & Value Assessment
- Wildlife & Wildlife Habitat Assessments
- Recreational Impacts on Wildlife
- Lake & Reservoir Ecology and Management
- Pesticide Impact Assessment
- Conservation Biology
- Geographic Information Systems

Education & Professional Training

- M.S. Natural Resources Planning, University of Vermont, 1992
- B.S. Zoological – Anthropology: University of Michigan, 1985
- Wildlife Biology: Michigan State University, 1977-1982
- Vermont Natural Shoreline Erosion Control Certification, 2016
- Wetland Ferns, 2013
- Aquatic Plants of Vermont, 2002
- Sedges of Vermont, 1998
- Lichens of Vermont, 2008
- Mosses of the Northeast, 2007

Mr. Parsons is the principle Wildlife Biologist for Arrowwood Environmental responsible for a wide variety of wildlife studies including: single-species and habitat assessments, wildlife impact assessments, field inventories, wildlife tracking and sign assessments, and grassland and high-elevation avian assessments. Mr. Parsons also conducts wetland delineations, function and value assessments, impact assessments, reclassifications, and mitigative and restoration plans and implementation. Accomplishments also include lake, pond and reservoir ecology and management plans, interpretive trail development, and recreational impacts on wildlife, community natural resource planning and environmental permitting.

Significant Projects & Experience

- Instructor: Vermont Law School: 1997-2003.
  - University of Vermont: 1993-1998.
  - Northern Vermont University: 1994-98, 2016-18.
  - Sterling College: 1992-2017.
- Vermont Pesticide Advisory Council: Health and Environment Representative 1991-2000.
- Interim Vermont Recreation Planner: Vermont Recreation Plan Wetlands Component and summary documents 1988
- Lecturer and Field Leader: Wetland Ecology for Federal District Court Judges (Vermont Law School).
- Black Bear Habitat Assessments: Smugglers' Notch Resort, Stowe Mountain Resort, Jay Peak Resort, Sugarbush Resort, Bromley Mountain.
- Bicknell's Thrush Habitat and Species Monitoring: Smugglers' Notch Resort, Jay Peak Resort, and Sugarbush Resort.
- Primary Ecologist and Project Coordinator: Lake and Pond Assessment and Management for Woodbury, Vt.
- Vermont's Golf Course Pesticide Risk Assessment: Author of Protocol addressing pesticide toxicity, half-life, and chemical mobility.
- Ecologist and Wildlife Biologist: Middlebury Gap and Smugglers' Notch Scenic Highway Management Plans .
- Ecologist and Wildlife Biologist: Inventory and management guidance for natural areas wetlands, and wildlife within the cities of Burlington and South Burlington.
- Lead Investigator: Inventory & Prioritization of wetlands for acquisition by the State of Vermont.