United States Department of Agriculture

Marketing and Regulatory Programs

Animal and Plant Health Inspection Service

Asian Citrus Psyllid Control Research Project

Hidalgo County, Texas

Environmental Assessment
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I. Purpose and Need

A. Introduction

Asian citrus psyllid (ACP) (*Diaphorina citri* Kuwayama*)* can cause economic damage to citrus in groves and nurseries by direct feeding. Both adults and nymphs feed on young foliage, depleting the sap and causing galling or curling of leaves. High populations feeding on a citrus shoot can kill the growing tip.

ACP serves as a vector of an uncultured *α-Proteobacteria*, "*Candidatus* Liberobacter asiaticum," which causes citrus greening disease (CG). CG, also known as huanglongbing or HLB, is considered to be one of the most serious citrus diseases in the world. CG attacks the vascular system of host plants. The bacteria present no threat to humans or animals. The bacteria are phloem-limited and cause yellow shoots, blotchy mottling and chlorosis, reduced foliage, and tip dieback of citrus plants. CG greatly reduces production, destroys the economic value of the fruit, and can kill trees. Once infected, there is no cure for a tree with CG. In areas of the world where CG is endemic, citrus trees decline and die within a few years and may never produce usable fruit.

Within the United States, ACP is currently present in Alabama, California, Florida, Georgia, Guam, Hawaii, Louisiana, Mississippi, South Carolina, Puerto Rico, and Texas. CG was first detected in the United States in Miami-Dade County, Florida in 2005 and is only known to be present in Florida and Louisiana.

The U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS) has undertaken measures to control the artificial spread[1] of ACP and CG to noninfested areas of the United States since its introduction in 2005. APHIS has issued numerous Federal Orders[2] designating quarantined areas and has imposed moving restrictions, including the requirement of chemical treatments, when CG and ACP host plant and plant material are moved interstate from quarantined areas.

APHIS, in cooperation with Texas A&M University – Kingsville Citrus Center (TAMU-KCC), is proposing to implement an ACP control research project in citrus groves and residential properties within Hidalgo County, Texas. The objective of the study is to demonstrate that ACP populations may be controlled in a coordinated fashion and at a regional level in

[1] Humans moving CG or ACP host plant material have been responsible for the long-distance spread of CG and ACP; this is often referred to as "artificial" spread.
[2] To view Federal Orders pertaining to controlling CG and ACP, go to http://www.aphis.usda.gov/plant_health/plant_pest_info/citrus_greening/regs.shtml.

managed and abandoned citrus groves and residential properties, to lower the potential risk posed by CG. This environmental assessment (EA) analyzes the potential environmental impacts of the proposed research project and its alternatives.

B. Purpose and Need

APHIS is responsible for taking actions to exclude, prevent, eradicate, and/or control plant pests, such as ACP, under the Plant Protection Act (7 United States Code (U.S.C.) 7701 et seq.). When scientific data is limited, APHIS may at times conduct research in an attempt to further develop pest control methods.

The need for the proposed research project is to better understand how to manage ACP, the vector of CG, in a coordinated area-wide approach. The purpose of the project is to help protect the citrus industry, including the individual growers who comprise the base of that industry, by developing and providing sound ACP control strategies. The overall goal of the research would be to demonstrate that ACP populations may be satisfactorily controlled in a coordinated fashion at a regional level. This would include managed and abandoned citrus orchards, residential properties, and other non-commercial sites in order to lower the potential risk posed by CG. The research would attempt to:

- Implement site-specific treatment regimes for ACP control in commercial citrus and refine monitoring methods for ACP populations and infestations before and after treatment;
- In collaboration with homeowners, develop effective and acceptable control programs in residential citrus trees using approved bio-pesticides and registered chemicals;
- Continue to test the efficacy of different insecticide application methods comprising aerial application (fixed winged aircraft) and ground application (standard high volume and reduced volume);
- Monitor and document the effects of different ACP population control options on non-target arthropods, including beneficial and secondary pests species;
- Develop grower and public education programs and promote cooperation and commitment from all stakeholders for dealing with ACP and the threat of CG in Texas.

This EA will analyze the environmental impacts anticipated from implementation of the proposed research project. This EA has been prepared consistent with the National Environmental Policy Act of 1969 (NEPA) (42 U.S.C. 4321, et seq.) and APHIS' NEPA implementing procedures (7 CFR Part 372). APHIS provided a public comment period for this EA that ended on February 13, 2009. Comments were to be sent

to USDA/APHIS/PPQ Office, 320 North Main St. Suite 119, McAllen, Texas 78501 by February 12, 2009. No comments were received.

II. Alternatives

APHIS has considered two alternatives in response to the need to better understand effective ACP control strategies: (1) no action and (2) the proposed action. Each alternative is described briefly in this section, and the potential environmental impacts of each are considered in the following section.

A. No Action

Under the no action alternative, APHIS would not conduct the control research project. If the proposed research project is not conducted, APHIS may need to implement ACP management programs without the best research available.

Hidalgo County is currently included in the October 1, 2008 Federal Order[3] for CG and ACP. Under this Federal Order, Hidalgo County is quarantined for ACP and therefore, any regulated articles[4] must be chemically treated or irradiated in order for them to be moved interstate. However, this Federal Order applies to nurseries and not citrus groves and residential properties. Citrus groves are not required to treat against ACP. However, growers independently conduct control actions against other citrus pests using different pesticides. While some citrus growers in Hidalgo County are beginning to voluntarily treat against ACP, others continue to apply pesticides primarily against other citrus pests such as citrus rust mites. Some of their pesticide applications may control ACP for short periods of time, but others may have little effect on ACP numbers. The lack of a coordinated approach may result in greater pesticide use and sporadic control.

B. Proposed Action

Under the proposed action alternative, APHIS would conduct an ACP control research project to better understand effective ACP control strategies. APHIS could utilize the results of the project to develop and implement sound ACP management practices and to minimize the risk of introducing CG in citrus groves and residential properties in Texas as well as throughout the United States.

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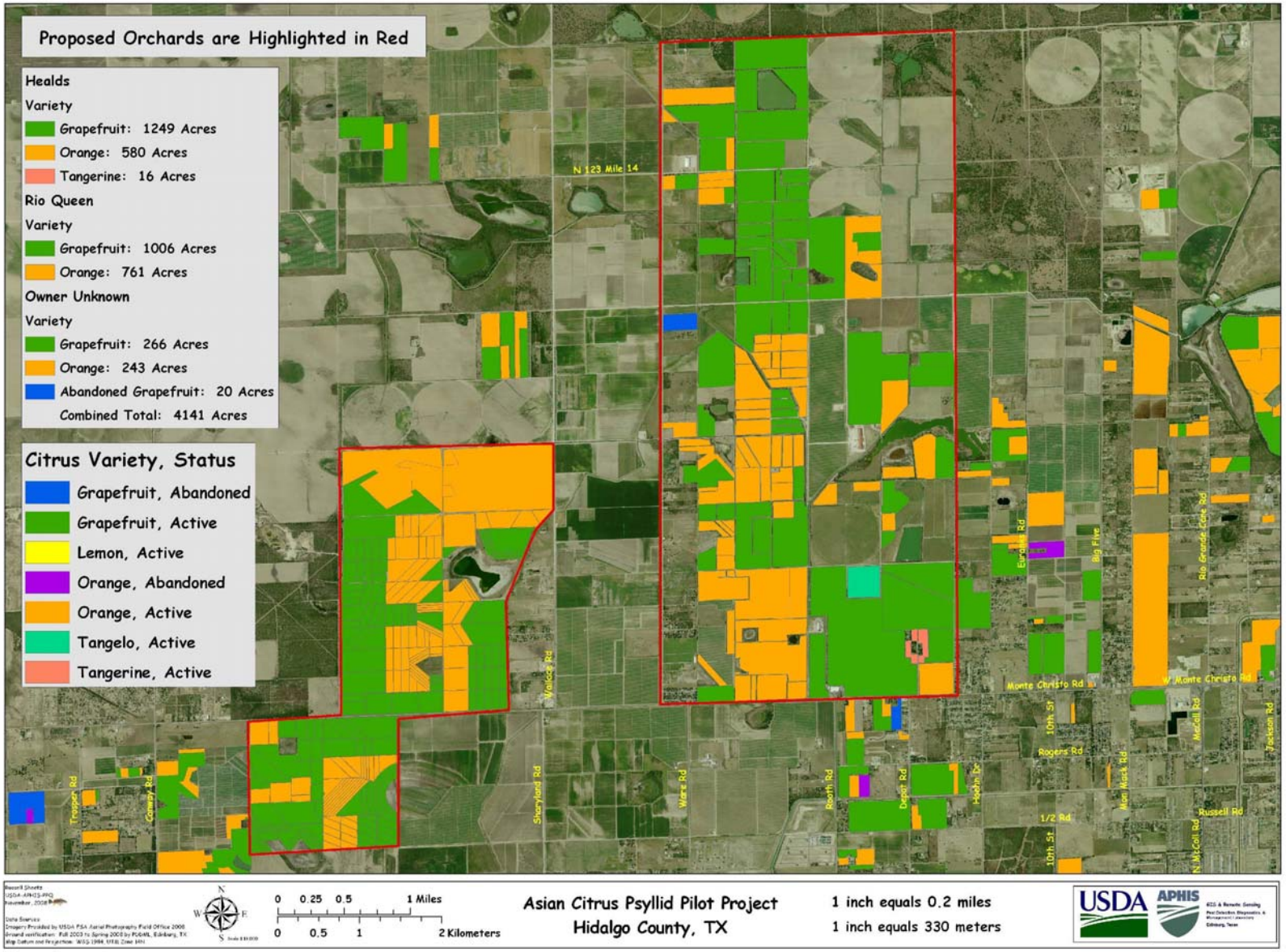
[3] To view the October 1, 2008 Federal Order, go to http://www.aphis.usda.gov/plant_health/plant_pest_info/citrus_greening/downloads/pdf_files/federalorder-10-1-08-san.pdf.

[4] As defined by the October 1, 2008 Federal Order, a regulated article includes all plants, budwood, cuttings, or other fresh or live plant parts, except seed and fruit, of a select group of ACP hosts.

APHIS, in cooperation with TAMU-KCC, would propose to citrus growers four treatment options to be applied on approximately 1,400 acres in Hidalgo, Texas. The 1,400 acres would lie within a 4,100 acre (13 square mile area) treatment plot outlined in red in Figure 1 (see following page).

Figure 1. Proposed Treatment Plot in Hidalgo, Texas.

The red outlined area indicates a 4,100 acre (13 square mile area) treatment plot. However, only approximately 1,400 acres within the red outlined area would be treated under the proposed action.



The actual number of acres that would be under research would depend on the treatment regime tested, funding available, and grower cooperation. Other details of the research are as follows:

1. **Monitoring for ACP populations**: Monitoring would be conducted both within the project-managed area and outside the managed area. A sticky trap grid would be set up within the project-managed area and extend into the surrounding region. Additional direct sampling observations would be made in the orchards. Flush[5] data would also be collected on the citrus trees.

2. **Chemical treatments**: Treatments would take place within citrus groves as well as residential properties. The implementation of any treatment program at a given participating orchard or residence would depend on the grower's or homeowner's choice of participating or not, and choice of treatment options. Several treatment options are proposed to allow flexibility and compatibility with ongoing grower pest management programs. Treatments would be applied via different application methods as noted in the tables below. Foliar applications in groves could be made by air or ground applications. Foliar applications on residential properties would be made via hand-held sprayers. All soil applications would be made below the surface of the soil.

   a. Treatment Options for Citrus Grove Growers:

Option #	Chemical Treatments	Application Method	Application Date
1	1) Fenpropathrin	Aerial or ground foliar application	mid February
	2) Aldicarb	Soil incorporation (burial) application	March
	3) Fenpropathrin	Aerial or ground foliar application	April
	4) Imidacloprid	Aerial or ground foliar application	June
	5) Chlorpyrifos	Aerial or ground foliar application	September
2	1) Fenpropathrin	Aerial or ground foliar application	mid February
	2) Imidacloprid	Soil injection application	March to April
	3) Zeta-cypermethrin	Aerial or ground foliar application	July
	4) Chlorpyrifos	Aerial or ground foliar application	September
3	1) Fenpropathrin	Aerial or ground foliar application	mid February
	2) Imidacloprid	Aerial or ground foliar application	March to April
	3) Imidacloprid	Soil injection application	June
	4) Chlorpyrifos	Aerial or ground foliar application	September
4	1) Pyrethrin	Aerial or ground foliar application	mid February
	2) Kaolin clay	Aerial or ground foliar application	March-April
	3) Citrus oil	Aerial or ground foliar application	June
	4) Neem oil	Aerial or ground foliar application	September

[5] Flush generally refers to that time early in the annual growing cycle when plants rapidly produce large amounts of new growth. Citrus trees in the Lower Rio Grand region flush early in the spring during bloom and typically have three or more additional periods of flush throughout the growing season based on irrigation and rain events.

Based on APHIS' proposed study, citrus oil, kaolin, pyrethrin, and neem oil would be used to treat no more than 100 acres within established citrus groves. Aldicarb and zeta-cypermethrin would be used to treat no more then 650 acres within established citrus groves. Chlorpyrifos, fenpropathrin, imidacloprid would be used to treat no more than 1,300 acres within established citrus groves.

b. Treatment Options for Residential Properties:

Option #	Chemical Treatments	Application Method
1	1) Pyrethrin, citrus oil, or neem oil	Ground foliar application via hand-held sprayer
	2) Imidacloprid	Soil injection and tablet
	3) Pyrethrin, citrus oil, or neem oil	Ground foliar application via hand-held sprayer
2	1) Kaolin clay	Ground foliar application via hand-held sprayer
	2) Citrus oil	Ground foliar application via hand-held sprayer
	3) Pyrethrin	Ground foliar application via hand-held sprayer

3. **Monitoring non-target species**: The effects of different ACP population control options on non-target arthropods, including beneficial and pest species, would be monitored using both yellow sticky cards and direct visual observations of citrus plants.

III. Environmental Impacts

The potential environmental effects from each of the alternatives being considered are discussed below.

A. No Action

Under the no action alternative, APHIS would not conduct the control research project. If the proposed research project is not conducted, APHIS may need to implement ACP management programs without the best research available. Control of ACP and CG may be compromised under this alternative, thereby risking damage to citrus groves.

While some growers in Hidalgo County are beginning to treat specifically against ACP, others continue to apply pesticides primarily against other citrus pests such as citrus rust mites. Some of their pesticide applications may control ACP, but others may have little effect on ACP numbers. This may result in uncoordinated applications of pesticides that may have limited impact on ACP pest populations, possibly increasing the number of applications by individual growers to manage ACP.

B. Proposed Action

Under the proposed action alternative, APHIS would conduct an ACP control research project to better understand effective ACP control strategies. APHIS could utilize the results to implement sound ACP management practices and minimize the risk of introducing CG in citrus groves and residential properties in Texas as well as throughout the United States.

The aspects of the project that include routine measures, i.e., monitoring, inspections, surveys, and sampling, are program activities that pose negligible environmental effects and will not be discussed further. The primary action in this proposed control research project that could be associated with any potentially noteworthy environmental impacts is the use of chemical treatments. The potential environmental impacts, including impacts to humans, from the use of chemical treatments are discussed below.

Due to the flexibility in treatment options, it is conceivable that in some cases there would not be a net increase in the number of chemical treatments used on any given citrus tree. There may actually be fewer chemical treatments because of the coordination of treatments between growers and combined treatments for multiple pests. Under the research program, growers may replace a pesticide used primarily to kill a pest such as the citrus rust mite with another pesticide effective at killing not only the citrus rust mite but also ACP.

The optional chemical treatments are listed below followed by a summary of effects to human health, non-target organisms, and overall environmental quality.

(1) Aldicarb (citrus grove use only)

(a) Human Health

Aldicarb is a N-methyl carbamate insecticide with a primary mode of action that acts through the inhibition of cholinesterase. Aldicarb is considered highly toxic to mammals through oral, inhalation, and dermal routes. Acute oral median lethality values are approximately 1 mg/kg for the technical material while the formulated material has a reported median lethality value of 8.4 mg/kg. Several subchronic and chronic studies assessing a variety of endpoints have been conducted with aldicarb and the most sensitive endpoint in most of those studies is a reduction in cholinesterase levels (EPA, 2006). Aldicarb is not considered to be a teratogen, mutagen or a carcinogen (EPA, 2006).

Significant exposure and risk are not expected for the general public because aldicarb would be applied as a granule into furrows where it must be applied at a minimum depth of 2 inches below the soil line and then covered with soil to reduce exposure to non-target organisms and maximize performance. However, there is the potential for exposure to workers and applicators. The area of treatment in this program would be no more than 650 acres contained within a larger citrus grove. Exposure to workers and applicators would be minimized through the use of personal protective equipment and adherence to all label language. All applications would be made using ground equipment, and aldicarb would be applied as a granule, thereby minimizing applicator exposure as well as off-site transport from drift or runoff. Although aldicarb does exhibit environmental fate properties that could pose a risk to drinking water, label language prohibits applications at a minimum distance of 50 feet from any drinking water well. Moreover, drinking water concerns are minimized by the absence of a high water table or drinking water reservoirs near the proposed application sites and by the lack of soils conducive for lateral or vertical transport of contaminated water.

(b) Non-target Organisms

Aldicarb is considered to be highly toxic to most non-target organisms. It is considered very highly toxic to birds with median lethal oral doses ranging from 0.82 mg/kg to approximately 5 mg/kg (EPA, 2009; EPA, 2005a). Aldicarb is also considered highly toxic to terrestrial invertebrates such as pollinators and earthworms (EPA, 2005a). Toxicity to aquatic organisms is more variable, depending on the test species. Aldicarb is moderately to highly toxic to aquatic invertebrates based on median lethality values that range from the low part per billion to low part per million range. Aldicarb is considered highly toxic to fish based on available acute toxicity data for several surrogate test species that report median lethality values in the low to mid part per billion range.

Exposure and risk to non-target organisms is expected to be minimal, based on the use pattern for aldicarb and the lack of sensitive natural aquatic resources near the site of application. Direct risk to mammals and birds would be minimal, based on the lack of exposure expected when the label directions are followed. Aldicarb would be applied as a granule into furrows where it must be applied at a minimum depth of 2 inches below the soil line and then covered with soil to reduce exposure to non-target organisms and maximize performance. The lack of granules on the ground surface would reduce the potential for primary or secondary risk to terrestrial vertebrates. Some soil invertebrates and those that feed on treated trees may be impacted by the treatment of aldicarb; however, the risk would be restricted to a small area within the citrus grove.

Exposure and risk to aquatic resources would also be minimized by the method of application which eliminates the possibility of drift and greatly reduces the potential for runoff. Natural aquatic habitats do not occur in proximity to the proposed treatment site which further reduces any risk from subsurface flow and runoff of aldicarb. Some man-made canals and ponds exist in the area; however, the method of application and adherence to the label would reduce potential exposure from runoff.

(c) Environmental Quality

The use of aldicarb in this program is not expected to cause significant negative impacts to soil, water, or air. Aldicarb use would be limited to an area of no greater than 650 acres within established citrus orchards. Based on the method of application and the low propensity for volatilization, aldicarb is not expected to impact air quality. There are concerns about aldicarb residues in water based on environmental fate characteristics; however, impacts to water are not expected, based on precautionary label language and the lack of proximity of drinking surface or groundwater to the proposed treatment area. Impacts to soil would be limited to those areas immediately adjacent to the areas where application occurs around an individual tree.

(2) Chlorpyrifos (citrus grove use only)

(a) Human Health

Chlorpyrifos is an organophosphate insecticide that can cause neurotoxic effects. The toxicity of chlorpyrifos occurs primarily through the inhibition of acetylcholinesterase enzyme activity which permits the transmission of nerve impulses across the nerve synapse. Signs and symptoms of low doses include localized effects (such as nosebleeds, blurred vision, and bronchial constriction) and systemic effects (such as nausea, sweating, dizziness, and muscular weakness). At higher doses the signs and symptoms include irregular heartbeat, elevated blood pressure, cramps, and convulsions. Acute oral toxicity is moderate, based on median lethality values ranging from 60 to 1000 mg/kg depending on the test species. Dermal toxicity is considered low, and the formulated material can cause moderate eye and skin irritation. Chlorpyrifos is not considered mutagenic, teratogenic, or carcinogenic by the U.S. Environmental Protection Agency (EPA) (USDA, APHIS, 2005).

The application of this pesticide would be limited to one application by either ground or air in areas that are established citrus groves. The potential area of application within groves would be no greater than 1,300 acres since it is planned for use in three of the four citrus grove options. The only individuals that could potentially be affected by the use of this insecticide are the citrus grove workers and applicators. Adherence

to label language regarding the application of chlorpyrifos, including personal protective equipment and safety precautions and standard program operating procedures, would minimize exposure and risk to program workers (USDA, APHIS, 2005).

(b) Non-target Organisms

Chlorpyrifos is considered to be moderately to highly toxic to birds, depending on the test species (EPA, 2009; USDA, APHIS, 2005). Symptoms of nonfatal exposure to birds include cholinesterase depression (ChE), weight loss, reduced egg production, and reduced hatchling survival. Chlorpyrifos applications would only occur within established citrus groves as a one time application to no more than 1,300 acres by either ground or air during late summer. Direct risk to birds and mammals in the area of treatment could occur; however, these animals are not expected to be present during the time of application due to disturbance from application equipment moving through the citrus grove. Terrestrial vertebrates outside the spray block would have reduced exposure based on the label requirements that would minimize off-site transport of chlorpyrifos. Indirect risk to terrestrial vertebrates through the loss of insect prey would be minimized by colonization of the area by other invertebrates after the individual treatment and the expanded foraging capability of mammals and birds into non-treated areas. Impacts to terrestrial invertebrates, such as earthworms and worker honey bees, are expected; nevertheless, this effect would be restricted to areas within the citrus grove, and invertebrates from outside the treatment area would repopulate areas after treatment. In addition, precautionary language prohibiting applications to blooming plants when bees are actively foraging would further reduce impacts to pollinators.

Chlorpyrifos is highly toxic to fish and aquatic invertebrates, with acute median lethality values ranging from the low parts per trillion to low part per billion range depending on the test species (EPA, 2009; USDA, APHIS, 2005). Exposure and risk to aquatic resources in man-made canals and farm ponds in the area would be minimized by following precautionary label language to reduce drift and by applying buffers of 25 feet for ground applications and 150 feet for aerial applications from all aquatic resources.

(c) Environmental Quality

Potential effects of chlorpyrifos on air, soil, or water quality would be restricted to the area of application. Chlorpyrifos can persist in soil and water for several months under certain conditions; however, the persistence is generally only for a month or less. This is dependent on the organic content of the soil. Chlorpyrifos degrades quickly in the presence of light, with a half life of approximately 2.7 hours, and in water will bind

readily with sediment with aqueous half lives ranging from 7 to 28 days. Chlorpyrifos can volatilize into the atmosphere; however, its persistence is expected to be short, with a half life of only a few hours due to photolytic sensitivity (USDA, APHIS, 2005). Chlorpyrifos can impact air quality through drift from ground or aerial applications. These impacts would be restricted to areas within established citrus groves with off-site transport reduced by strict adherence to all precautionary label language regarding the minimization of drift.

(3) Citrus Oil

(a) Human Health

Citrus oil is a biological insecticide derived from the extraction of oils from citrus that can be used to control certain insect pests. These oils are a proprietary mixture of different materials, with limonene being one of the components with insecticidal activity. Constituents of citrus oil have been shown to have low mammalian toxicity (EPA 1994). Prolonged inhalation of mist or vapors of the formulated material can cause adverse effects, and contact with the eye can cause substantial irritation.

Citrus oil use in this program would be as a foliar application in citrus groves or to host plants on residential properties. Applications in citrus groves can occur via ground or air to no more than 100 acres, while residential applications would be made using hand-held sprayers. In citrus groves exposure would be restricted to workers and applicators. Based on available toxicity data and the requirements for personal protective equipment, human health risk is expected to be minimal. Significant exposure and risk to residents are also not expected, based on the method of application and proper notification to residents whose property may be treated.

(b) Non-target Organisms

Environmental toxicology data for citrus oils is limited; however, data for some constituents contained within these types of materials, such as limonene, demonstrate that acute and subacute toxicity to birds is extremely low, with values exceeding the highest test concentration. Toxicity to terrestrial invertebrates such as honey bees is unknown. Aquatic toxicity is low, with median lethality values in the low part per million range for invertebrates and fish based on limited data (Kassir, et al. 1989; EPA, 1994).

The low toxicity to terrestrial vertebrates suggests minimal direct risk to wild mammals and birds. Indirect risk through the loss of insect prey to this group of organisms is unknown based on the lack of data for terrestrial invertebrates, but is expected to be minimal since only one

application is being made to an area no greater than 100 acres within established citrus groves and some host plants on residential properties. Any impacts to terrestrial invertebrates would be localized and smaller than foraging areas for most terrestrial vertebrates. In addition, citrus oils are not considered broad spectrum insecticides; therefore, not all invertebrates would be impacted. Exposure and risk to aquatic resources are expected to be minimal. Natural aquatic habitats do not occur in proximity to the areas of treatments; and even under worse case exposure, scenarios risk to aquatic resources located in ponds and canals is expected to be minimal. Citrus oil applications are not expected to impact surface drinking water supplies or groundwater since these sources do not occur in proximity to the proposed application, and citrus oil would not be considered a mobile pesticide.

(c) Environmental Quality

Citrus oil impacts to soil, water, and air quality are expected to be negligible. It would only be applied once within a season to an area no greater than 100 acres in size and to host plants on some residential properties. All treatments would be made so as to minimize off-site transport, thereby minimizing impacts to water quality. Citrus oil can occur in the atmosphere as drift from ground and aerial applications; however, this impact would be short in duration and minimized by using larger droplet sizes, where applicable, and by using drift best management practices that enhance efficacy and reduce offsite transport.

(4) Fenpropathrin (citrus grove use only)

(a) Human Health

Fenpropathrin is a synthetic pyrethroid insecticide which affects the nervous system. It is a moderate skin and eye irritant. Signs and symptoms can include muscle contractions, tremors, ataxia, and nerve paralysis at moderate to high levels of exposure. Fenpropathrin is not considered carcinogenic by EPA (USDA, APHIS, 2005).

The application of this pesticide would be limited to one ground or aerial treatment to no more than 1,300 acres within an established citrus grove. Potential pesticide exposures would be limited to citrus grove workers and the occupational workers who apply the pesticide. Personal protective equipment and safety precautions required by the label and standard program operating procedures are designed to ensure that no adverse effects to applicators are expected (USDA, APHIS, 2005).

(b) Non-target Organisms

The program use of fenpropathrin is unlikely to impact most non-target wildlife. The toxicity of fenpropathrin is moderate to mammals and has a slight oral toxicity to birds. Direct risk to terrestrial vertebrates is not expected due to the moderate toxicity of fenpropathrin and expected low exposure from ground or aerial applications. Terrestrial invertebrates would be impacted in areas of treatment; however, these effects would be restricted to treated areas within the citrus grove and would be temporary due to recolonization from untreated areas (USDA, APHIS, 2005). Indirect risk to terrestrial vertebrates through the loss of insect prey would be minimized by recolonization of the area by other invertebrates after the individual treatment and the expanded foraging capability of mammals and birds into non-treated areas. Impacts to honey bees would be reduced by adherence to precautionary language present on the label.

Fenpropathrin is highly toxic to aquatic organisms, with median lethality values ranging from the low part per trillion to low part per billion range for fish and aquatic invertebrates. Risk to aquatic resources in natural aquatic habitats is not expected due to the lack of these resources being present near the area of application. There are farm ponds and man-made canals in proximity to the proposed area of treatment; however, exposure and risk to these habitats would be minimized by following precautionary label language to reduce drift and label requirements for application buffers of 25 feet for ground applications and 250 feet for aerial applications adjacent to aquatic water bodies.

(c) Environmental Quality

Impacts to air, water, and soil from the proposed fenpropathrin applications are expected to be minimal, based on its use pattern and environmental fate properties. Fenpropathrin is considered persistent in water at environmentally relevant pH values; however, it will dissipate rapidly due to its strong binding affinity to soil and sediment. Photolytic degradation in soil is more rapid when compared to water, with reported half lives in water greater than a year and 14 days in soil. Potential mobility is low, based on low water solubility and a high binding affinity for soil, which reduces the potential for runoff. Residues on treated vegetation are also of short persistence (USDA, APHIS, 2005).

(5) Imidacloprid (citrus grove and residential use)

(a) Human Health

Imidacloprid belongs to a class of insecticides called neonicitinoids, which act by binding directly to the acetylcholine binding receptor. Imidacloprid is a chemical that has systemic transport qualities in plants, which make it

efficacious against psyllids and other sucking insects when it is applied as a soil injection or tablet treatment to soil or as a foliar spray.

The acute oral median lethal toxicity of imidacloprid is considered to be moderate to mammals. Inhalation and acute dermal toxicity are considered to be low. The formulation of imidacloprid to be used in the program is of comparable or lower toxicity than the active ingredient. The program applications are not expected to pose dermal irritation or sensitization, and only mild eye irritation. Primary metabolites and degradation products of imidacloprid are of lower toxicity than the parent compound, based on available data. Imidacloprid is rapidly excreted by mammals. Based upon several in vitro and in vivo studies, imidacloprid is not considered to be mutagenic or genotoxic (USDA, APHIS, 2008). The EPA has classified imidacloprid in "Group E" in regard to carcinogenic potential. This indicates that the submitted studies provide evidence of noncarcinogenicity to humans.

In this program, imidacloprid is applied as a soil injection or tablet below the soil surface, or as a foliar treatment. The total amount of acreage potentially treated would be no greater than approximately 1,300 acres since it would be used in three of the four application scenarios in citrus groves as well as one of the options in treating dooryard citrus. Exposure of applicators via inhalation, dermal contact, and oral intake of the active ingredient in these formulations would be minimal due to the method of application, personal protective equipment, and the environmental fate of imidacloprid. This is especially the case for the tablet and soil injection applications. Potential acute and chronic exposure scenarios indicate minimal risk to workers as well as to residents where soil injection or tablet applications would occur (USDA, APHIS, 2008). Foliar applications would also result in negligible risk to workers and applicators based on the toxicity of imidacloprid and the use of appropriate protective equipment. In cases where dooryard citrus applications are made, proper notification would be given to those residents to further reduce exposure.

(b) Non-target Organisms

Imidacloprid is considered to be toxic to birds, with acute oral median lethal toxicity values ranging from 41 to 152 mg/kg. The limited applications to specific citrus host plants result in potential effects to invertebrates that are likely to be localized. Concerns have been raised about potential lethal and sublethal effects to honey bees and other pollinators. Median lethal toxicity values of imidacloprid have been based upon oral or contact exposure. Laboratory and field studies of honey bees indicate a lack of adverse effects at test concentrations comparable to realistic exposure scenarios, and adverse health impacts to hives only with greater exposures (USDA, APHIS, 2008).

Exposure to wild mammals and birds from applications of imidacloprid and associated residues is not expected to occur at levels that could result in significant risk (USDA, APHIS, 2008). The terrestrial insects that feed upon vegetation of those host plants that have been treated with tablet, foliar, or soil injection applications are likely to be impacted, but the effects would be restricted to the areas of treatment. Any predatory or parasitic insects that depend upon these phytophagous insects would also be affected due to loss of prey. Mammals and birds that are insectivorous would not depend upon the affected insects and would expand their foraging range to ensure adequate consumption. Risk to honey bees and pollinators is expected to be minimal, based upon the expected residues and lack of observed impact from acute and chronic toxicity studies of such applications.

Aquatic vertebrates and invertebrates can be exposed through runoff or drift from the site of application. Significant drift is not expected from the soil injection and tablet applications, but some drift could occur with foliar applications in citrus groves. This is not expected to result in toxic effects to aquatic vertebrates, but could pose some risks to aquatic invertebrates (USDA, APHIS, 2008). Exposure and risk to aquatic invertebrates would be minimized due to the lack of natural aquatic habitats near the area of treatment. Exposure and risk to aquatic resources in man-made canals and farm ponds in the area would be minimized by following precautionary label language to reduce drift and application buffers of 25 feet for ground applications and 150 feet for aerial applications from all aquatic resources.

(c) Environmental Quality

The half life of imidacloprid in soil under field conditions ranges from 7 to 107 days. Imidacloprid does not adsorb strongly to soil particles. Imidacloprid is soluble in water and has a half life under natural light of less than 5 hours in water. Imidacloprid is not expected to volatilize to the atmosphere to any measurable extent. The half life of imidacloprid on vegetation ranges from 1.17 to 9.8 days, but the tablet and injection do not involve foliar exposure other than some residues splashed on ground covering plants (USDA, APHIS, 2008). Imidacloprid is readily taken up by plants and translocated; however, program treatments are not expected to result in any bioaccumulation hazards (USDA, APHIS, 2005).

(6) Kaolin Clay

(a) Human Health

Kaolin is a naturally occurring aluminosilicate material that has a non-toxic mode of action by acting as a repellant or by providing a protective barrier from insects and disease. In addition to its use for insect and disease control, kaolin is widely used in health products and toiletries and

as an indirect food additive (EPA, 2000). The formulation proposed for use in this program is OMRI (Organic Materials Review Institute) certified.

Based on available toxicity data, kaolin has low acute toxicity via oral, dermal, and inhalation routes. Kaolin is a minor eye irritant and is not considered a dermal irritant. The formulated product proposed for use in this program, which is a dust, may cause irritation to the throat, eye, and skin to workers; however, adherence to the label and recommended personal protective equipment would reduce exposure. Exposure to workers and applicators to the formulated material would be substantially reduced once the product is mixed with water per label directions. Applications in citrus groves would be limited to one application to an area no greater than 100 acres. A ground treatment for host plants may occur as part of the dooryard citrus application; however, risk to any residents in the area is expected to be minimal based on the low toxicity of kaolin clay and expected low exposure. Applications to properties where residents may be present would only occur after proper notification so that residents can take appropriate precautionary steps.

(b) Non-target Organisms

Available toxicity data for kaolin as well as other clay materials suggest low toxicity to non-target terrestrial vertebrates. Toxicity to terrestrial invertebrates, such as pollinators, is also considered low, based on available data where acute median lethality values were greater than the highest concentration tested (EPA, 2000). Available toxicity data for related clay materials to non-target aquatic organisms demonstrate very low toxicity to aquatic invertebrates and vertebrates, with toxicity values typically above 100 parts per million (WHO, 2005). Exposure and risk to non-target organisms are expected to be minimal, based on the low toxicity of kaolin and the relatively small areas of treatment within citrus groves and residential properties.

(c) Environmental Quality

Kaolin use in this program is not expected to cause adverse impacts to soil, water, or air. Its use would be limited to a small area within citrus groves or to host plants on residential properties, and is not expected to have adverse impacts on soil or water. In addition, significant volatilization or drift is not expected into the atmosphere, based on the physical properties of kaolin once it is mixed and applied to the foliage of host plants.

(7) Neem Oil

(a) Human Health

Neem oil is an extract from the neem plant that contains azadirachtin, which has insecticidal properties by disrupting insect molting by acting as an ecdysone antagonist. The formulated material has very low acute oral, dermal, and inhalation toxicity, with all median lethality values greater than the highest concentration tested. It is considered a mild skin irritant but is not an eye irritant or a skin sensitizer. Azadirachtin is not considered mutagenic or carcinogenic according to the data provided on the material safety data sheet. The formulation proposed for use in this program is OMRI (Organic Materials Review Institute) certified.

Exposure and risk to humans from neem applications are expected to be minimal. An aerial or ground application would occur within established citrus groves to an area no greater than 100 acres, where exposure would be greatest for workers and applicators. The low toxicity and adherence to label recommendations would minimize risk to this segment of the population. A ground treatment may occur as part of the dooryard citrus application; however, risk to any residents in the area is expected to be minimal, based on the low toxicity of neem oil and the expected low exposure. Applications to properties where residents may be present would only occur after proper notification. Neem oil is not expected to be a threat to surface drinking water supplies or groundwater based on its chemical properties and the lack of these sources present in proximity to the proposed treatment area.

(b) Non-target Organisms

Azadirachtin is considered practically non-toxic to birds, with reported median lethality values greater than the highest test concentration. It is considered moderately toxic to some terrestrial invertebrates, including honey bees, and is considered toxic to aquatic organisms, with median lethality toxicity values ranging from the low part per billion to low part per million range (EPA, 2009).

Significant exposure and risk to terrestrial vertebrates are not expected from the use of azadirachtin due to its low toxicity and limited application to small areas within established citrus groves. Applications in citrus groves can occur by air or ground, but would be limited to one application to a maximum area of 100 acres. Some residential applications may also occur via ground hand-held spray equipment. Indirect risk to vertebrates that use invertebrate prey as a food source would be low, since azadirachtin is selective in its impacts to terrestrial invertebrates and the area of treatment is small relative to the foraging area for most vertebrates.

Exposure and risk to aquatic resources are also expected to be minimal. Application rates and the lack of natural aquatic habitats in proximity to the area of treatment would minimize risk to aquatic resources. There are man-made canals and farm ponds in proximity to the treatment block; however, the low application rates and adherence to the precautionary statements on the label would minimize risk and exposure to aquatic resources.

(c) Environmental Quality

Azadirachtin use in this program is not expected to cause adverse impacts to soil, water, or air. Its use would be limited to a small area within citrus groves or to host plants on residential properties and is not expected to have adverse impacts to soil or water. Degradation in soil appears to be mediated by microbial organism resulting in half lives of approximately 20 days at 25°C (Stark and Walter, 1995). Persistence in water varies, with reported dissipation half lives as short as a day up to 30 days (Thompson et al., 2004). Azadirachtin is not expected to sorb strongly to soil and is very susceptible to photolysis with half lives less than one hour (Johnson and Dureja, 2002). Azadirachtin is not expected to volatilize into the atmosphere and would only occur as drift from ground or aerial applications. Photolytic instability and the use pattern in this program would minimize any potential off-site impacts to air quality.

(8) Pyrethrin

(a) Human Health

Pyrethrins are naturally derived extracts from certain species of chrysanthemum plants that have insecticidal properties. The mode of toxic action occurs through effects on the sodium channels to stimulate nerves to produce repetitive discharges. Muscle contractions are sustained until a block of the contractions occurs. Nerve paralysis can occur at high levels of exposure (Walker and Keith, 1992). Pyrethrins have certain properties that serve to both intoxicate and repel certain insects. Their control activity occurs through contact exposure, so thorough coverage of the host plants is important to successful control of ACP.

The acute oral toxicity of pyrethrin to mammals is considered to be low to moderate. Acute dermal and inhalation toxicity are also low. The formulation of pyrethrin to be used in the program has comparable acute toxicity to the active ingredient. This formulation poses slight dermal and eye irritation. The primary metabolites and degradation products of pyrethrin are considered to be of lower toxicity than the parent compound (EPA, 2005b). Pyrethrin is not considered mutagenic, teratogenic, or carcinogenic, based on available toxicity data (EPA, 2005b)

Pyrethrin is applied one time as an aerial or ground foliar treatment in citrus groves or by ground on residential properties. Worker exposure is minimized through the use of protective clothing and adherence to safety precautions. The potential exposure to applicators was determined to be from one to three orders of magnitude lower than the toxicity reference dose, suggesting minimal risk to workers (USDA, 2008). Based on the available toxicity data, residential exposure and risk would be minimal through notification of residents at the time of application so as to minimize exposure. Ingestion of contaminated drinking water and treated citrus fruit in residential applications were exposure scenarios analyzed for the use of pyrethrin. All potential risks for children and adults were determined to be negligible (USDA, 2008).

(b) Non-target Organisms

Pyrethrins have low toxicity to terrestrial vertebrates such as birds and mammals, suggesting low direct risk. Indirect risk to terrestrial vertebrates through the loss of terrestrial invertebrate prey is not expected due to the limited areas of application relative to the foraging range for most mammals and birds. Impacts to terrestrial invertebrates, such as pollinators, would be expected where pyrethrin applications are made; however, these impacts would be minimized by selective treatment of citrus and adherence to all precautionary label language.

Pyrethrins are highly toxic to aquatic invertebrates and vertebrates. Acute median lethality values are in the low ppb range based on available data. Exposure in natural aquatic habitats is not expected due to the lack of these habitats being present in the area of treatment. There are man-made canals and farm ponds in proximity to the treatment block; however, adherence to precautionary label language would reduce exposure and risk to aquatic resources in these habitats.

(c) Environmental Quality

The use of pyrethrins in this program is not expected to have adverse impacts to soil, water, or air, due to their limited use and environmental fate profile. Half lives in soil and water are very short, thereby reducing the time for any potential impacts to soil and water quality. The half life of pyrethrin in soil ranges from 3.2 to 10.5 days. Pyrethrins bind tightly to soil particles, reducing the bioavailability in terrestrial and aquatic systems. Pyrethrins are light sensitive and have a photolysis half life less than 4 hours. Pyrethrins have low water solubility and short half lives of 14 to 17 hours in alkaline water. In addition, no sensitive, naturally occurring, aquatic habitats are in proximity to the application sites. Impacts to air quality are also not expected, based on the chemical characteristics of pyrethrin that suggest low volatility. Pyrethrin would occur in the atmosphere as drift from ground and aerial applications;

however, adherence to the label would minimize the potential for off-site drift.

(9) Zeta-cypermethrin (citrus grove use only)

(a) Human Health

Zeta-cypermethrin is a synthetic pyrethroid insecticide that is used to control a variety of insect pests in agricultural and structural/residential uses. The active ingredient is a combination of eight isomers, with four of the most insecticidally active occurring at higher concentrations compared to cypermethrin. Formulated zeta-cypermethrin is moderately toxic via oral and inhalation routes of exposure to mammals but is considered to have low dermal toxicity. The formulated material is moderately irritating to the eye and skin but is not considered a skin sensitizer. Zeta-cypermethrin is not considered mutagenic or teratogenic but is considered a possible carcinogen, based on results from a chronic mouse study where benign alveologenic neoplasms were observed at the highest dose level. These levels are well above those expected in this program. Similar effects were not observed in other test species in chronic studies (EPA, 2005).

Exposure of the general public to zeta-cypermethrin during applications in this program is not expected since applications would occur within established citrus groves. The potential for exposure is greatest for workers and applicators during the time of application. The one-time application would be restricted to an area no greater than 650 acres. Adherence to label language regarding personal protective equipment and other label requirements would minimize exposure to workers and applicators and provide adequate margins of safety. Applications are not expected to impact drinking water supplies due to the absence of surface drinking water or groundwater supplies in proximity to the area of application. In addition, zeta-cypermethrin has very low solubility and a high binding affinity for soil, which indicates a low probability of vertical or lateral transport into groundwater.

(b) Non-target Organisms

Zeta-cypermethrin has low acute and chronic avian toxicity, with reported acute median lethal doses and chronic no observable effect concentrations greater than the highest test concentration (EPA, 2005). Toxicity is high to most terrestrial invertebrates, including honey bees, with label statements regarding minimizing exposure in areas where bees are actively foraging. Zeta-cypermethrin is considered highly toxic to aquatic invertebrates and vertebrates, with reported median lethality values in the low part per trillion to low part per billion range depending on the test

species. However, fish were slightly less sensitive when compared to aquatic invertebrates (Solomon et al., 2001; EPA, 2005; EPA, 2009).

Risk to terrestrial vertebrates is expected to be minimal, based on the low toxicity of zeta-cypermethrin to birds and mammals and its limited use in the program, where no more than 650 acres would be treated once within a citrus grove. Indirect risk to birds and animals that depend on insect prey is expected to be minimal and localized, based on the small area of treatment. Terrestrial invertebrates would be impacted in the area of treatment; however, recolonization of non-target terrestrial invertebrates should occur quickly due to the size of the treatment area. The risk to aquatic resources would be limited to man-made canals or ponds located in the treatment area. No naturally occurring aquatic habitats are present in the proposed area of treatment, and the risk to aquatic resources in canals and ponds would be reduced by the use of aerial and ground application buffers, drift mitigation language, and vegetative filter strips – all of which are stated on the label.

(c) Environmental Quality

Zeta- cypermethrin is not expected to cause adverse impacts to soil, water, or air quality, based on its limited use in this program, mitigation measures proposed on the label, and environmental fate characteristics. Its use would be limited to one application on no more than 650 acres within an established citrus orchard. Therefore, any potential impacts would be localized. Zeta-cypermethrin breaks down in soil under aerobic and anaerobic conditions, with half lives less than 65 days. Zeta-cypermethrin is not expected to impact water quality due to the absence of sensitive aquatic habitats or drinking water supplies located in proximity to the area of treatment. In addition, the label requires vegetative buffer strips and application buffers from aquatic habitats, reducing the potential for exposure from ground or aerial applications. Zeta-cypermerthrin has very low water solubility and a high binding affinity to soil and sediment, further reducing the potential for runoff into any drinking water supply or sensitive aquatic habitat. Physical and chemical characteristics for zeta-cypermethrin preclude significant volatilization into the atmosphere. Zeta-cypermethrin may be present as drift in the air, following ground and aerial applications; however, strict adherence to the label, including the spray drift precautionary language, as well as the small area of treatment would minimize off-site transport.

C. Cumulative Effects

The proposed research project is short-term (mid February to September) and would take place in a very limited area (approximately 1,400 acres within a 4,100 acre treatment area). APHIS is attempting to develop a

treatment protocol that would effectively eliminate ACP while also being effective against other citrus pests that are commonly treated. If successful, the utilization of such an efficient treatment protocol could decrease the gross amount of pesticides used in citrus groves with ACP.

IV. Other Environmental Considerations

A. Endangered Species Act

Section 7 of the Endangered Species Act and its implementing regulations require Federal agencies to ensure their actions are not likely to jeopardize the continued existence of endangered or threatened species or result in the destruction or adverse modification of critical habitat.

APHIS prepared a biological assessment that considered the impact of the proposed program on federally listed threatened and endangered species and designated critical habitat in Hidalgo County, Texas. Upon concluding the assessment, APHIS determined that the program would have no effect on the Texas ayenia and star cactus. APHIS also determined that the program may affect, but is not likely to adversely affect, the Gulf Coast jaguarundi, northern aplomado falcon, ocelot, and Walker's manioc. APHIS requested concurrence with this determination from the U.S. Fish and Wildlife Service, Ecological Services Field Office in Corpus Christi, Texas, and received a concurrence letter dated February 9, 2009. No specific mitigation measures are required to protect listed species except for the northern aplomado falcon. To protect this species from disturbance, no aerial or ground treatments would be made within a ¼-mile of occupied falcon nests. Aerial pesticide applications should be made in swaths parallel to a falcon nest and its aerial buffer zone.

APHIS also received a report from Texas Parks and Wildlife indicating that there were no known occurrences of federal or state-listed species documented in the Texas Natural Diversity database within 1.5 mile of the proposed project area.

B. Executive Orders

Consistent with Executive Order (EO) 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-income Populations," APHIS considered the potential for the proposed action to have any disproportionately high and adverse human health or environmental effects on any minority populations and low-income

populations. Colonias[6] are located within Hidalgo County. There is one colonia within the proposed treatment boundary; however, the colonia is not located within a citrus grove. There are six additional colonias located outside but adjacent to the treatment boundary.

Due to the limited number of applications being applied to a limited area, as well as the labeled precautions that must be taken by applicators, APHIS has determined that the human health and environmental effects from the proposed applications are minimal and are not expected to have disproportionate adverse effects to any colonia or any other minority or low-income populations.

Consistent with EO 13045, "Protection of Children from Environmental Health Risks and Safety Risks," APHIS considered the potential for disproportionately high and adverse environmental health and safety risks to children resulting from the proposed action. Due to the limited number of applications being applied to a limited area, as well as the labeled precautions that must be followed by applicators, no exposure to children is expected to occur. It is the responsibility and obligation of the program pesticide applicators to ensure that the general public is not in or around areas being treated. This ensures that no exposure of the general public or children would occur during the application process. The only possible exposure would be to the applicator and nursery workers when not following the prescribed label use and safety directions. Therefore, it was determined that no disproportionate effects to children are anticipated as a consequence of implementing the proposed action alternative.

[6] The term "colonia" in Spanish means a community or neighborhood. The Office of the Texas Secretary of State defines a "colonia" as a residential area along the Texas-Mexico border that may lack some of the most basic living necessities, such as potable water and sewer systems, electricity, paved roads, and safe and sanitary housing.

V. Agencies, Organizations, and Individuals Consulted

U.S. Department of Agriculture
Animal and Plant Health Inspection Service
Policy and Program Development
Environmental Services
4700 River Road, Unit 149
Riverdale, MD 20737

U.S. Department of Agriculture
Animal and Plant Health Inspection Service
Plant Protection and Quarantine
Emergency and Domestic Programs
4700 River Road, Unit 134
Riverdale, MD 20737

U.S. Department of Agriculture
Animal and Plant Health Inspection Service
Plant Protection and Quarantine
903 San Jacinto Blvd
Austin, TX 78701

U.S. Department of Agriculture
Animal and Plant Health Inspection Service
Plant Protection and Quarantine
Center for Plant Health Science & Technology
Mission Texas Laboratory
Moore Air Base, Building 6414
22675 N. Moorefield Road
Edinburg, TX 78541

Texas A&M University
Kingsville Citrus Center
312 N. International Blvd,
Weslaco, TX 78596

U.S. Fish and Wildlife Service
Corpus Christi Ecological Services Field Office
Texas A&M University-Corpus Christi
6300 Ocean Dr.
Cess Bldg. Rm. 118
Corpus Christi, TX 78412

VI. References

EPA—See U.S. Environmental Protection Agency

Johnson, S. and P. Dureja. 2002. Effect of surfactants on persistence of azadirachtin a (Neem based pesticide). J. Environ. Sci. Health, B37(1), 75–80.

Kassir, J.T., Mohsen, Z.H. and N.S. Mehdi. 1989. Toxic effects of limonene against *Culex quinquefasciatus* (Say) larvae and its interference with oviposition. Anz. Schadlingskde., Pflanzenschutz, Umweltschutz 62, 19-21.

Solomon, K.R., Giddings, J.M., and Maund, S.J., 2001. Probabilistic risk assessment of cotton pyrethroids: I. Distributional analysis of laboratory aquatic toxicity data. Env. Toxicol. Chem. 20(3):652–659.

Stark, J.D. and J.F. Walter. 1995. Persistence of azadirachtin A and B in soil: Effects of temperature and microbial activity. J. Environ. Sci. Health, Part B: Pest. Food Contam. Agric. Wastes. Vol. B30(5): 685-698.

Thompson, D.G., Chartrand, D.T. and D.P. Kreutweiser. 2004. Fate and effects of azadirachtin in aquatic mesocosms—1: fate in water and bottom sediments. Ecotoxicology and Environmental Safety (59):186–193.

USDA—See U.S. Department of Agriculture, Animal and Plant Health Inspection Service

U.S. Department of Agriculture, Animal and Plant Health Inspection Service, 2005. Citrus greening eradication program pesticide applications human health and non-target species risk assessment, September, 2005. USDA, APHIS, Riverdale, Maryland.

U.S. Department of Agriculture, Animal and Plant Health Inspection Service, 2008. Asian citrus psyllid cooperative control program chemical risk assessment—December 2008. USDA, APHIS, Riverdale, MD.

U.S. Environmental Protection Agency, Office of Pesticide Programs. 2009. OPP Ecotox Database. [Online]. Available: http://www.ipmcenters.org/index.cfm. [January 11, 2009].

U.S. Environmental Protection Agency, 2006. Human Health Risk Assessment: Aldicarb. Office of Pesticide Programs. 54 pp.

U.S. Environmental Protection Agency, 2005a. Aldicarb: Ecological Risk Assessment. Environmental Fate and Effects Division. Office of Pesticide Programs. 362 pp.

U.S. Environmental Protection Agency, 2005b. Pyrethrins: Revised Human Health Risk Assessment for the Reregistration Eligibility Decision. 103 pp.

U.S. Environmental Protection Agency, 2000. Kaolin Reregistration Eligibility Decision. Accessed January 7, 2009 at http://www.epa.gov/pesticides/biopesticides/ingredients/tech_docs/red_100104.htm.

U.S. Environmental Protection Agency, 1994. Limonene Reregistration Eligibility Decision. Office of Pesticide Programs. 200 pp.

Walker, M.M., and Keith, L.H., 1992. EPA's pesticide fact sheet database. Lewis Publishers, Boca Raton, FL.

World Health Organization. 2005. Environmental Health Criteria for Bentonite, Kaolin, and Selected Clay Minerals. Environmental Health Criteria 231.