The PMI Africa IRS (AIRS) Project
Indoor Residual Spraying (IRS) 2
Task Order Six

ZAMBIA
SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT FOR INDOOR RESIDUAL SPRAYING FOR MALARIA CONTROL
2015 – 2020

A NATIONWIDE SEA FOR IRS USING PYRETHROIDS, CARBAMATES, ORGANOPHOSPHATES, DICHLORODIPHENYLTRICHLOROETHANE AND CHLORFENAPYR
SEPTEMBER 2015
ZAMBIA
SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT FOR INDOOR RESIDUAL SPRAYING FOR MALARIA CONTROL
2015-2020

August 2015
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<td>ACTs</td>
<td>Artemisinin-based Combination Therapies</td>
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<tr>
<td>AIRS</td>
<td>Africa Indoor Residual Spraying project</td>
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<tr>
<td>CDC</td>
<td>Centers for Disease Control and Prevention</td>
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<tr>
<td>CFR</td>
<td>Code of Federal Regulations</td>
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<tr>
<td>COP</td>
<td>Chief of Party</td>
</tr>
<tr>
<td>COR</td>
<td>Contracting Officer's Representative</td>
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<tr>
<td>DECS</td>
<td>Director of Environmental Compliance and Safety</td>
</tr>
<tr>
<td>DCMO</td>
<td>District Community Medical Office</td>
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<tr>
<td>DDT</td>
<td>Dichlorodiphenyltrichloroethane</td>
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<tr>
<td>ECO</td>
<td>Environmental Compliance Officer</td>
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<td>EIA</td>
<td>Environmental Impact Assessments</td>
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<td>EOSR</td>
<td>End of Spray Report</td>
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<tr>
<td>GMA</td>
<td>Game Management Area</td>
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<td>GRZ</td>
<td>Government of the Republic of Zambia</td>
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<tr>
<td>IEC</td>
<td>Information Education Communication</td>
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<tr>
<td>IP</td>
<td>Implementing Partner</td>
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<tr>
<td>IPTp</td>
<td>Intermittent preventive treatment of malaria for pregnant women</td>
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<tr>
<td>IRMTWG</td>
<td>Insecticide Resistance Management Technical Working Group</td>
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<td>IRS</td>
<td>Indoor Residual Spraying</td>
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<td>ITNs</td>
<td>Insecticide Treated Nets</td>
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<tr>
<td>IVM</td>
<td>Integrated Vector Management</td>
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<tr>
<td>LLIN</td>
<td>Long-lasting insecticide-treated nets</td>
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<tr>
<td>M&amp;E</td>
<td>Monitoring and Evaluation</td>
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<tr>
<td>MCDMCH</td>
<td>Ministry of Community Development, Mother and Child Health</td>
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<td>MOH</td>
<td>Ministry of Health</td>
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<tr>
<td>MOP</td>
<td>Malaria Operation Plan</td>
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<td>MSP</td>
<td>Mobile Soak Pit</td>
</tr>
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<td>NIP</td>
<td>National Implementation Plan</td>
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<td>NMCP</td>
<td>National Malaria Control Program</td>
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<td>President's Malaria Initiative</td>
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<tr>
<td>Acronym</td>
<td>Full Form</td>
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<tr>
<td>POPs</td>
<td>Persistent Organic Pollutants</td>
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<td>PPE</td>
<td>Personal Protective Equipment</td>
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<td>PSECA</td>
<td>Pre-Spray Environmental Compliance Assessment</td>
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<tr>
<td>SEA</td>
<td>Supplemental Environmental Assessment</td>
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<tr>
<td>SOP</td>
<td>Spray Operator</td>
</tr>
<tr>
<td>SUAP</td>
<td>Safer Use Action Plan</td>
</tr>
<tr>
<td>TAC</td>
<td>Technical Advisory Committee</td>
</tr>
<tr>
<td>USAID</td>
<td>United States Agency for International Development</td>
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<tr>
<td>USEPA</td>
<td>United States Environmental Protection Authority</td>
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<tr>
<td>USG</td>
<td>United States Government</td>
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<td>WHO</td>
<td>World Health Organization</td>
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<tr>
<td>WHOPES</td>
<td>World Health Organization Pesticide Evaluation Schemes</td>
</tr>
<tr>
<td>ZAWA</td>
<td>Zambia Wildlife Authority</td>
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<td>ZEMA</td>
<td>Zambia Environmental Management Agency</td>
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This document has been prepared to serve as a Supplemental Environmental Assessment (SEA) for Indoor Residual Spraying (IRS) in Zambia for the period 2015-2020. Previous environmental documentation for PMI-supported IRS in Zambia authorized the use of the pyrethroid, carbamate and organophosphate classes of the WHOPES-recommended pesticides in the high malaria burden regions of Zambia from 2010-15, and was prepared in accordance with the provisions of USAID 22 CFR (216) regarding the use and application of pesticides. This SEA proposes to be nationwide in scope and to reauthorize the use of the same 3 classes of WHOPES-recommended insecticides, to reauthorize the use of dichlorodiphenytrichloroethane (DDT), and to expand the authorization to include the use of chlorfenapyr (when recommended by WHOPES).

Zambia’s entire population of 14.6 million (Census 2010 with 2.8% growth), consisting of 40% residing in urban and 60% in rural areas, is at risk of malaria infection, but children under five years of age and pregnant women are at higher risk of severe illness due to lowered immunity. Malaria is ranked as a leading cause of under-five mortality, and according to the Demographic and Health Survey, the under-five mortality rate in 2013 was 75/1,000 live births, or approximately 1 in 13 children die before their fifth birthday (DHS) 2013–2014. Zambia has been consistently implementing IRS for malaria control as part of an integrated vector control management (IVM) strategy since 2003.

PMI support of IRS in Zambia began in 2008. In 2014, with Abt Associates as implementing partner (IP), IRS was exclusively transitioned to the President’s Malaria Initiative (PMI) Africa Indoor Residual Spraying Project (AIRS). During the 2014 IRS campaign, 40 high-burden malaria districts in five provinces were sprayed, with a total number of 472,000 targeted structures. In 2015, it is proposed to spray the same 40 high burden malaria districts in the Northern Region, but this SEA is written to accommodate the expansion or relocation of PMI support to all or any areas of the country.

Changing or rotating insecticides of different classes over time and space is a leading way to manage vector resistance. In Zambia, entomological monitoring has demonstrated that local mosquitoes have developed some level of resistance to the pyrethroid, carbamate and organochlorine (DDT) class of insecticides, but have full susceptibility to the organophosphate, pirimiphos methyl, which is currently being used for IRS.

DDT was last used in Zambia for IRS operations in 2010 and its registration has since expired, but NMCP may consider using it in IRS operations where pesticide resistance is low and other options are not feasible. PMI will work in close collaboration with NMCP and ZEMA to have DDT re-registered for use in IRS operations in Zambia.

DDT is unique among other IRS insecticides, in that it is a persistent organic pollutant (POP). As stated by the Stockholm Convention, POPs such as DDT “possess toxic properties, resist degradation, bioaccumulate and are transported, through air, water, and migratory species, across international boundaries and deposited far from their place of release, where they accumulate in terrestrial and aquatic ecosystems.” Because of these characteristics, prior to the use of DDT in IRS operations, a baseline environmental assessment will be conducted in all the districts considered for DDT use, to analyze the quality of both soil and vegetative matter. This baseline assessment will allow for measuring
any subsequent changes in ambient DDT concentrations that may be attributable to IRS, in order to make informed decisions about its continued use.

The proposal to include chlorfenapyr is also prompted by the need to increase the options of approved insecticides available for spray activities. Chlorfenapyr, an Active Ingredient (AI) in the pyrrole chemical class is under WHOPES review, and if recommended for use will offer an additional option for insecticide rotation.

This SEA also requests authorization of small-scale, closely-supervised hut trials using new IRS insecticides, such as chlorfenapyr, once the insecticide has been submitted for Phase III WHOPES evaluation and country-level required documentation has been submitted.

This SEA for IRS in Zambia outlines the monitoring and mitigation measures that will be employed by the PMI IP to minimize or reduce any unintended adverse impacts of pesticide application. Those measures are found in the Safer Use Action Plan (Section 6), and summarized in the Environmental Mitigation and Monitoring Plan (EMMP) found in Annex A. All PMI IRS operations in Zambia will be performed according to the protocols and procedures found therein. These procedures do not change with the use of different classes of authorized pesticides, with the following exceptions:

1. The potential cumulative effects of organophosphate exposure (cholinesterase depression) require increased emphasis and training on the ability and responsibility of team leaders and senior personnel to constantly monitor the appearance and behavior of their team members, and to recognize the symptoms of organophosphate exposure. However, biomonitoring is not required for the use of pirimiphos methyl formulations.

2. Pirimiphos-methyl formulations are supplied in plastic bottles, which if not controlled carefully may be used inappropriately after being emptied of the formulation. In addition, incineration of the bottles may cause harmful emissions. Because of these potential problems, the following procedures and protocols have been established:
   a. A triple rinse for the plastic bottles has been incorporated during the pesticide make-up procedure, whereby the pesticide container is emptied into the spray tank and then three times it is partially filled with clean make-up water, capped, shaken, and emptied into the spray tank. This ensures that the pesticide is used more efficiently, the container is thoroughly rinsed of pesticide, and it is safe for handling and subsequent processing. The risk of exposure due to pesticide residue in the container is essentially eliminated; however, the following procedures are also followed.
   b. Containers are punctured multiple times to eliminate the ability to reuse the containers, and,
   c. Recycling programs have been established to turn the plastic into usable products. As long as a suitable recycling program is available, through close supervision and chain of custody, and in partnership with the Zambia Environmental Management Agency (ZEMA), the IP will ensure that the plastic remains segregated from other materials and is used for non-consumptive purposes.

3. Soak pits are treatment devices that reduce or eliminate concentrations of most pesticides in the rinsewater used for washing pumps and personal protective equipment (PPE). Soak pits are used with the pyrethroid, carbamate, and organophosphate classes of pesticide. However, because of its environmental persistence and potential for bioaccumulation, the use of DDT
requires construction and use of alternative treatment devices such as evaporation tanks, so that little or no residue is left behind at operational sites.

The PMI IP will implement the EMMP in Annex A, with guidance from ZEMA, MOH, MCDMCH and the NMCP, and with the assistance and involvement of the local communities. All senior staff in charge of implementation of IRS will be trained to monitor operations when in the field, in order to maximize supervisory oversight and ensure effectiveness of the mitigation measures during spray operation. The District Coordinators will monitor environmental compliance during the IRS campaign. The IP will complete the annual EMMR Form in Annex C, and submit it to USAID along with the annual end of spray report.

On an annual basis, a letter report will be submitted to the BEO (regional and pillar). It must contain information regarding program changes (such as mortality rates etc.), entomological/resistance monitoring results and data, and program response to those results. It should also contain the results of the environmental monitoring results and how the program will improve areas of deficiency.

The following assessment draws heavily on the Programmatic Environmental Assessment (PEA) for Integrated Vector Management, approved in November 2012, and many other reference documents, as noted throughout this document.
PRINCIPAL PROPOSALS & CLEARANCE

1. The Zambia Supplemental Environmental Assessment (SEA) (2010), as amended in 2011 (amendment #1) was valid for implementing PMI-supported IRS in selected districts in the Northern Region of Zambia, using all WHO-recommended pesticides in the pyrethroid, carbamate and organophosphate classes for the period 2010-2015.

2. In order to continue with PMI IRS, PMI is seeking approval for a new SEA for a further 5 years (2015-2020).

3. It is proposed in this SEA to expand the permissible insecticide options to include chlorfenapyr, when recommended by WHOPES, in addition to carbamates, pyrethroids, DDT, and organophosphates, and for the SEA to be nationwide in scope.

4. It is further proposed in this SEA to conduct soil, vegetative, sediment, and other media baseline chemical sampling and analysis prior to the use of DDT, and to perform subsequent environmental monitoring as recommended by the PMI IRS Best Management Practices (BMPs).

5. It is further proposed to allow for small studies or hut trials to evaluate new IRS insecticides such as chlorfenapyr, once the insecticide has been submitted for Phase III WHOPES evaluation and country-level required documentation has been submitted. The guidelines for laboratory testing and small and large-scale field trials are provided in “Test procedures for insecticide resistance monitoring in malaria vector mosquitoes” (WHO, April 2013).

6. This SEA contains the condition that spraying will not be performed by PMI within 30 meters of natural water bodies, wetlands or marshes, organic farming areas, beekeeping areas or core areas within protected forests, parks or habitats.

7. The Safer Use Action Plan in Chapter 6 provides detailed guidance on the performance of all activities associated with IRS. The attached, updated Environmental Mitigation and Monitoring Plan (EMMP) (Annex A) summarizes the required mitigation measures, as well as the monitoring and reporting requirements and schedule.

8. The preparation of this SEA renders the preparation of a Letter Report unnecessary for 2015. In subsequent years, provided DDT is not to be used for IRS in Zambia, a Letter Report will be submitted to USAID annually that will discuss significant changes in the IRS program for that particular year’s spray campaign. For each year that DDT is to be used for IRS in Zambia, an SEA amendment will be prepared for approval by all signatories to the current SEA before any spraying is allowed.

9. It is PMI policy that the first use of organophosphates in a given country requires the signature of the Africa Bureau and Global Health BEOs on the annual Letter Report. Use of organophosphates in subsequent years does not require BEO signatures. As organophosphates have been used in Zambia since 2012, BEO signatures are not required on the annual Letter Reports.
10. This SEA contains an updated Pesticides Procedures section, which, together with the also-
included Safer Use Action Plan constitute the elements of a PERSUAP.

Signature approval of this SEA will indicate acceptance of these proposals. Therefore, the following
conditions will apply:

1. All WHOPES-recommended insecticides in the pyrethroid, carbamate, organochlorine and
organophosphate classes, as well as chlorfenapyr, once it is recommended by WHOPES, will be
eligible for IRS in all areas of Zambia from 2015-2020, except within core protected areas and
within 30 meters of other sensitive areas.

2. This SEA will comprise a free-standing document fulfilling the environmental documentation
requirements of US 22 CFR 216 for PMI IRS in Zambia from 2015-2020, unless DDT is
proposed for use in a given year, or changes are made to the program that are not covered or
anticipated in this assessment.
APPROVAL OF ENVIRONMENTAL ACTION RECOMMENDED
2015-2020 SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT FOR PRESIDENT’S MALARIA INITIATIVE INDOOR RESIDUAL SPRAYING (IRS) FOR MALARIA CONTROL IN ZAMBIA

The United States Agency for International Development, Global Health Bureau has determined that the proposed IRS effort, as described in the 2015-2020 Supplemental Environmental Assessment: Indoor Residual Spraying for malaria control in Zambia responds to the needs of the community and country as it relates to managing malaria in Zambia, and also conforms to the requirements established in 22 CFR 216.

This document does not mandate the execution of the proposed IRS, rather, it documents the environmental planning and impact analysis executed by the IRS team in preparation for the proposed action. The design and standards of operation of the IRS program are established to avoid and reduce any potential impact. USAID has concluded that the proposed action, when executed as described in the Supplemental Environmental Assessment and the Programmatic Environmental Assessment for PMI IVM (2012), is consistent with the Government of Zambia’s and USAID’s goal of reducing malaria incidence in Zambia while minimizing negative impact to the environment and to human health.

The proposed actions recommended for approval in this 2015 SEA are:

1. The continuation of IRS implementation using pyrethroids, carbamates, DDT, organophosphates, and/or chlorfenapyr when recommended by WHOPE, where appropriate, based on pesticide resistance patterns throughout the country.

2. This SEA will extend coverage to all geographical areas in Zambia where IRS may be implemented or where national or regional level support may be provided by PMI as decided by the National Malaria Control Program and PMI for the 5-year period from 2015 to 2020.

3. This SEA authorizes small, closely supervised studies or Hut Trials to study new IRS insecticides such as chlorfenapyr, once the insecticide has been submitted for Phase III WHOPE evaluation and country-level required documentation has been submitted.

4. Due to the need to protect the population from malaria in Game Management Areas (GMAs), which serve as buffer zones of protected areas,, and given the successful record of PMI in implementing IRS in Zambia without significant environmental consequences, it is proposed to allow IRS in these buffer zones using the strict protocols and procedures contained in the PMI Best Management Practices (BMP) manual, and observing all precautions and prescriptions in this SEA.

5. This SEA further authorizes analysis of samples of soil, sediment, and other relevant media in all affected districts in Zambia prior to the re-introduction of DDT in IRS operations, to serve as a baseline, with subsequent periodical environmental monitoring.

The Safer Use Action Plan in chapter 6 and the PMI BMP manual provides detailed guidance on the performance of all activities associated with IRS. Through the use of this and other guidance, PMI has maintained an excellent record of success in executing IRS without substantial environmental or human health impact.
CLEARANCE:
Mission Director: USAID/Zambia
Michael Yates, Ph.D.
Date: 9/24/15

CONCURRENCE:
Bureau Environmental Officer/GH: Rachel Dagovitz
Date: ________________

ADDITIONAL CLEARANCES:
Bureau Environmental Officer/AFR: Brian Hirsch
Date: ________________

PMI Advisor: PMI/Zambia
Chomba Sinyangwe
Date: 8/26/2015

Mission Environmental Officer: USAID/Zambia
Mwewa Katongo
Date: 8/26/2015

Regional Environmental Advisor: USAID/Southern Africa
/email clearance/
Diana Shannon
Date: 8/19/2015
CLEARANCE:
Mission Director: ____________________________  Date: ________________
USAID/Zambia  Susan Brems

CONCURRENCE:
Bureau Environmental Officer/GH: ____________________________  Date: 9/31/15
Rachel Dagovitz

ADDITIONAL CLEARANCES:
Bureau Environmental Officer/AFR: ____________________________  Date: ________________
Brian Hirsch

PMI Advisor:
PMI/Zambia  ____________________________  Date: ________________
Chomba Sinyangwe

Mission Environmental Officer:
USAID/Zambia  ____________________________  Date: ________________
Mwewa Katongo

Regional Environmental Advisor:
USAID/Southern Africa  ____________________________  Date: ________________
Diana Shannon
I'm prepared to provide clearance, with that revision. Do you need a scanned signature? I'm happy to have you simply list me as clearing by email. Your choice.

Thanks!

Brian

Brian Hirsch
Bureau Environmental Officer / Acting Chief, Economic Growth, Environment and Agriculture Division
USAID/AFR/SD/EGEA; RRB 4.06-117
Washington, DC 20523
202-712-5613; bhirsch@usaid.gov

[Quoted text hidden]
From: Diana Shannon <dshannon@usaid.gov>
To: Mwewa Katongo <mkatongo@usaid.gov>
Subject: Fwd: 2015 - 2020 Zambia SEA, Indoor Residual Spraying - REO Clearance

Dear Mwewa:

Please accept this email as my REO clearance.

I am sorry I took so long with this review - I was out of the office. My apologies.

Please send onward are Rachel, with copy to Brian, Alexis, and Walter, and afrbeo-support@cadmusgroup.com and me. Remember to send a Word document and pdf, and note in the documents the electronic clearances.

I hope to get up to Zambia and in the field with you. Let me know as the spray season approaches when you will be available.

Thank you for all your work on this.

Diana
1. BACKGROUND & PURPOSE

1.1 PRESIDENT’S MALARIA INITIATIVE

Launched in 2005, the President’s Malaria Initiative (PMI) is a five-year, $1.2 billion expansion of U.S. Government efforts to reduce the intolerable burden of malaria and help relieve poverty on the African continent. The goal of PMI is to reduce malaria-related deaths by 50 percent in 19 countries in Africa that have a high burden of malaria by expanding coverage of four highly effective malaria prevention and treatment measures to the most vulnerable populations: pregnant women and children under five years of age (USAID 2005). These interventions include insecticide-treated mosquito nets (ITNs), indoor residual spraying (IRS) with insecticides, intermittent preventive treatment for pregnant women (IPTp), and prompt use of artemisinin-based combination therapies (ACTs) for those who have been diagnosed with malaria.

1.2 PROGRAM OBJECTIVES

PMI will assist Zambia to achieve the following targets in populations at risk for malaria by the end of 2020:

- Reduce malaria mortality by one-third from 2015 levels in PMI-supported districts, achieving a greater than 80 percent reduction from PMI’s original 2000 baseline levels.
- Reduce malaria morbidity in PMI-supported districts by 40 percent from 2015 levels.

Zambia covers an area of approximately 752,600 square kilometers with a population of approximately 15,023,315 people of which 2,770,815 are children under the age of five (Central Statistical Office, Zambia: 2013). The entire population is at risk for malaria, including children under the age of five and pregnant women. The country has three distinct malaria epidemiological strata: classified as low with parasitemia below 1%, moderate with parasitemia between 2 and 14% and high transmission with parasitemia above 15% in children below 5 years (Masaninga et al, 2013). Most of the districts experience malaria that is characterized by seasonal peaks of transmission occurring between March and April. Climate (humid subtropical or tropical wet and dry) and altitude are major factors that influence malaria prevalence in the country. Other contributors are: poor housing (especially in peri-urban and rural areas), high human population concentration, and presence of lakes, swamps and dambos (especially in the Luapula and Northern provinces of the country). Based on the National Malaria Strategic Plan (NMSP) 2011-2015, (MOH, 2010) the country seeks to consolidate the significant progress made over the previous five years in malaria control through fine-tuning the strategies that call for focused and sustained high impact interventions based on evidence derived from epidemiological and entomological data.

Among the malaria control strategies applied in Zambia, IRS has been carried out since 2003 with concentration on the districts along railroad lines. In 2006, the NMCP, with support from the USAID-funded Health Services and Systems Program (HSSP), conducted IRS in 15 districts in five provinces. PMI began supporting IRS activities in Zambia in 2008 covering the same 15 districts with a primary focus on pre-spray activities (planning of spray operations, conducting needs assessments, procuring and distributing insecticides and personal protective equipment (PPE), enumerating structures, building IRS human capacity), and district spray supervision. In 2009, the NMCP expanded the reach of IRS to 36
districts covering all of the then nine provinces of the country, with at least three districts covered per province. In 2010, a total of 1.3 million structures were sprayed in 54 districts, representing 75% of the districts in the country and protecting over 6 million people. Beginning in 2011, the huge burden of malaria incidence in the eastern half of the country prompted adjustments from the concentration on rail lines to the eastern half of the country. The initial district wide blanket IRS coverage has since been adjusted, to a more targeted focal spraying to cover high risk areas.

In May 2014, the PMI-supported IRS program in Zambia was exclusively transitioned to the President’s Malaria Initiative (PMI) Africa Indoor Residual Spraying (AIRS) Project. Working in close collaboration with the Ministry of Health (MOH), 40 high-burden malaria districts were identified in five provinces in which IRS was implemented. The five provinces were Central (4 districts), Eastern (9 districts), Luapula (11 districts), Muchinga (7 districts) and Northern (9 districts) with a total of 472,000 structures targeted. A total of 409,544 structures in the 40 districts were sprayed between October and December of 2014 and protected 2,000,824 people using the long lasting organophosphate Actellic 300CS.

**FIGURE 1: PMI IRS COVERAGE (NORTHERN REGION) 2014-2015**

In 2015, PMI will conduct an IRS campaign that covers the same five provinces as in 2014, representing 40 high burden malaria districts in the Northern Region of Zambia, and will target approximately 486,772 structures and protect 2.2 million people using the long lasting organophosphate Actellic 300CS. Because Actellic 300CS has a residual activity of over six months that will span the annual period of high malaria transmission, no repeat spray round is expected. According to the 2011-2016 NMCP strategic Plan, targeting of IRS by districts and within districts will be based largely on disease burden, population density, and entomological surveillance. The targets for the 2015 spray campaign were based on the number of structures found in the 2014 spray season with a 10% buffer per district. Working in close collaboration with the MOH and Ministry of Community Development, Mother and Child Health (MCDMCH), PMI Zambia aims at ultimately achieving at least 85% spray coverage in the IRS target areas of the targeted 486,772 structures, thereby contributing to the national strategic goal of 75% reduction in malaria, and PMI’s goal of a 50% reduction in mortality in targeted areas.
In addition to PMI sponsored IRS, GRZ, through the MOH is charge of IRS in the remaining districts in five provinces (Southern, North Western, Copperbelt, Western, Lusaka and some parts of central) with support from mining companies, the Global Fund, and the Bill and Melinda Gates Foundation, through the Malaria Control and Evaluation Partnership in Africa. The table below summarizes results and targets of the USAID/PMI-supported IRS campaigns for the period from 2006 to 2015 by structures sprayed, population and districts covered, and insecticide used. It also includes PMI targets for 2015.

<table>
<thead>
<tr>
<th>Year</th>
<th># of Structures Sprayed</th>
<th># of Persons Protected</th>
<th># of USAID Supported Districts</th>
<th># of PMI Supported Districts</th>
<th>Insecticide Used</th>
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<tbody>
<tr>
<td>2006</td>
<td>537,877</td>
<td>—</td>
<td>15</td>
<td></td>
<td>DDT and pyrethroids</td>
</tr>
<tr>
<td>2007</td>
<td>657,219</td>
<td>—</td>
<td>15</td>
<td></td>
<td>DDT and pyrethroids</td>
</tr>
<tr>
<td>2008</td>
<td>1,039,154</td>
<td>—</td>
<td>36</td>
<td></td>
<td>DDT and pyrethroids</td>
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<tr>
<td>2009</td>
<td>1,191,517</td>
<td>—</td>
<td>36</td>
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<td>DDT and pyrethroids</td>
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<tr>
<td>2010</td>
<td>740,699</td>
<td>2,721,166</td>
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<td>DDT and pyrethroids</td>
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<td>2011</td>
<td>814,706</td>
<td>3,351,158</td>
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<td>Carbamates and pyrethroids</td>
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<td>2012</td>
<td>460,358</td>
<td>1,710,833</td>
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<td>Carbamates and organophosphates</td>
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<td>2013</td>
<td>432,398</td>
<td>1,842,821</td>
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<td></td>
<td>Organophosphates</td>
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<tr>
<td>2014</td>
<td>409,544</td>
<td>2,000,824</td>
<td>40</td>
<td></td>
<td>Organophosphates</td>
</tr>
<tr>
<td>2015</td>
<td>486,772 (target)</td>
<td>2,000,824 (target)</td>
<td>40</td>
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<td>Organophosphates</td>
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</table>

Entomological monitoring (sentinel) sites are located in six IRS districts: Kasama, Isoka, Milenge, Serenje, Katete and Mwense from where mosquito collections are carried out on a monthly basis using CDC light traps and pyrethrum spray catches. Morphological identification shows that Anopheles funestus is the predominant vector in nearly all six sentinel sites. Cone bioassays were conducted in November, 2014, within 48 hours after the IRS application to assess the spray quality. The results showed 100% mortality rates during and after the 24 hour holding period. Between March 2015 and February 2016, PMI Zambia entomology team in collaboration with NMCP and MCDMCH will continue to conduct entomological surveillance including assessing malaria vector density and species composition in intervention areas; establish vector feeding time and location; monitor the quality of insecticide application and insecticide decay rates as well as testing vector susceptibility in all the six sentinel sites. The level of vector resistance to at least one insecticide from the four classes of insecticides recommended by the WHOPES for IRS use will be monitored at all the sites. During this period, the
following insecticides will be tested using WHO tube tests (filter paper) for routine activities: bendiocarb, deltamethrin, permethrin, DDT, pirimiphos-methyl, and chlorfenapyr.

**FIGURE 2: SUSCEPTIBILITY TESTS FOR AN. FUNESTUS**

Feb – April, 2014

**FIGURE 3: SUSCEPTIBILITY TESTS FOR AN. GAMBIAE**

Feb – April, 2014
This section describes the alternatives for malaria control that were considered in the preparation of this report, including those that were accepted or rejected. Alternatives considered include the following:

1. **Preferred action**: Establish annual IRS campaigns that spray pesticides of the pyrethroid, carbamate, organophosphate and organochlorine classes, as well as chlorfenapyr (when recommended by WHOPES) in high-risk districts and sectors identified by the evaluation of criteria such as transmission rate, vector susceptibility, residual effect, appropriate home and wall structure, economic factors, and ecological/human health impacts.

2. **No action alternative**: This action would discontinue PMI support for IRS activities in Zambia.

3. **Spraying in alternative geographic regions**: This alternative would use different criteria to select alternative districts and sectors to spray.

4. **Use of alternative pesticides**: This alternative would consider pesticides other than those recommended by WHOPES.

5. **Alternative technologies**: This alternative would consider methods other than IRS to achieve the stated goals of reduction in malaria mortality and morbidity.

### 2.1 Description of Proposed Action

The preferred action is to implement an IRS program in selected communities, choosing among the WHOPES-recommended pesticides in the pyrethroid, carbamate, organophosphate, organochlorine classes, and chlorfenapyr (once recommended by WHOPES), considering current entomological, epidemiological, logistical, environmental, and economic conditions. The pesticide to be used will be determined by a process fully explained in Pesticide Procedures part b (see section 4.2).

### 2.2 No Project Alternative

IRS is one of the critical interventions in the control of the spread of malaria. A no project alternative will result in rising rates of infections, transmissions, mortality and morbidity due to the increased prevalence of infected vectors. Therefore, the “no action” alternative does not meet the overall goal of the Zambia NMCP and PMI, which is to reduce malaria mortality by one-third from 2015 levels in PMI-supported countries, achieving a greater than 80 percent reduction from PMI’s original 2000 baseline levels.

### 2.3 Alternative IRS Geographical Sites Considered

Although this SEA proposes to allow IRS in all 10 provinces in Zambia, in IRS implementation, areas considered as highly malarious and those areas that fit within the NMCP strategic plan are considered,
while lower risk areas are not considered for IRS as an intervention in a given year. Using different criteria for selecting geographical sites would reduce the effectiveness and impact of IRS, decreasing progress towards the goals of the Zambia NMCP and PMI.

### 2.4 Use of Alternative Insecticide(s)

For IRS to be implemented with PMI support, a pesticide recommended by the World Health Organization (WHO) under the World Health Organization Pesticide Evaluation Scheme (WHOPES) must be selected for use. To date WHOPES has recommended twelve insecticides for use in IRS for malaria control within the following four classes of pesticides: pyrethroids, carbamates, organochlorines, and organophosphates. This SEA also covers chlorfenapyr in anticipation that this new insecticide – currently under WHOPES review – will, within the time span of this SEA be fully recommended by WHOPES for IRS and being registered for public health use in Zambia.

Currently, there are no other pesticides eligible for use in PMI-sponsored IRS, so deliberations are confined to these classes of pesticides.

### 2.5 Alternative Technologies

A full range of known, available technologies is continually considered for use by the stakeholders in malaria prevention and control efforts. It has been determined that IRS plays a significant part in malaria prevention in concert with those other technologies. The specific focus of this PMI effort and the role that PMI plays in Zambia includes IRS. If other viable approaches were to arise that would replace or improve upon the role that IRS plays, the NMCP, PMI and its partners would evaluate them and proceed accordingly.
3. Affected Environment in Zambia

3.1 Overview of Zambia

Zambia is a vast, landlocked tropical plateau with an area of 752,614 km² situated in the southern part of Africa bordered by Angola to the west, Democratic Republic of Congo (DRC) to the North; Tanzania to the northeast; Malawi and Mozambique to the east; Zimbabwe and Botswana to the south and the Caprivi Strip of Namibia to the southwest.

3.2 Administrative and Political Units

Zambia has a 2013 estimated population of 15,023,315 (Central Statistical Office, Zambia: 2013), with 40% residing in urban and 60% in rural areas. The country is divided into 10 provinces that, since 2013 are subdivided into 103 districts. Each of the 10 provinces is administered by the Provincial Minister. The 103 districts are further subdivided into 150 constituencies with representation at the national assembly by the respective Member of Parliament.

Following the change of government in October 2011, the Zambian Government re-aligned the health portfolio functions between the MOH and the MCDMCH. Under the new arrangement, the MOH is responsible for planning, health policy guidelines, surveillance, and evaluation, allocating funds, and sourcing key health inputs including drugs and equipment for service delivery through NMCP. The provincial Health offices which are also under MOH are responsible for monitoring and supervision of malaria activities that are being implemented in the districts. The MCDMCH is responsible for providing technical oversight for the implementation of health activities at district, health center, health post, and community levels.

The District Community Medical Office (DCMO) provides overall planning, coordination, and monitoring of malaria activities within their districts. Health posts are intended to cover 500–1,000 households. A newly created cadre of Community Health Assistants trained for one year and on government pay role has been deployed at some Health Posts in selected districts. At community level, Community Health Workers provide malaria diagnostic and treatment services through the Integrated Community Case Management program. Health centers, staffed by a clinical officer, nurse, or environmental health technician, serve a catchment area of 10,000 residents.

3.3 Physical Environment

3.3.1 Climate

Zambia is a tropical plateau in southern Africa lying between latitudes 8° and 18°S, and 22° and 34°E. Zambia’s climate is relatively mild, with 3 distinct seasons, a cool dry season (May to August); a hot dry season (August to October) and the warm wet season (November to April). The average annual temperature ranges between 18°C and 20°C. The minimum and maximum annual average temperature is 32°C and 40°C, respectively.
3.3.2 Rainfall Patterns

Since Zambia lies in the tropics, it receives substantial rainfall with the northern part of the country receiving the highest rainfall with an annual range of 1,100 mm to over 1,400 mm. The southern and eastern parts of the country have less rainfall, ranging from 600 mm to 1,100 mm annually. In some years the driest areas may receive as little as 500 mm and the season may be confined to January, February and March. In contrast, the wettest areas may receive as much as 1,500 mm in a season lasting from September to May.

The rains are brought by the Inter-tropical Convergence Zone (ITCZ) and are characterized by thunderstorms, occasionally severe, with much lightning and sometimes hail. The ITCZ is located north of Zambia in the dry season. It moves southwards in the second half of the year, and northwards in the first half of the year. At the height of the wet season it rains on seven or eight days out of ten. In exceptional years the influence of ITCZ is felt much farther to the southern part of Zambia, resulting in excessive rain in the Southern Province and partial drought in the north for about three to four weeks in December. The highest rainfall is in the north, especially the north-west and the north-east, decreasing towards the south; the driest areas are in the far south-west and the Luangwa River and middle Zambezi River valleys, parts of which are considered semi-arid.

3.3.3 Topography, Geology and Soils

The country is on the great plateau of Central Africa, at an average altitude of 1,200 m. The lower parts of the plateau (dambos) have a reliable supply of water during the dry season. They are flooded in the rainy season. The Mafinga Mountains form part of a great escarpment running down the east side of the Luangwa river valley. The country rises to a higher plateau in the east.

The country has three main topographical features:

- Mountains with an altitude of at least 1,500 meters;
- A plateau with an altitude ranging from 900 to 1,500 meters; and;
- Lowlands with an altitude of between 400 and 900 meters.

Most of Zambia's plateau and some hilly areas have been degraded due to geomorphological processes. The main soils are loamy-sand or sand Alfisols, interspersed with clay. Upland soils are of low inherent fertility; most are moderately leached sandveldts, loams and clays. Their texture and structure and physical properties vary. Soils in most dambo areas are characterized by a dark color in the top 30 cm of the profile. In more cases the layer is covered by silt loams underlain by silt clay loam with clay developing in deeper layers. Clay appears to have deposited to lower horizons into water tables. Black color is chiefly on account of their high organic matter content.

3.3.4 Biological Environment

Plant Life

Zambia's vegetation is of the savanna woodlands type in high rainfall regions and tropical grassland in low rainfall regions. It is estimated that 60 percent of the country's total land area (752,000 km²) is covered with natural forests. Of these forests, about 7.2 million hectares are under government control in the form of 432 forest reserves. In addition, there are 6.4 million hectares of national parks and 15.6 million hectares of game management areas. There are also about 15.4 million hectares of forest under
traditional or customary zoning and/or ownership. There is no reliable information on the growing stock as most of the inventories in natural forests were conducted in the 1960’s.

Zambia has four major vegetation formations namely; closed forests, woodlands or open forests, termitaria and grasslands. Closed forests are sub-divided into five categories, namely the dry evergreen forests, the dry deciduous forests, the montane forest, the swamp forest and the riparian forest. The closed forests are limited in extent, covering only about 6% of the country. The most extensive closed forests are Cryptosepalum and Baikiaea forests covering parts of North-Western and Western Province (Ministry of Tourism, Environment and Natural Resources (MTENR), 2003).

There are four types of woodlands in the country of which the most extensive is Miombo woodland covering 42% and characterized by the following genera: Brachystegia, Julbernadia and Isoberlinia genera (MTENR, 2002). The other types of woodlands are: Kalahari which is widespread on the Kalahari sands of the Western province and part of North-Western province; Mopane which occurs mainly in the hotter, drier, lower parts of the country, including the Luangwa and Zambezi valleys and Munga (or savanna woodland) which are thorny woodlands mainly covering the southern parts of Zambia.

Anthill vegetation (Termitaria) covers 3% and is present in all regions of the country except in areas of pure sands. It is classified according to association with other vegetation types; hence the classification: Miombo Termitaria, Kalahari Termitaria, Mopane Termitaria, Munga Termitaria, Riparian Termitaria and the Grassland Termitaria.

Grassland is widespread in the northern and western parts of Zambia. It is mostly land which is naturally without trees, and is found in places with a permanently high water table. It includes dambos, flood plains, and the margins of pans, swamps and lakes.
### TABLE 2: VEGETATION TYPES OF ZAMBIA

<table>
<thead>
<tr>
<th>Main vegetation types</th>
<th>Sub-types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed forests</td>
<td>Dry evergreen forests</td>
</tr>
<tr>
<td></td>
<td>- Parinari</td>
</tr>
<tr>
<td></td>
<td>- Marquesia</td>
</tr>
<tr>
<td></td>
<td>- Cryptosepalum</td>
</tr>
<tr>
<td></td>
<td>- Lake basin</td>
</tr>
<tr>
<td>Dry deciduous forests</td>
<td>- Baikiaea</td>
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<tr>
<td></td>
<td>- Itigi</td>
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<tr>
<td>Montane</td>
<td></td>
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<tr>
<td>Swamp</td>
<td></td>
</tr>
<tr>
<td>Riparian</td>
<td></td>
</tr>
<tr>
<td>Woodlands (or open forests)</td>
<td>Miombo</td>
</tr>
<tr>
<td></td>
<td>Kalahari</td>
</tr>
<tr>
<td></td>
<td>Mopane</td>
</tr>
<tr>
<td></td>
<td>Munga</td>
</tr>
<tr>
<td>Termitaria</td>
<td>Miombo</td>
</tr>
<tr>
<td></td>
<td>Kalahari</td>
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<tr>
<td></td>
<td>Mopane</td>
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<tr>
<td></td>
<td>Munga</td>
</tr>
<tr>
<td>Grasslands</td>
<td>Mostly land which is naturally without trees;</td>
</tr>
<tr>
<td></td>
<td>dambos, flood plains, and the margins of pans,</td>
</tr>
<tr>
<td></td>
<td>swamps and lakes</td>
</tr>
</tbody>
</table>

**ANIMAL LIFE**

The development of human settlements and human-related activities such as hunting has had the effect of reducing the relatively rich animal life in Zambia. Large mammals that can be found in Zambia include lions, leopards, hyenas, elephants, buffalo, cheetah, giraffe, wild dogs, rhino, monkeys as well as antelopes which are found in a variety of forms like the wildebeest, reedbuck, Steenbok, roan antelope, impala, Lechwe Puku, sable antelope, the common eland, the bushbuck, the common Duiker, the blue wildebeest and several others. Among the snakes are pythons, cobras, puff adders, hissing sound, vipers, twig, night adder, and black mambas. Hippopotamus, crocodiles, and other reptiles are found in the rivers and lakes. There are many species of lizards, tortoises, and giant snails in Zambia.

Among the numerous birds are doves, pigeons, parrots, cuckoos, owls, nightjars, kingfishers, hornbills and the broad-billed roller, barbets, honey guides, woodpeckers, swallows, the fork-tailed drongo and
flycatchers, red-necked falcon, crested guinea fowl, African broadbill, black-breasted snake eagle, and the lesser spotted eagle.

The rivers and inland lakes are rich in fish and other forms of life. A small pelagic clupeid, locally known as *chisense*, is increasingly fished in the northern lakes of Mweru and Bangweulu, involving a large share of female work force. Lake Kariba is providing mainly *Kapenta* (Lake Tanganyika sardine), tiger fish, mormyrids and tilapias. Lake Itzhi-Tezhi is yet to start providing the Kapenta, which was trans-located in the late 80s and has now fully colonized the once open niche. In general Zambia’s fish resources revolve on the following species most of which are common to most of the fisheries although there are some that are endemic to selected fishery areas: normyridae, Clupeidae, Characidae, Cyprinidae, Centroponidae, Cichlidae.

Insect life is particularly abundant in Zambia. There are beetles, fireflies, ants, termites, butterflies, crickets, and bugs. Among the most dangerous insects are mosquitoes, tsetse flies, and blackflies, which are responsible for transmitting the endemic diseases of malaria and yellow fever, trypanosomiasis (sleeping sickness), and onchocerciasis (river blindness, a parasitic disease), respectively.

### 3.3.5 Major Water Bodies

The major water bodies in Zambia are the Zambezi, Lake Mweru Wantipa Catchment, Luapula Basin, and Lake Tanganyika. The Luapula Basin consists of the Chambeshi river, Bangweulu lakes and swamps complex, Luapula River and Lake Mweru. The Zambezi basin is the largest, comprising Luangwa River, Lukanga swamps, Kafue River, Upper Zambezi, Lake Kariba and Lower Zambezi. The Lake Tanganyika basin is the smallest, with fish fauna of Nilotic affinities. The Lake Mweru Wantipa catchment could be considered as standalone as it is an internal drainage system with no outlet.

**Lakes**

Lakes Bangweulu, Mweru, and Tanganyika are all located in the northern reaches of the country, near its borders with Tanzania and the Democratic Republic of the Congo. Lake Tanganyika is the largest of these three, but only its southern end is situated within Zambia. Lake Mweru is a much smaller and shallower freshwater basin located along the border with the Democratic Republic of the Congo. Lake Bangweulu is the smallest of the three northern lakes, but it is the largest found entirely within Zambia, with a surface area of 9,840 square kilometers (3,000 square miles). The Luapala River drains Lake Bangweulu; the lake, combined with several smaller bodies of water, forms the Bangweulu Swamp complex, which is the largest swamp area in the country. Lake Kariba, on Zambia’s southern border, is one of the largest artificial lakes in the world. It is shared by Zambia and Zimbabwe.

**Rivers**

Most of Zambia’s streams ultimately drain into the Indian Ocean via the Zambezi River and its main tributaries. In addition to those streams that enter the Zambezi directly, there are three main tributary systems: the Kafue, Luangwa, and Lunsemfwa Rivers. With a total length of 2,735 kilometers (1,700 miles), the Zambezi River is the longest river in Zambia. The upper Zambezi, running roughly from north to south, passes through floodplains and swamps. After turning eastward, the Zambezi flows over Victoria Falls and through the middle Zambezi Valley. The flow of all watercourses in Zambia is affected by the clear demarcation between rainy and dry seasons.

**Wetlands**

Many extensive floodplains have formed where large rivers cross flat plateaus. The Zambezi and several of its tributaries form a very extensive system of plains in Western Province and the western part of
North-western Province. The Kafue has large floodplains on two of its tributaries, the Lufupa (Busanga Plain) and the Lukanga, in addition to the Kafue Flats. The Chambeshi enters the Bwela flats near its source and spills into the vast Bangweulu swamp, which is drained by the Luapula River. These plains all have rich and distinctive floras. Large areas of floodplain may be inundated for the whole of the dry season during wet spells, but may not flood at all during dry years. Such areas have two complementary floras, one aquatic and the other adapted to dryland conditions. The aquatic flora consists of species, such as the wild rice *Oryza longistaminata*, which are rooted in the ground and have stems which are elongate to keep pace with the rising flood, so that the leafy tips are always above water. The water may rise 4 meters or more. As the flood recedes, the vegetation lies down to form a dense mat. Characteristic of the elevated levees and the higher levels of the plains are groves of fan-palms, *Borassus aethiopium* and *Hyphaene petersiana*. Termite mounds on sandy floodplains frequently have the wild date-palm (*Phoenix reclinata*).

**FIGURE 4: MAJOR WATER BODIES**

Source: Zambia Wildlife Authority (ZAWA): 2015

### 3.3.6 SPECIAL CONDITIONS (WATER CROSSINGS)

Luapula, Western and Northern provinces have sites with sensitive ecosystems lying on water. Lunga Leyalui and Chilubi Districts are the three areas that may require special conditions due to the fact that...
chemicals are required to be transported on water to the islands using a boat. Chilubi District has three regions, the mainland, islands and the swamps whereas Leyalui District is a seasonal island; it lies on the barotse floodplains and gets flooded during rainy season.

Lunga District comprises four chiefdoms, namely; Bwalya Mponda, Kalima Nkonde, Kasoma Lunga and Nsamb, and each chiefdom occupies an independent island which is distant from all others. The island or catchment area in the district nearest to the mainland is Bwalya Mponda and it takes more than two hours of travel on water by speed boat to get there from Samfya harbor. The factors that contribute to the delays in accessing the district may be attributed to the following facts:

1. All four chiefdoms lie in the swamps of Lake Bangweulu that can only be accessed through water channels and these channels get blocked, especially during any flooding event – usually during the rainy season, due to overgrown grass.

2. During summer, the situation gets exacerbated by the low water levels on the lake which could lead to a damaged engine and stranding of the crew and cargo. Hence, the only option is to use banana boats, which are not stable on water, especially during storms.

If an accident occurs, a large area within Bangweulu may be contaminated with pesticides, and this could be disastrous as the livelihoods of inhabitants in the area are dependent on a healthy lake. If IRS is to take place in this district, the stringent measures that have been laid out in the 2012 PMI BMP manual on how to safely transport chemicals on water (BMP #10) must be followed to protect the people and the environment. All pesticide being transported over water must be wrapped in water-tight packaging.

The entire Lunga District is a flood prone zone and as such, an IRS operational base with a soak pit, storage facility and bath rooms could be submerged in water during rainy season when the water level in Lake Bangweulu rises. For this reason, all storage must be temporary, and operations must be completed before the rainy season starts, so that the storeroom can be emptied prior to flooding.

Additionally, if permanent soakpits were used and the area subsequently floods, the pesticide that was captured by the soak pit would be mobilized and dispersed to the environment with detrimental effects. In addition, digging a traditional soak pit 1 meter in depth is difficult or impossible, given the high groundwater table. A mobile soak pit (MSP) is much shallower, and at the end of operations, it is removed from the ground along with the contaminants it has trapped. These features make the MSP a better choice for this location.

Finally, to minimize the risk to operators, a recommendation would be to use a community-based IRS approach, so that operators do not have to travel between islands, thus limiting the risk of accident.

3.4 PROTECTED AREAS

Zambia has the second largest proportion of land under protected status in Southern Africa with approximately 225,000 square kilometers designated as protected areas. This amounts to 30% of the total land cover and of this, 8% are National Parks (NPs) and 22% are Game Management Areas (GMA). Zambia has abundant natural resources and among these is wildlife. Protected areas are declared by law for the purpose of protecting and perpetuating the integrity of ecosystems and biodiversity for present and future generations. Zambia has a total of nineteen National Parks covering a total land area of approximately 60,000 Km² and 34 game management areas. The national parks are administered by the Zambia Wildlife Authority, an autonomous body responsible to the Ministry of Lands, Natural
Resources and Environmental Protection. In approximate order of importance in terms of wildlife resources, the eight main prominent and functioning national parks are: South Luangwa, Kafue, Lower Zambezi, Nsumbu, Kasanka, Lochinvar, Blue Lagoon and Victoria Falls.

The PMI IRS IP will not perform IRS within Zambia’s core protected areas. Protected areas in Zambia have a core protected area, with stringent regulations restricting uses, entry, and activities, and buffer areas referred to as GMAs with less stringent protection. In general, the GMAs are designed to protect the environment while allowing sustainable use of resources. PMI will only perform IRS within buffer areas of Zambia’s protected areas, as allowed by national and local regulation, if needed and required by the NMCP to protect the population in these areas from malaria, using the strict protocols and procedures contained in the PMI Best Management Practices (BMP) manual, and observing all precautions and prescriptions in this Supplemental Environmental Assessment (SEA). PMI-sponsored IRS will not be performed within 30 meters of the core protected areas. Operations sites for storing pesticide and performing clean-up activities will not be allowed in the buffer or core areas.

3.4.1 KAFUE NATIONAL PARK
The Kafue is the largest and oldest National Park in Zambia. It covers a total of 22,480km² and was declared a National Park in 1950. It is situated entirely upon a plateau. The Kafue National Park environment is one of the largest coverage of miombo woodland in protected areas in Africa. It is blessed with a vast landscape with rock outcrops, rivers, floodplains, swamps and woodlands that form part of the physical environment where economic potential is high. In terms of biodiversity, Kafue National Park has one of the highest species diversity in Zambia. One hundred and fifty eight (158) species of fishes are known to occur in the park. All the large mammals naturally occurring in Zambia are found in the park except for the giraffe and tsessebe, although black rhinoceros seems to be extinct.

3.4.2 SOUTH LUANGWA NATIONAL PARK
The South Luangwa is the second largest of Zambia's national parks, created in 1972. It occupies 9,050 km² in the mid-Luangwa valley. The landscape has all the major vegetation types of Central African Valleys and provides continuous and spectacular ranges of rifts and scarps from Great East African Valley and the Muchinga Escarpment lies adjacent to the park from North to South. The park has about 60 different animal species and over 400 different bird species.

3.4.3 LOWER ZAMBEZI NATIONAL PARK
Lower Zambezi National Park is situated east of Lusaka about 120km from the capital city. It covers an area of about 4,092 km². It falls under the jurisdiction of Central Region of ZAWA. The broad classification of vegetation in the Park includes forests found along the fringes of the Zambezi River and its tributaries, woodland comprising of mopane, miombo and acacia and grassland found mainly in dambos, marshes and on the Zambezi River flood plains.
3.5 AGRICULTURE AND ORGANIC FARMING

Dambo soils have supported crop production on a sustainable basis for decades without having to apply external inorganic fertilizers on account of their organic matter and high nutrient pool. There is currently an increasing trend to dambo cultivation due to their wetness and high fertility status. Zambia has a landmass of approximately 752,614 square kilometers, of which 56 percent is arable land (42 million hectares). In addition about 35 percent of the fresh water resources in the Southern African Development Community (SADC) region are in Zambia, which if well nurtured, could make agriculture the mainstay of the economy (MFNP, 2006). Agriculture has become an increasingly important contributor to Zambia’s economy and agriculture-based exports accounted for 22 percent of GDP in 2001 as compared to 20 percent in 1990. The main agricultural crops grown are maize, sweet potatoes, groundnuts, sorghum, millet, soya beans, mixed beans, sunflower, cotton, and paddy rice. Since 2001, the sector has shown signs of improvement particularly for cash crop production such as cotton, tobacco and wheat. This was driven by the increased role of the private sector through-out-grower schemes (MFNP, 2006).
3.5.1 **BEE KEEPING**

Approximately 66 percent of Zambia is covered with woodlands and dry forests. Miombo woodlands, widespread on the plateau are dominated by Brachystegia, Julbernardia and Isoberlinia, which are preferred nectar sources for bees. The strong link between forests and traditional beekeeping creates opportunities for promoting beekeeping as an incentive for sustainable forest management. Beekeeping and honey production improve diets for an estimated 250,000 farmers and are an important source of income for 20,000 rural households in Zambia. These activities are done during the time when labor demands for agriculture are low, thereby providing alternative employment for rural people.

About 70% of Zambia’s beekeepers live in Northwestern Province and in 2004, North Western Bee Products was recorded as being the second largest employer in Kabompo district. Zambian honey is favored on the international market because most of it is produced in relatively undisturbed environments and can therefore be classified as organic. Two large companies (North Western Bee Products and Forest Fruits Zambia Ltd.) export approximately 400 metric tons of certified organic honey per year. An additional 200 tons is exported by several smaller companies. The main export markets for Zambian honey are the UK (55%) and Germany (35%). Other increasingly important markets are the Arab countries, the USA and the SADC region. Beeswax is used by beekeepers for baiting their hives, or sold locally as a floor polish and for making candles. Among the formal honey traders are also the non-governmental organizations that buy honey from producers in their operational areas. For example, the organizations Mpongwe Beekeeping Enterprise and Environment and Development in Zambia train farmers and provide inputs (wooden hives, top bars, veils, smoker etc.), which the beekeepers —pay back in the form of honey. Certified organic beeswax is also exported and a significant, but unknown, amount of beeswax is bought by Tanzanian traders.

Spraying in areas near beehives can lead to the death of the bees, which are vulnerable to all WHO-recommended pesticides. In addition, spraying near hives can lead to contamination of edible honey. These risks must be mitigated at all times. The project will make conscientious efforts to identify locations where beehives are kept, and observe a 30 meter no-spray buffer zone around them.

3.6 **SUMMARY**

Zambia still has high prevalence and transmission rates of malaria and IRS has been demonstrated to help reduce these rates in the areas where it has been employed. Zambia also has a rich and diverse natural environment that needs to be preserved for future generations. The people are part of this environment, and they must be cared for as well. PMI has a strong record of IRS execution without environmental degradation, and it is highly likely that with continued adherence to the environmental mitigation and monitoring plan, which is key to this history of success, that implementing contractors will continue to deliver life-saving IRS with insignificant environmental impact. Therefore, it is recommended that IRS be permitted to continue in the areas identified by the NMCP, including in the buffer areas of the above-mentioned protected areas.
4. PESTICIDE PROCEDURES

Title 22 of the United States Code of Federal Regulations, Part 216 (22 CFR 216) mandates the consideration of twelve factors when a project includes “assistance for the procurement or use, or both, of pesticides”. As the PMI Zambia IRS program includes assistance in both of these aspects, it is subject to this regulation. This section therefore addresses each of the twelve factors for the IRS Malaria Control Program in Zambia.

4.1 A. THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY’S REGISTRATION STATUS OF THE REQUESTED PESTICIDE

Pesticides registered for IRS or a similar use in the United States and the host country government will be preferred in this IRS project. Some of the pesticides on the WHOPES list are not registered with the USEPA for economic, technical, or regulatory reasons. There is a very limited market in the US for IRS, and as a result, registrations for this use of these pesticides have been voluntarily withdrawn, or never filed. However, US 22 CFR 216.3(b)(1)(iii) allows for the use of pesticides not registered for the same or similar use by USEPA, provided that:

1. The proper assessments are performed,
2. The assessments include an evaluation of the factors in Sections 4.1-4.12 of this document, and
3. Notification is provided to, and authorization received from the host country government for the use of the pesticide in-country.

PMI/USAID works closely with host country governments, with full and clear disclosure, as well as providing any necessary assistance in the mitigation of risk from the use of these WHOPES pesticides. This SEA, supported by the PMI IVM PEA, and distributed to ZEMA and MOH, provides the assessment, notification and mitigation requirements of US regulations. PMI/USAID is therefore empowered, upon acceptance of this document and the receipt of formal authorization from a competent Zambian authority, to use in Zambia all WHOPES-recommended pesticides in the pyrethroid, carbamate, DDT and organophosphate classes, and chlorfenapyr when recommended by WHOPES.

4.2 B. THE BASIS FOR SELECTION OF THE REQUESTED PESTICIDES

In addition to the above criteria, insecticide selection for any PMI supported program is subject to the following considerations.

4.2.1 PRIMARY CRITERIA FOR CHOOSING PESTICIDES

Approval by the World Health Organization Pesticide Evaluation Scheme: Only insecticides recommended by WHOPES can be used in IRS. Certain pesticides in the organophosphate, carbamate, pyrethroid and organochlorine classes are WHOPES-recommended for use in IRS. Table
3 shows the list of WHO-recommended pesticides. Chlorfenapyr is not yet recommended by WHOPES, but authorization is requested in this SEA to use it for trials, and for IRS when and if it receives WHOPES-recommendation.

Table 3: WHOPES Recommended Pesticides With Effective Duration

Updated: 2 March 2015

**WHO recommended insecticides for indoor residual spraying against malaria vectors**

<table>
<thead>
<tr>
<th>Insecticide compounds and formulations</th>
<th>Class group (^1)</th>
<th>Dosage (g a.i./m²)</th>
<th>Mode of action</th>
<th>Duration of effective action (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDT WP</td>
<td>OC</td>
<td>1-2</td>
<td>contact</td>
<td>&gt;6</td>
</tr>
<tr>
<td>Malathion WP</td>
<td>OP</td>
<td>2</td>
<td>contact</td>
<td>2-3</td>
</tr>
<tr>
<td>Fenitrothion WP</td>
<td>OP</td>
<td>2</td>
<td>contact &amp; airborne</td>
<td>3-6</td>
</tr>
<tr>
<td>Pirimiphos-methyl WP, EC</td>
<td>OP</td>
<td>1-2</td>
<td>contact &amp; airborne</td>
<td>2-3</td>
</tr>
<tr>
<td>Pirimiphos-methyl CS</td>
<td>OP</td>
<td>1</td>
<td>contact &amp; airborne</td>
<td>4-6</td>
</tr>
<tr>
<td>Bendiocarb WP, WP-SB</td>
<td>C</td>
<td>0.1–0.4</td>
<td>contact &amp; airborne</td>
<td>2-6</td>
</tr>
<tr>
<td>Propoxur WP</td>
<td>C</td>
<td>1–2</td>
<td>contact &amp; airborne</td>
<td>3-6</td>
</tr>
<tr>
<td>Alpha-cypermethrin WP, SC</td>
<td>PY</td>
<td>0.02–0.03</td>
<td>contact</td>
<td>4-6</td>
</tr>
<tr>
<td>Alpha-cypermethrin WG-SB</td>
<td>PY</td>
<td>0.02–0.03</td>
<td>contact</td>
<td>up to 4</td>
</tr>
<tr>
<td>Bifenthrin WP</td>
<td>PY</td>
<td>0.025–0.05</td>
<td>contact</td>
<td>3-6</td>
</tr>
<tr>
<td>Cyluthrin WP</td>
<td>PY</td>
<td>0.02–0.05</td>
<td>contact</td>
<td>3-6</td>
</tr>
<tr>
<td>Deltamethrin SC-PE</td>
<td>PY</td>
<td>0.02–0.025</td>
<td>contact</td>
<td>6</td>
</tr>
<tr>
<td>Deltamethrin WP, WG, WG-SB</td>
<td>PY</td>
<td>0.02–0.025</td>
<td>contact</td>
<td>3-6</td>
</tr>
<tr>
<td>Etofenprox WP</td>
<td>PY</td>
<td>0.1–0.3</td>
<td>contact</td>
<td>3-6</td>
</tr>
<tr>
<td>Lambda-cyhalothrin WP, CS</td>
<td>PY</td>
<td>0.02–0.03</td>
<td>contact</td>
<td>3-6</td>
</tr>
</tbody>
</table>

**Chlorfenapyr 240 SC**: The current assessments of Chlorfenapyr SC (class group: pyrrole) are available in the report of the 16th WHOPES Working Group meeting, 22–30 July 2013 and the report of the 17th WHOPES Working Group meeting, 15–19 September 2014 (both reports available at [http://www.who.int/whopess/resources/en/](http://www.who.int/whopess/resources/en/)).

**Note**: WHO recommendations on the use of pesticides in public health are valid ONLY if linked to WHO specifications for their quality control. WHO specifications for public health pesticides are available on the WHO homepage on the Internet at [http://www.who.int/whopess/quality/en/](http://www.who.int/whopess/quality/en/).

1. CS = capsule suspension; EC = emulsifiable concentrate; SC = suspension concentrate; SC-PE = polymer enhanced suspension concentrate; WG = water dispersible granules; WG-SB = water dispersible granules in sealed water soluble bags; WP = wettable powder; WP-SB = wettable powder in sealed water soluble bags.

2. OC = organochlorines; OP = organophosphates; C = carbamates; PY = pyrethrins.

**Registration for use in Zambia**: In the case where the insecticide proposed for use in IRS is not registered in Zambia, PMI will work with MOH and ZEMA to obtain special authorization for the
use of the pesticide. Since the registration of DDT for use in IRS operations in Zambia has expired, the MOH will have to work with ZEMA and potential vendors to ensure that it is re-registered before it is used for IRS in Zambia.

**Residual effect for a period longer than, or at least equal to, the average duration of the malaria transmission season in the area:** As seen in the table above, all pyrethroids, carbamates, and organophosphates are expected to stay active and effective for 3 to 6 months after application; however, the effective duration varies under different climatic conditions and other factors. Three pyrethroids, known as longer-lasting pyrethroids, can last up to eleven months based on various field trials. For this reason, pyrethroids have traditionally made the best choice for extended seasons. However, in order to manage vector resistance, it has proven to be necessary to periodically switch the class of pesticides used in IRS. The duration of effectiveness on the primary wall surface types will continue to be researched and considered when selecting insecticide class and active ingredient.

**Pesticide must be appropriate for use on the wall surfaces of the selected location:** Structures in Zambia are mainly of 3 different types: plastered and painted; plastered and not painted; and mud. Pyrethroids, carbamates, DDT and organophosphates are known to function well on mud and cement walled houses and are therefore appropriate for use. A few villages also have structures made of woven grass (which seems like temporary structures) scattered on the lake shores, river banks, islands and the swamps in Luapula, Northern and Western provinces. The current PMI IRS Project in Zambia does not operate in areas with these structures. However, if such structures are found in a target spray area, we will investigate whether the chosen pesticide is appropriate for use on this surface.

**Local vector susceptibility to the insecticide:** Resistance to insecticide develops when a hereditary feature is selected in an insect population that reduces the population’s sensitivity to a given insecticide. In Zambia, vector susceptibility studies are conducted on the two main vectors; An. *funestus* s.l, which is the predominant vector, and An. *gambiae* s.l, by the PMI IP in collaboration with TAC and IRMTWG. Recent entomological data suggests An. *gambiae* s.s in most geographical areas has shown high resistance to DDT, and pyrethroids (deltamethrin and permethrin) but slight resistance to carbamates (Bendiocarb) and full susceptibility to pirimiphos methyl. An. *funestus* however has shown resistance to carbamates (bendiocarb) and pyrethroids (deltamethrin and permethrin), but is still susceptible to DDT and pirimiphos methyl. Since the PMI IP has confirmed the effectiveness of pirimiphos methyl in all these districts, it is now being used for IRS in the current spray districts to manage resistance and to take advantage of the long residual effect.

**Ecological impact:** Zambia boasts of a diverse wildlife throughout the country, but especially in the national parks and protected areas, and it is extremely important that IRS does not in any way diminish this biodiversity. The ecological impact of the WHOPES pesticides is well-documented, recently in the 2012 PMI IVM Program Environmental Assessment (IVM PEA). However, if BMPs for IRS are strictly followed, the release to the environment, and therefore the impact to the environment, should be negligible. More information on ecological impact of the proposed pesticides is found in sections 4.5 and 4.7 below, as well as other sections of this document.

**Human health impact:** The 2012 IVM PEA assessed cancer and non-cancer risks associated with all WHOPES-recommended insecticides by process (e.g., mixing insecticide, spraying, residing in sprayed house, etc.) and pathway (e.g. inhalation, dermal, ingestion, etc.), and cancer risks by process and pathway where available (mainly for DDT and select pyrethroids). In general, pyrethroids and carbamates pose less non-cancer risks via any pathway than organophosphates when risks are assessed, but the risks of organophosphates can be managed by following standard
PMI IRS procedures and protocols (BMPs). The results of a bio-monitoring pilot conducted in 2015 may contribute to a needs assessment and guidelines for PMI spray operations.

4.2.2 **SECONDARY SELECTION CRITERIA:**

- Appropriate packaging for safety and standard delivery tools
- Unit cost of insecticide
- Timely delivery of the insecticide to the preferred point of delivery
- Local representation of supplier in host country
- Technical assistance with training and troubleshooting by supplier

4.3 **C. THE EXTENT TO WHICH THE PROPOSED PESTICIDE USE IS PART OF AN INTEGRATED PEST MANAGEMENT (IPM) PROGRAM**

IPM is defined as “an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials (pesticides) are selected and applied in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment.”

IPM is often used in an agricultural context, but similar in nature is the concept of Integrated Vector Management (IVM).

The major characteristics of IVM include:

- *Methods based on knowledge of factors influencing local vector biology, disease transmission, and morbidity;*
- *Use of a range of interventions, often in combination and synergistically;*
- *Collaboration within the health sector and with other public and private sectors that impact vectors;*
- *A public health regulatory and legislative framework.*

Use of IVM for the control of the malaria vector population is practiced using four primary interventions, insecticide-treated nets, indoor residual spray, artemisinin-based combination therapies (ACT), and intermittent preventive treatment for pregnant women (IPTp). Environmental management for malaria control is limited to some common sense safeguards, such as limiting standing water which can serve as a breeding ground for mosquitoes. PMI does not support environmental management as a vector control method. Because of the life-cycle requirements and the adaptability shown by IRS vectors, these practices have not demonstrated large-scale effectiveness. PMI strategy has been that IRS will be implemented as a component of IVM for malaria control.

1 [http://www.ipm.ucdavis.edu/IPMPROJECT/about.html](http://www.ipm.ucdavis.edu/IPMPROJECT/about.html)
4.4 **D. THE PROPOSED METHOD OR METHODS OF APPLICATION, INCLUDING AVAILABILITY OF APPROPRIATE APPLICATION AND SAFETY EQUIPMENT**

IRS involves spraying a liquid insecticide with long lasting residual activity on indoor wall and ceiling surfaces where mosquitoes usually rest. The pesticide then dries up and leaves a crystalline deposit on the sprayed surface. A lethal dose of the insecticide is absorbed when the mosquito rests on the surface, which kills the mosquito.

Pesticide will only be applied using pressurized spray equipment approved for the pesticide in use, by trained spray operators wearing gloves, overalls, hard hats with face shields, neck shields, and boots. All necessary PPE for this activity is supplied by PMI, and its use is supervised and enforced throughout the course of the campaign. Spray operators are trained in and use spray patterns that have proven effective for providing long-lasting toxicity toward the malaria vector mosquito.

The spray operators who implement IRS use backpack compression sprayers to apply a measured amount of insecticide on the interior walls of houses and structures. A water-soluble insecticide is added to the sprayer containing a pre-measured amount of water, the sprayer is pressurized, and the material is then applied. After the day’s spraying is complete, spray operators clean the sprayer following PMI BMPs to maintain proper functioning of the pump, reuse leftover pesticide on the following day, and to guard against release of and/or exposure to pesticides. They also follow the manufacturer’s recommendations to ensure their proper operation and calibration.

4.5 **E. ACUTE AND LONG-TERM TOXICOLOGICAL HAZARDS ASSOCIATED WITH THE PROPOSED USE AND MEASURES AVAILABLE TO MINIMIZE SUCH HAZARDS**

The IVM PEA assessed the toxicity of WHO-recommended IRS insecticides to non-target organisms, including mammals, birds, fish, bees, and other aquatic organisms. The table below provides graphic information on the toxicity and some of the other characteristics of the WHOPES pesticides. In general, most of them are toxic to bees, fish, and other aquatic organisms, and less so to mammals and birds.

“Indoor” being an important operative word in IRS, the risks to biodiversity from spray operations are minimal if PMI BMPs are followed. The BMPs have been designed to prevent any significant release to the environment, and a strong, automated, smart-phone-based supervisory system ensures that BMPs are followed or non-compliance is immediately corrected.

The reader is referred to Annex E of the 2012 IVM PEA, and to Chapter 5 of this SEA for greater detail about pesticide toxicity.
**TABLE 4: PESTICIDE TOXICITY**

<table>
<thead>
<tr>
<th>IRS Insecticide</th>
<th>Mammal</th>
<th>Bird</th>
<th>Fish</th>
<th>Other Aquatic</th>
<th>Bee</th>
<th>Persistence</th>
<th>Bioaccumulate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha-cypermethrin (P)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bendiocarb (C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bifenthrin (P)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyfluthrin (P)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>DDT (OC)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deltamethrin (P)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Etofenprox (P)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Fenitrothion (OP)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lambda-cyhalothrin (P)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malathion (OP)</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pirimiphos-methyl (OP)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Propoxur (C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorfenapyr (PR)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: IVM PEA 2012

Key

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>High Toxicity</td>
<td>Red</td>
</tr>
<tr>
<td>Medium to High</td>
<td>Orange</td>
</tr>
<tr>
<td>Medium Toxicity</td>
<td>Yellow</td>
</tr>
<tr>
<td>Low to Medium</td>
<td>Green</td>
</tr>
<tr>
<td>Low Toxicity</td>
<td>Green</td>
</tr>
<tr>
<td>Data Not Found</td>
<td>White</td>
</tr>
</tbody>
</table>

### 4.5.1 HAZARDS

The two broad categories of hazard are release and exposure to humans and domestic animals, and releases causing environmental damage. Release and exposure may occur at any point, from the production or importation of the pesticide through transportation, storage, distribution, pesticide make-up, spray application, clean-up, and final disposal, as well as post-spray due to improper spray deposition on household articles, or improper behavior of beneficiaries regarding sprayed surfaces.

In humans, both organophosphates and carbamates can produce cholinesterase depression if the proper protective measures are not utilized and exposure results. Cholinesterase inhibition results in overstimulation of the nervous system, with symptoms that include nausea, dizziness, confusion, and respiratory paralysis and death at very high exposures (U.S. EPA, 2000b). The two classes of insecticides differ in their impact on human health in that with carbamates, the cholinesterase inhibition is temporary, and may dissipate in as little as 2-3 hours, providing the exposure is eliminated. With organophosphates, the inhibition is longer-lasting and cumulative, and thus more dangerous.
DDT has been used in large populations for more than 60 years with little evidence of acute toxicity, except from accidental, large-scale exposures. In these relatively rare instances, DDT acts by impairing the conduction of nerve impulses. Symptoms of acute exposure to high levels of DDT by any route include mild altered sensations, tremors, convulsions, and respiratory depression. Additional effects observed in humans after acute DDT exposure include headaches; nausea and vomiting; diarrhea; numbness; paresthesia (a burning, tingling, or stinging of the skin); increased liver enzyme activity; irritation of the eyes, nose, or throat; altered gait; and malaise or excitability. In addition to potential acute effects, DDT is a liver toxicant, and is associated with various reproductive and developmental effects. Recent data indicate that exposure to DDT in amounts necessary for malaria control may cause preterm birth, decreased birth weight, early weaning, and pregnancy loss. The International Agency for Research on Cancer (IARC) has classified DDT in Group B2, “probable human carcinogen.” These hazards are discussed in more detail, along with the mitigation measures to be employed, in the IVM PEA, in Chapter 6, the Safer Use Action Plan, and in the Environmental Mitigation and Monitoring Plan (Annex A).

4.6 **F. The Effectiveness of the Requested Pesticide for the Proposed Use**

Pesticides are selected for IRS based on technical efficacy and economic efficiency in the intended use, along with other extrinsic variables. Complete selection criteria can be found in Section 4.2 of this SEA. Knowledge of vector susceptibility is critical to planning and evaluating the effectiveness of the IRS program. It enables timely forward planning to (i) manage the development of the resistance and (ii) evaluate new or alternative insecticides for possible future introduction should a change of pesticide be required. Resistance testing is done to (i) establish a baseline susceptibility of the local vectors for future reference, (ii) monitor changes that occur as time progresses, (iii) identify the mechanisms of resistance and cross-resistance to inform the resistance management strategy that will be adopted, and (iv) evaluate the susceptibility of the local vectors to potential alternative insecticides, should there be a need to change pesticide.

Prior to each campaign, it is necessary to measure vector resistance in the target areas, to ensure that acceptable kill levels will be achieved. A resistance monitoring program has been established by the NMCP in collaboration with the PMI supported AIRS Zambia project, and the results from this ongoing program are the primary determinants of the choice of pesticide and other supplementary actions.

Pesticide efficacy is also affected by vector behavior, insecticide quality, and the residual action of the pesticide. The probability of vector-pesticide contact depends on whether the targeted vector feeds indoors (endophagic) and rests indoors (endophilic), as this increases the likelihood of the vector resting on the sprayed wall. The efficacy of the pesticide to kill may be compromised if the vector exits after feeding without resting on the wall, or if the vector feeds outdoors (exophagic) and rests outdoors (exophilic). *An. gambiae*, *An. arabiensis* and *An. funestus*, the major malaria vectors in Zambia, are mainly endophagic and endophilic. This makes them suitable targets for IRS.

Vector resistance may differ in origin, intensity, type, and significance for vector/disease control in a given population. The evaluation of the significance of resistance to vector control should therefore consider the biochemical and genetic characteristics of the resistance, as well as the eco-epidemiology of the disease and operational characteristics. Resistance also tends to be highly focal (i.e., limited to a definite area). It is therefore important to ascertain the spatial distribution of the observed resistance to
better inform the resistance management strategy to be employed and the geographical extent to which it will apply (e.g., what geographical area a possible change in pesticides for IRS should cover).

The residual efficacy of the pesticide being used for IRS is crucial to evaluating the implication of vector resistance. The wall surface to which the pesticide is applied is a factor affecting residual efficacy, and must be taken into account. It is important that bioassays on various wall surfaces be carried out at specified intervals after the IRS operation in order to determine the period and level of residual activity in a given locality and the sprayed surface.

A third major factor affecting the effectiveness of the pesticides is their quality (specification). If the active ingredient, for example, is not up to the recommended specification and concentration, it may lead to under-dosage of deposited pesticide, which then contributes to intervention failure. Storage of pesticide for too long a time, or in extremely hot warehouses can lead to breakdown of the active ingredient. Poor pesticide quality may present additional risks to the pesticide handlers and spray operators who may be exposed. For this reason, samples of the pesticide should be taken prior to use, and analyzed for the concentration of the active ingredient. If feasible, susceptibility testing should also be performed, but seasonal dips in vector population usually limit this activity. In all PMI AIRS warehouses the temperature is monitored and controlled as much as possible to avoid temperatures that could alter the chemistry or the characteristics of the pesticide.

4.7 G. COMPATIBILITY OF THE PROPOSED PESTICIDE WITH TARGET AND NON-TARGET ECOSYSTEMS

The pesticides are compatible with the target environment (walls, ceilings, eaves) in that they dry on these surfaces, and are not released to receptors or the general environment to any great extent. The dried pesticide remains on the sprayed surfaces, and performs as designed, killing vector mosquitoes that rest on them, and the exposure to non-target organisms and ecosystems is very limited.

The WHOPES recommended pesticides are incompatible with the non-target ecosystems (humans, animals, and the environment), in that, if they are released to the environment in large quantities, they would have negative effects on land and water based flora and fauna (See Table 4). However, the IRS implementation process is designed to ensure that to the maximum extent possible, pesticides are deliberately and carefully applied to the walls and ceilings of dwellings, and do not come in contact with humans, animals, or the environment. IRS implementation is also planned to minimize and responsibly manage the liquid wastes through the reuse of leftover pesticides, the triple rinsing of equipment, and the daily washing of PPE with rinsewater treatment to remove trace pesticide. Wherever possible, recycling is incorporated into the waste management plan, particularly in the case of plastic bottles used for pesticide containers. Where it is not feasible to recycle materials, they are either washed thoroughly and disposed of in a landfill, or contaminated solid wastes are incinerated in an approved incinerator that will destroy the pesticide and prevent environmental contamination. The Environmental Mitigation and Monitoring Plan in Annex A details the measures that have been and will be enacted to prevent contamination of ecosystems. In addition, there are solid and liquid waste management plans contained in the Safer Use Action Plan of this SEA (Chapter 6).

4.8 H. THE CONDITIONS UNDER WHICH THE PESTICIDE IS TO BE USED

Chapter 3 of this document provides a detailed account of the environmental conditions in Zambia under which the pesticide is to be used. IRS is scheduled to be performed prior to the rainy season in
each location to maximize the effectiveness of IRS, and to avoid logistical complications from the degradation of transportation infrastructure due to flooding and washout.

During IRS, particular attention will be paid to any sensitive areas identified in Chapter 3, including water bodies, schools, hospitals, any area where organic farming is practiced, where bee-keeping or natural bee habitats are established, etc. In addition, bird-nesting habitat will be protected, and all insecticides will be kept away from all water habitats and resources. Prior to spraying, geographical reconnaissance will include identification of households in sensitive areas, and the IP will train sprayers to identify houses that should not be sprayed. IRS will be prohibited within 30 meters of sensitive ecosystems. If pesticide drift is observed, spraying will be halted until the cause has been determined. Drift could be a result of spraying an inappropriate surface with gaps that allow pesticide to escape, so the wall surface must be evaluated for fitness for spraying, and the structure potentially disqualified. Alternately, if drift is caused by excessive wind (especially if spraying eaves outdoors) operators must wait until wind conditions subside. The IP will consult with ZEMA and ZAWA regarding the application of pesticides in or near ecologically sensitive areas, such as wetlands, lake shore, river edge and protected areas and follow their policies and guidelines, unless the conditions prescribed herein are more strict, in which case the SEA will have precedence. Strict supervisory control will also be established to prevent contamination of agricultural products.

4.9 1. THE AVAILABILITY AND EFFECTIVENESS OF OTHER PESTICIDES OR NON-CHEMICAL CONTROL METHODS

In Zambia, as in many countries, a full range of malaria control methods are employed, and in some circumstances, one method may be favored over another. However, PMI has determined that IRS is part of the overall effort to decrease malaria morbidity and mortality in Zambia and in many other countries. This IRS program is limited to using those pesticides that are on the WHOPES list of recommended pesticides. WHO currently recommends 15 formulations from four chemical classes for IRS, each with a specific dosage regime, duration of effectiveness, and safety rating.\(^2\) Each of these agents has been evaluated for effectiveness within the program, and continuing monitoring for resistance and susceptibility will be employed to allow up-to-date decisions prior to each spray campaign. One goal of this SEA is to broaden the options for pesticide use to five pesticide classes (including chlorfenapyr in


\(^3\) Chlorfenapyr is currently under consideration to be included. The 17th WHOPES Working Group (2014) recommended that, considering the potential efficacy of chlorfenapyr to kill pyrethroid-resistant Anopheles, further evidence be gathered in Phase II to assess the efficacy of indoor residual application of chlorfenapyr 240 SC against malaria vectors, following the WHO guidelines for IRS. It is recommended that the trials should be conducted at a minimum of three study sites, the applied doses should comply with target doses, the vectors are susceptible to chlorfenapyr, and use should be made of appropriate positive controls (i.e. WHO-recommended insecticides for IRS) to which local vectors are susceptible (control 1) and resistant (control 2). If, in a specific situation, local vectors are not susceptible to the positive controls, in at least the two other study sites the local vectors should be susceptible to the positive controls.
the pyrrole class, if and when it is recommended by WHOPES), to combat periodic resistance development.

Non-chemical means of malaria vector control are examined and discussed briefly under section 5.3, Integrated Pesticide/Vector Management (IPM/IVM), but are generally not effective on a large scale. For example, while elimination of standing water breeding habitats is a logical and sensible concept, the malaria mosquitoes only need the smallest of aquatic habitats to successfully reproduce, and it is nearly impossible to eliminate all of these minute breeding habitats.

4.10 J. THE REQUESTING COUNTRY’S ABILITY TO REGULATE OR CONTROL THE DISTRIBUTION, STORAGE, USE, AND DISPOSAL OF THE REQUESTED PESTICIDE

4.10.1 THE ENVIRONMENTAL MANAGEMENT ACT (NO. 12 OF 2011)

Zambia’s principal national law and policy on environment is the Environmental Management Act (No. 12 of 2011) which lays down basic environmental principles and promulgates the National Environmental Action Plan (NEAP) of which the state of the environment report is published every five years.

ENVIRONMENTAL ASSESSMENT REGULATION

Industrial and commercial development in Zambia, particularly large-scale mining, the growth in manufacturing activities, and a corresponding increase in population have brought about the risk of environmental damage by exerting pressures on the environment. In an effort to ensure that environmental concerns are integrated into economic development and as a way of preventing, minimizing, mitigating or compensating for adverse environmental impacts, the government introduced the EIA process and therefore promulgated the EIA Regulations, Statutory Instrument No.28 of 1997 (SI 28, 1997).

This legislation requires all investments with potential impacts on the environment to conduct a systematic investigation of conditions within the environment of the proposed development or project followed by an assessment of the impacts that the development or project will have on the environment in its totality i.e., physical, biological and socio economic aspects. A proponent shall not undertake any project that may have an effect on the environment without the written approval of ZEMA, and except in accordance with any conditions imposed in that approval. The amendment of the Environmental Protection and Pollution Control Act in 2011 strengthened the Environmental Assessment regulation by introducing a Strategic Environmental Assessment, for a draft policy, program or plan that could have an adverse effect on environmental management or on the sustainable management and utilization of natural resources which must be presented to ZEMA for approval. This SEA report will be submitted to ZEMA. This IRS must therefore fulfill the requirement for ensuring that all investments are subjected to environmental assessment as represented by this SEA report.

PESTICIDE AND TOXIC SUBSTANCE REGULATION

Zambia pesticide and toxic substance regulations provide the guidelines and measures for management of pesticides including storage, transport, usage etc. The regulation further deals with importation, licensing and permitting procedures. ZEMA’s mission under this regulation is to ensure the proper
labelling, distribution, storage, transportation, use, application, and disposal of chemicals and associated 
hazardous waste within Zambia through fair and equitable implementation and enforcement of the 
regulation.

ZEMA further provides the regulation on the use of pesticides for agriculture, horticulture, forestry, 
gardening and public health and other pesticides related uses as well as monitoring the use of pesticides 
and take enforcement action against illegal use. It also provides permitting of chemical imports and 
exports as well as Pesticides Registration & Licensing.

This legislation is significant to the IRS program in the sense that all the pesticides proposed for use 
must be registered for use under the Act including importation licenses. Pyrethroids, organophosphates, 
and carbamates have been registered for use in public health under this regulation. However, the 
registration of DDT for use in IRS has expired and there is need to have it re-registered since TAC and 
IRMTWG may consider it for use in IRS in order to manage resistance. Therefore, If DDT and 
chlorfenapyr are proposed for use for IRS in Zambia, PMI will work with the MOH and ZEMA to get 
them registered before purchasing and using them as IRS pesticides. These regulations will be complied 
with in the implementation of the IRS program.

INSTITUTIONS

The Environmental Council of Zambia was established by the Environmental Protection and Pollution 
Control Act of 1990 as the first environmental protection agency in Zambia. In 2011, it was re-named 
by an act of parliament as the Zambia Environmental Management Agency (ZEMA). ZEMA’s functions 
include advising the Minister on the formulation of policies on all aspects of the environment and, in 
particular, make recommendations for the sustainable management of the environment. The Agency is 
also supposed to co-ordinate the implementation of activities of all ministries, appropriate authorities 
and conservancy authorities in matters relating to the environment. It has responsibility to co-ordinate 
the activities of bodies that generate waste with the aim of controlling the generation, treatment, 
storage and transportation of industrial waste. It must develop and enforce measures aimed at 
preventing and controlling pollution. It has power to issue environmental permits and pollution 
abatement notices to control waste discharges and emissions and to prevent or reduce noise pollution. 
It is supposed to develop, in liaison with the relevant appropriate authority, standards and guidelines 
relating to the protection of air, water, land and other natural resources and the prevention and control 
of pollution, the discharge of waste and the control of toxic substances. It also has authority to ensure 
that developers comply with environmental impact assessments of their development plans before they 
begin development.

ZEMA by virtue of its mandate and functions is one of the institutions that are involved in all aspects of 
pesticide application and management. It ensures, through the concept of Environmental Impact 
Assessments (EIA) that the negative impact of development projects are reduced through the 
monitoring of the proponents mitigation plans.
### TABLE 5: SUMMARY OF LEGISLATIVE REQUIREMENTS

<table>
<thead>
<tr>
<th>Legislation</th>
<th>Significance</th>
<th>License/Permit</th>
<th>Responsibility</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Management Act</td>
<td>Requires EIA report before approval for commencement of project.</td>
<td>Issues EIA license after which project can commence</td>
<td>MOH/NMCP is responsible for preparing and submitting the EIA report.</td>
<td>Strategic Environmental Ass. Report was prepared and submitted in 2011 by MOH/NMCP</td>
</tr>
<tr>
<td>Pesticide Control and Toxic Substances Regulation</td>
<td>All pesticides to be procured must be reviewed by ZEMA</td>
<td>Permit for importation and licenses given</td>
<td>A list of pesticides to be procured by PMI Zambia will be presented to ZEMA to get necessary permits</td>
<td>Import permits for pyrethroids, carbamates and organophosphates have been obtained</td>
</tr>
</tbody>
</table>

4.11 **K. THE PROVISIONS MADE FOR TRAINING OF USERS AND APPLICATORS**

The effectiveness of the IRS program depends on the availability of adequately trained spraying personnel, well-maintained equipment, and competent supervision, as well as end-user acceptability and compliance. USAID has developed guidelines for IRS operations (“Best Management Practices (BMP) for Indoor Residual Spraying in Vector Control Interventions”, updated 2015), and provides a training manual “Spray Operator Pocket Guide” (A. Were, (2014)) Other resources include the *WHO-UNEP Manual on Sound Management of Pesticides and Diagnosis and Treatment of Pesticide Poisoning*, USAID PMI’s IVM PEA (USAID, 2012 Update), as well as this SEA, all of which provide precautions and recommendations on many aspects of IRS operations. The IRS BMP manual and the PMI IVM PEA requirements are the primary references and have precedence, but the other documents may be used as a reference. It is not incumbent upon the IP to comply with non-PMI documentation except where required by law. However, PMI/USAID requirements are usually stricter than others’, so there should not be a conflict.

PMI will support the training of spray operators and supervisors, and provide overall guidance and logistical support to the IRS operations in Zambia. The contractor will continue to provide technical support for environmental compliance, with a medium-term goal of building national capacity to progressively transfer responsibilities. Preparations will include the following:

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• A training of trainers program, in which potential supervisors, storekeepers and team leaders are trained on all aspects of IRS operation. Areas of training shall include planning of IRS, household preparations, record keeping, community mobilization, rational/judicious use of insecticides including sprayer and PPE cleaning, personnel management, environmental aspects of IRS – including geographical reconnaissance, and data recording and analysis.

• The training of temporary workers recruited from local areas and trained as spray team members (operators, team leaders, and wash persons). New operators will receive five to seven days of training prior to the spray operations.

4.12 L. THE PROVISIONS MADE FOR MONITORING THE USE AND EFFECTIVENESS OF THE PESTICIDE

Two kinds of measurements are needed to provide a complete understanding of the effectiveness of pesticide that is being used for IRS. The immediate (output) level relates to the efficacy of the pesticide, that is, the degree to which the pesticide is able to kill the targeted mosquito vectors, and involves direct entomological evaluations on pesticide contact bioassays and related pesticide resistance methodologies as recommended by WHO. The second broad level of measuring the effectiveness of the pesticides relates to the general goal of reducing the local disease burden. This will require specialized entomological and epidemiological skills and the assessment of the impact of vector control operations, and possibly the assignment of the contributory impact of the IRS operations. This latter measurement is usually done through a combination of methodologies such as measuring the changes in parasite inoculation rates, passive case detection at health centers, and periodic community fever and parasite surveys (active case detection).

Another key characteristic of pesticide effectiveness is the longevity of the treatment. This characteristic has important economic and health implications: the program must adjust its spray schedule to make sure that there is active pesticide on the walls of homes during critical breeding periods. Unfortunately, the guidance that is provided with regard to effective period for each pesticide is very broad (e.g. 3-6 months), and the effective period is probably subject to complex environmental factors such as heat, humidity, and substrate (wall, ceiling) composition.

However, pesticide manufacturers are well aware of the need for duration of effectiveness, and in some cases are reworking their formulations to provide greater longevity. This is the case for pirimiphos-methyl organophosphate, which has been formulated as a capsule suspension (CS) that may extend the effectiveness of the application out to six months. Because of the length of the malaria season in Zambia, this characteristic may be critical to the success of IRS. Therefore pirimiphos-methyl in the CS formulation has been used for PMI spraying in the Northern Region of Zambia since 2013, and will continue to be used in 2015.

5 These are usually health-related government staff within the targeted district (health assistants/educators/inspectors, nursing assistants, and community development assistants).
5. ENVIRONMENTAL & HEALTH IMPACTS

5.1 POTENTIAL POSITIVE EFFECTS OF THE IRS PROGRAM

5.1.1 DIRECT POSITIVE EFFECTS

The direct positive impacts of the IRS program are the reduction in child and adult malaria morbidity and mortality that will result in a reduction in human suffering. In addition, economic losses due to absenteeism or inability to work will be reduced. Other positive impacts include reduced incidence of miscarriages, low birth-weight, adverse effects on malaria-induced fetal neurodevelopment, and reduced incidence of malaria-related childhood and maternal anemia, complications, and organ failure. There is also the benefit of elimination of other household insects, as well as vermin in some cases.

5.1.2 INDIRECT POSITIVE EFFECTS

IRS will build human and institutional capacity building by providing broad-based training to a large number of people associated with IRS operations. From this training, there will be an increase in knowledge and understanding of both IRS-specific and general health and environmental risks and impacts, as well as methods of mitigation of those risks. One of the goals of the IRS program is to build in-country capacity to the point where IRS can be conducted by national or local government, or by the self-organization of communities, without large-scale external assistance or intervention.

By reducing the malaria burden, the IRS program will improve the education level amongst children of school going age, as a result of the reduction in the number of school days missed, and improve the productivity of the workforce as a result of the reduction in missed work days and days of reduced productivity.

The IRS program will indirectly contribute to the enhancement of the local economy in that IRS staff and workers will receive payment for their work. At least some of the money that they receive will be spent and injected into the local economy with a magnification effect, improving revenues for various businesses and per capita income.

In addition, the implementation of IRS requires certain local purchases of products and services, such as building and construction materials, rental of building space and vehicles, and hiring of local labor for the construction or renovation of storehouses and soak pits. Again, these revenues are injected into the economy with potentially positive magnification effects.

Finally, a reduction in household pests from IRS may result in a reduction in other diseases carried by the pests.

5.2 POTENTIAL ADVERSE IMPACTS

Adverse impacts of the IRS project are those unintended effects of the project that can compromise the well-being of the environment and/or human health. Table 4 in section 4.5 provides a graphic representation of the potential impacts on various receptors, as well as certain physical and chemical properties of the WHOPES pesticides.
5.2.1 DIRECT POTENTIAL ADVERSE EFFECTS

**Contamination of Surface Watercourses and Underground Water**

During IRS implementation, it is possible to accidentally release insecticides into water bodies during the transportation and storage of pesticides, application of insecticides to walls, and clean-up of IRS equipment and PPE. It is also possible to have a release that will affect surface or groundwater through washing in areas other than the soak pit, or improper disposal of leftover pesticide. A spill into surface water bodies is a key concern in IRS because it could lead to contamination of water routinely used for multiple domestic purposes. Fish and other aquatic organisms that are vital to a healthy ecosystem could also be wiped out.

Contamination of underground water resources is possible through improper disposal of leftover pesticide on the ground, especially if there is a high water table. However, the impacts of this risk are likely to be insignificant, primarily because pesticide disposal is strictly controlled and supervised, and the sites for soak pits are carefully chosen according to the criteria in the PMI BMPs. Secondarily, most formulations of pyrethroids, OPs, and carbamates move slowly through soil, and degrade quickly when exposed to sunlight, hydrolysis, or microbial action in the soil. If wash areas and soak pits are properly constructed and employed, liquid pesticide traces will be captured in the charcoal layer of the soak pit or organic matter in soil, and held until degradation by natural processes.

**Potential Impacts to Non-Target Organisms From Pesticides**

The degree of toxicity of the four WHOPES-recommended pesticide classes and chlorfenapyr to birdlife, aquatic life and insects, as well as pesticide persistence and bio-accumulation potential is documented in Table 4 in Section 4.5 of this SEA.

**Special Note: Impacts on Bees**

Spraying in areas near beehives can lead to the death of the bees, which are vulnerable to all WHO-recommended pesticides. In addition, spraying near hives can lead to contamination of edible honey. These risks must be mitigated at all times. Bee keeping in Zambia is mainly conducted away from the household and the sale of honey provides some income to the residents. The project will identify locations where beehives are kept, and observe a 30 meter no-spray buffer zone around them. Bee-hive owners will be advised accordingly.

5.2.2 INDIRECT ADVERSE EFFECTS

Upon termination of the IRS program, USAID will properly dispose of the IRS equipment and will no longer supervise its use. IRS equipment that may be disposed of to district health officials includes backpack compression sprayers, used, clean boots, wash basins, progressive rinse barrels, etc. that are still in operable condition. Improper use of this equipment could lead to contamination of the environment or adverse health effects as noted.

In general, if PMI supports the procurement of insecticide or disposition of unused insecticide to the GRZ, this activity is required to be mentioned in the annual Letter Report, in addition to this SEA. This type of support requires annual environmental compliance monitoring by USAID and/or the USAID IP, requires that USAID and/or the USAID IP provide environmental training to the GRZ in the PMI IRS BMPs, and language must be inserted into the government to government agreement that PMI must provide technical assistance for insecticide selection to ensure quality/appropriateness of the product. If PMI supports the procurement, loan, or disposition of spray pumps or personal protective equipment to
the GRZ these activities must be mentioned in the annual Letter Report, in addition to this SEA. These activities do not require environmental compliance monitoring, however, USAID and/or the USAID IP must provide environmental training in the PMI IRS BMPs. These requirements relate to the use of non-DDT insecticides by the GRZ.

In the case where the insecticide in use is DDT, government to government support to the GRZ or non-PMI partner to procure insecticide or dispose of unused insecticides is not allowed due to the fact that the risk involved when DDT is the insecticide used in IRS is too high. It is also a requirement that SEAs involving DDT are done on an annual basis. If PMI supports the procurement, loan, or disposition of spray pumps and PPE, supports TOTs or lower level trainings, or builds evaporation tanks, these activities are required to be included in the SEA. This type of support requires annual environmental compliance monitoring by USAID and/or the USAID IP. It further requires that USAID and/or the USAID IP provide environmental training to the GRZ in the PMI IRS BMPs. If PMI supports Behavior Change Communication (BCC), Monitoring and Evaluation, microplanning, budgeting, and environmental training when the SEA that covers DDT is in place, no other documentation is needed. However, if the existing SEA does not include DDT or there is no SEA at all then an amendment or creation of a SEA is required. These activities do not require environmental compliance monitoring, however, USAID and/or the USAID IP must provide environmental training in the PMI IRS BMPs.

The conduct of IRS by District Health Officers with communities, using properly working equipment left behind by USAID may temporarily, and in a minor way increase the total pesticide load on the environment. However, since the IRS equipment will be in operable conditions and capacity has been built among the District Health Officers, it is expected that spray operations will be according to BMPs, and the total pesticide load on the environment is expected to be less than if the donation is not made.

5.3 Human Exposure Risks/Impacts

Worker and Resident Exposure Pathways

During the IRS spraying process, spray personnel are at risk of unintentional or deliberate exposure through accidents or poor and improper handling of the spray chemical. Worker exposure to the chemical could arise during the pre-spraying, spraying and post-spraying phase of the IRS operations. Beneficiaries can also be exposed during each of these phases, and additionally over the life of the pesticide on the wall. Exposure risks of all WHO-recommended pesticides in relation to cancer and non-cancer endpoints are presented in IVM PEA 2012. The exposure risk for cancer and non-cancer endpoints is presented at different stages of the pesticide application including mixing, spraying, post spraying, dermal risk, etc.

5.3.1 Pre Spraying Exposure Pathway

Preparing pesticide solutions during the IRS requires pouring the pesticide in the spray pump to ensure ample mix with the water. The process of mixing the pesticide can lead to exposures via inhalation, dermal contact, and incidental ingestion, mostly from releases of pesticide vapors, and solutions. Vapor releases can occur when liquid concentrated emulsions are diluted. Workers or residents can inhale the vapors or the particulates or be exposed through dermal contact. Spills could also pose significant risk, especially for children who ingest the resulting residues that are left on surfaces such as food, floors, soil, as well as absorbing additional doses from eating plants and animals contaminated during the preparation for spraying.
5.3.2 EXPOSURE DURING SPRAYING
Inhalation of aerosol vapors during spraying is the main process for worker exposure during IRS, however, dermal exposure through spills or absorption onto cotton overalls is also a significant risk. Especially in the case of OPs, the dermal hazard is significant, and can cause cholinesterase depression. Residents are mainly exposed through dermal contact with sprayed surfaces and incidental ingestion of insecticide after their houses have been sprayed, especially when food or drink are left in the house during spraying. Leaky equipment can also lead to insecticide exposure through dermal contact with the floors and incidental ingestion by children who may come in contact with the spills before they are cleaned up.

5.3.3 EXPOSURE DURING DISPOSAL (INCLUDING PROGRESSIVE RINSING)
Disposal is a key issue with IRS intervention that utilizes pesticides especially during the decontamination process and disposal of the liquid effluent that will arise from washing and progressive rinse. Both burying and dumping can lead to dermal exposure to residents who come in contact with the soil or water in which the pesticide was disposed. Ingestion exposure can occur from drinking contaminated surface water. Once the excess formulation gets into the soil, the pesticide can reach the groundwater, which may be used as a water supply via household wells. Residents may then be exposed to this contaminated water by ingestion or by dermal contact when it is used for cleaning or drinking purposes.

5.3.4 OCCUPANT LONG-TERM EXPOSURE FROM RESIDUE
Residents of sprayed structures, especially crawling babies and children, will have a finite exposure risk due to physical contact with sprayed surfaces, as well as small amounts released from substrate walls, ceilings, and eaves, due to physical surface breakdown.

5.4 PESTICIDE-SPECIFIC POTENTIAL IMPACTS
5.4.1 INHALATION EXPOSURE AND RISK DURING MIXING
- Of the proposed pesticides, only etofenprox (pyrethroid) and propoxur (carbamate) have carcinogenic properties once threshold levels are exceeded.

5.4.2 DERMAL EXPOSURE AND RISK DURING MIXING
- On the WHOPES list of insecticides to be used in IRS only three (DDT, etofenprox (pyrethroid) and propoxur (carbamate)) have been determined to be carcinogenic at dermal exposure levels of 8E-07 mg/kg-day for etofenprox and 4E-06 mg/kg-day for propoxur

5.4.3 INHALATION EXPOSURE AND RISK DURING SPRAYING
- Of the proposed pesticides, only etofenprox (pyrethroid) and propoxur (carbamate) have carcinogenic properties once threshold levels are exceeded.

5.4.4 DERMAL EXPOSURE AND RISK DURING SPRAYING
- Of the proposed pesticides, fenitrothion and pirimiphos-methyl have non-cancer risks (cholinesterase depression) due to dermal exposure
5.4.5 **RESIDENT DERMAL EXPOSURE AND INGESTION RISK AFTER SPRAYING**

- The only concerns are to adults when using cyfluthrin and etofenprox (pyrethroids) and propoxur (carbamate). The risk is however very low.

5.4.6 **RESIDENT EXPOSURE AND RISK DUE TO CHRONIC INGESTION AFTER SPRAYING**

- There are four insecticides with potential impact due to chronic ingestion by drinking insecticide contaminated water. These are Cyfluthrin, Permethrin and Etofenprox (pyrethroids) and propoxur (carbamate). Best management practices are recommended.

5.4.7 **RESIDENT DERMAL EXPOSURE AND RISK DUE TO BATHING USING CONTAMINATED GROUNDWATER**

- Cyfluthrin and etofenprox (pyrethroids) have potential impact for dermal exposure using contaminated groundwater. When best management practices are applied in IRS, this risk is significantly reduced.

5.4.8 **RESIDENT EXPOSURE AND RISK DUE TO REUSE OF PESTICIDE CONTAINERS**

- Only deltamethrin is considered to have potential for acute ingestion hazard from using pesticide containers. However, residents will have no access to pesticide containers used in IRS. The pesticide containers are carefully inventoried and stored in IRS storage facilities which are securely double locked. When an appropriate recycle system is available, they will be disposed by recycling into non-consumer products. Otherwise they will be landfilled after washing and puncturing, or as a last resort, incinerated.

5.4.9 **WORKER EXPOSURE AND RISK DUE TO INHALATION DURING SPILLAGE**

According to information presented in the IVM PEA, etofenprox and propoxur have potential to impact workers through inhalation during spillage. The workers are trained on how to handle spillage and must be equipped with appropriate PPE.

5.5 **CUMULATIVE IMPACT**

Organophosphates and DDT are the pesticides with the highest potential for cumulative impacts. Pyrethroids, carbamates, and most organophosphate formulations break down readily in the environment, limiting the risk of cumulative environmental impact.

Repeated exposures to organophosphates result in cumulative cholinesterase depression, with increasingly severe effects. For this reason it is exceptionally important that PPE is worn properly and at all times when pesticide contact is possible. Formulations of the organophosphate pirimiphos-methyl have been used for several years and in several countries without any report of observed symptoms of cholinesterase depression. At the present time, PMI is conducting evaluations to determine the need for closer scrutiny or monitoring.

Because DDT is persistent and has the potential for bio-accumulation, there is a risk of a cumulative impact from long-term use. To mitigate this risk, PMI uses evaporation tanks or other treatment devices to capture and properly dispose of DDT wastes. PMI will also monitor this risk by performing baseline and ongoing sampling and testing of DDT residues in soil and plants near the IRS operations sites, where the risk of release and build-up is greatest. If analysis should indicate that ambient DDT levels are increasing, the IP will identify and eliminate any PMI-related source of releases.
6. SAFER USE ACTION PLAN

This section outlines the safer use action plan proposed for the potential adverse impacts outlined above. The primary mitigation measures include delivery of a mix of IEC approaches targeting the residents and spray operators and all IRS personnel, training of spray operators and strengthening supervision and monitoring, and provision of appropriate PPE. The mitigation measures, along with monitoring and reporting information, are compiled in the EMMP found in Annex A and in Annex C.

6.1 IMPLEMENTATION CONDITIONS

During implementation, USAID/PMI/Zambia and its PMI IRS IPs will adhere to the conditions detailed in this Safer Use Action Plan, and in the Environmental Monitoring and Mitigation Plan (EMMP), Annex A of this report.

6.1.1 PREPARATION FOR SPRAY

Prior to spraying, the contractor or implementing partner will:

- Conduct a preliminary logistical assessment to quantify eligible house structures, target population, spray equipment, insecticide, and spray teams and identify suitable sites and facilities for pesticide storage and disposal of effluent waste.
- Develop selected sites for year-round and temporary storage of IRS equipment and insecticide, and construct effluent waste disposal facilities as necessary.
- Identify sensitive areas (water bodies, protected habitat, aquacultural activities, etc.) to avoid during IRS.
- Promote acceptance of IRS in the targeted communities through information, education and communication (IEC) activities. Households have the opportunity to “opt-out” of participation in IRS after hearing the IEC messages on benefits and risks.
- Train spray teams in a variety of positions, including site managers, team leaders, spray operators, overalls washers, site attendants, security guards, and water fetchers.
- Procure, transport, and store all necessary spray and personnel protective equipment (PPE), insecticides, and consumables
- Implement this Safer Use Action Plan and the Environmental Mitigation and Monitoring Plan (EMMP) in Annex A of this SEA throughout all processes.

6.1.2 IMPLEMENTING PARTNER REQUIREMENT

1. The prime contractor for the project ("the contractor", or “the PMI IRS implementing partner") or his designee will develop this SEA that specifies the conditions under which IRS may be implemented.
2. The PMI IRS implementing partner(s) will follow the prescriptions of the EMMP contained herein, including monitoring and reporting to assure appropriate implementation and the sufficiency of environmental compliance measures.

3. The PMI IRS implementing partner(s) shall integrate these environmental compliance measures into the project work plan and report on them in the normal basis of project reporting, including the EMMR Annual Reporting Form, which will be included in the end-of-spray report (EOSR). The PMI IRS team shall assure that this integration occurs.

4. The PMI IRS implementing partner(s) will ensure that training is provided to all IRS staff and workers as prescribed by the EMMP and USAID’s Automated Directives System (ADS) 204.5.4.

5. The PMI IRS implementing partner(s) will notify PMI/IRS of any work plan activities outside the scope of the SEA, and the PMI unit will independently audit the work plan against the requirements of the SEA.

6. Any activities not addressed within the SEA must be addressed with an SEA amendment that must be approved by the Global Health and Africa Bureau Environmental Officers (BEO) before the activities in question can go forward.

7. The PMI IRS team shall ensure that the contractor’s or PMI IRS implementing partner’s responsibilities with respect to environmental mitigation and monitoring will be incorporated into contracts, grants or any other sub-agreement and scopes of work.

8. For projects currently in implementation, PMI/Zambia, with the assistance of the Mission Environmental Officer (MEO) and/or the Regional Environmental Advisor (REA) as necessary, will discuss SEA conditions with the contractor, and where necessary, come to appropriate agreement regarding the process for implementing these conditions as a mid-project adjustment.

9. As devising and implementing environmental compliance approaches should be an integral part of work plan development, these procedures place this responsibility principally on prime contractors. PMI IRS team’s primary role is thus to review and monitor, as with the execution of any other part of the work plan. Where such review and monitoring indicates unforeseen environmental impacts or that mitigation and control measures are insufficient, the PMI IRS unit will consult promptly with the REA, to revise and adapt the environmental mitigation measures as necessary.

6.1.3 POLICY PLANNING AND INSTITUTIONAL REQUIREMENTS

- Prohibit IRS in sensitive ecosystems (i.e. within 30 meters of the core zone of protected areas (National Parks, National Reserves, etc.), flood zones, wetlands, rivers, dams, lakes, fish farms, beekeeping areas, etc.); IRS uses insecticides that could negatively impact such sites. In line with the established best practices for IRS, and relevant national and USAID policies, the PMI IRS implementing partner will establish and implement mitigation measures to assure adequate protection of these sensitive ecosystems.

- Develop and implement a vector resistance management plan. Appropriate measures will be undertaken to prevent/manage resistance and to ensure the continued effectiveness of insecticides used for IRS.

- Promote inter-sectoral collaboration frameworks and institutional arrangements to facilitate a comprehensive approach to vector control and associated pesticides management. Coordination between the Ministry of Health and major stakeholders will be strengthened. This will include collaboration with:
Ministry of Health (MOH) is responsible for planning, health policy guidelines, surveillance, monitoring and evaluation, allocating funds, and sourcing key health inputs including drugs and equipment for service delivery.

The Ministry of Community Development Mother and Child Health (MCDMCH) is responsible for providing technical oversight for the implementation of health activities at district, health center, health post, and community levels. NMCP and Provincial Medical Offices have the mandate to provide technical but not operational assistance to the DCMOs in the implementation of IRS in Zambia. DCMOs are commissioned by the MCDMCH to provide services at the district and community level.

Ministry of Lands, Natural Resources and Environmental Protection (ENRMD) is the principle authority for policy formulation on land, environment, natural resources and pollution control. The ENRMD co-ordinates, monitors and evaluates the operations of the executive agencies that have been created to implement policies on behalf of the government. ZEMA is responsible for implementing the Environmental Management Act (EMA) which provides a legal framework for the use and correct management of the environment and its components and to assure the sustainable development of Zambia. ZEMA under PTS regulation is responsible for regulating the importation and use of pesticides as well as implementing international conventions governing such pesticides. It issues permits for the importation, distribution and storage of pesticides.

DDT was last used in Zambia for IRS operations in 2010 and its registration has since expired, but NMCP may consider using it in IRS operations where pesticide resistance is low and other options are not feasible. DDT is categorized as a persistent organic pollutant (POP); therefore, its management needs to be in accordance to the Stockholm Convention on Persistent Organic Pollutants. Other conventions that regulate DDT management and use include the Basel Convention on the Control of Trans-boundary Movement of Hazardous Wastes and Their Disposal, and the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade. The use of DDT for IRS must be closely monitored and reported to WHO and to the Secretariat of the Stockholm Convention. PMI IP Zambia will assist the GRZ as necessary with Stockholm Convention reporting requirements.

DDT should be used under strict control and only for the intended purpose. Using it in any other way would have important consequences, such as violation of international conventions, and the possible contamination of food and agricultural products, including export goods, with a potential impact on international trade.

The need for DDT should be evaluated regularly by the parties to the Stockholm Convention. The results from these evaluations will depend, among other things, on: insecticide resistance status of local vectors; availability of alternative insecticides; control methods and strategies; and level of IPfunding allocated to malaria vector control.

### 6.1.4 OPERATIONAL REQUIREMENTS

PMI and the PMI IRS implementing partner will work with ZEMA, NMCP and MCDMCH to access relevant country level authorization and support needed for successful IRS implementation. PMI IRS implementing partner will work closely with the NMCP, MCDMCH and the DCMOs to coordinate and implement the IRS program at the field level. PMI will work with all government partners in the following areas:
• Ensure quality assurance for commodity procurement and IRS operations to minimize risks to human health and the environment. This will include ensuring legitimate procurement sources, verifiable chain of custody of commodities, and representative sampling and analysis of pesticide, as well as effective quality compliance inspections of IRS activities in the field.

• Ensure compliance with national regulations on pesticides and this SEA EMMP for registering, importing, transporting, labeling, handling, use, storage, and disposal of pesticides. If there is a conflict, this SEA’s EMMP normally has precedence, as it is based on the USAID PMI IRS BMP that was prepared specifically for PMI IRS programs and includes international regulations. USAID compliance requirements are usually stricter than country requirements; however, if country requirements are stricter, they must take precedence.

• Train relevant categories of workers involved in IRS operations (e.g. district program managers/coordinators, team leaders, spray operators, porters, storekeepers, pesticide transporters/drivers, washpersons, and guards) on best practices in accordance with national pesticides regulations and this SEA (which includes recommendations/guidelines of World Health Organization (WHO)). Criteria for reprimanding or punishing non-observance of best practices by these workers will be established.

• Ensure use of appropriate PPE and best practices, including effective field supervision of spray operations, for adequate protection of spray operators and other handlers of pesticides or pesticide-contaminated waste.

• To avoid undue exposure of householders and spray operators to DDT, standard operating procedures and national guidelines should be in place and strictly followed. Appropriate management of DDT also entails adoption and enforcement of stringent rules and regulations to avoid leakage (e.g., into agricultural use) and misuse (e.g., when used in domestic hygiene). This includes the possibility of appropriate legal measures in the event that individuals or entities do not comply with this condition.

• Train health workers in the management of insecticide poisoning. This will include pesticide-specific guidelines on poison treatment; designation of district hospitals or health centers within the target areas for appropriate treatment of insecticide poisoning; training of IRS workers to recognize early danger signs of poisoning and taking appropriate action.

• Enforce protection of fetuses and suckling children against exposure in spray operations. Exclude pregnant women and breast-feeding mothers from direct handling of pesticides (e.g. sprayers or washers, entry into pesticide storage areas, etc.). Before each spray season, and every thirty days thereafter during operations, pregnancy testing will be established for potential female handlers of pesticides.

• Work with NMCP to carry out Information, Education, and Communication (IEC) activities for targeted communities and households to reduce exposure. Provide information on the removal of food, cooking and water utensils, covering of unmovable furniture with impermeable plastic prior to spraying; exclusion of spraying homes inhabited by pregnant women or sick individuals who are unable to leave the structure to be sprayed; preventing the reentry to sprayed rooms for at least two hours after spraying, then airing sprayed rooms at least ½ hour via open windows and doors; sweeping of floor residues before reentry of children or animals and disposal cleaning wastes including dead insects in pits or latrines.

• Establish strict practices to reduce environmental contamination from pesticides used in this program. This will include comprehensive pesticide chain of custody, auditing of pesticide stocks and pesticide usage, as well as enforcing best practices related to the handling, washing and
disposal of containers; Progressive use of waste/wash water and ablution blocks, and training on proper maintenance of spray pumps to prevent leakages.

- **Establish best practice for the transport of spray operators.** This includes providing trucks with benches for transport of spray operators, and ensuring that bulk insecticides are not transported in the same compartment as spray operators. Contract specific insurance for covering spray operators during spray operation. Strengthen training of drivers to limit risk of traffic accidents.

- **Provide IRS Training of Trainers (TOT) and training of spray operators on potential negative impacts of environmental contamination and the appropriate PMI IRS BMPs to avoid or minimize these impacts.**

- **Provide training support, as necessary, to strengthen the supervisory capacity of ZEMA and MCDMCH at National, Regional and District level for day-to-day monitoring environmental compliance of IRS activities.**

**SUPERVISORY STRUCTURE**

In coordination with the PMI IRS contractor, ZEMA with the NMCP/MCHMCH will carry out routine compliance inspections of all IRS districts, including unannounced spot inspections, to verify compliance with all relevant national regulations. The PMI IRS contractor will also conduct inspections, including unannounced spot inspections, of IRS activities and facilities in the IRS districts.

The District Community Medical Office team or DCMO is composed of the District Medical Officer (DMO), Clinical Care Specialist, Public Health Officer, the Environmental Health Officer (IRS Managers) and other health personnel. The DCMO team has a strong supervisory role throughout the duration of the spray round. Each DMO supervises the field activities in his/her district to help ensure quality and performance of the spray teams.

AIRS Zambia will take the lead on implementation of IRS activities in the spray districts while the NMCP will lead IEC efforts, or BCC efforts, in all districts that will receive direct funding from PMI. In addition, the NMCP will lead the national planning meeting, national evaluation meeting, TOTs, and IEC trainings in all districts. The PMI Zambia IP will work together with the NMCP and DCMOs to ensure supervision of spray performance during the campaign.

The District Coordinator (DC) will ensure the quality of the spray operations and administrative duties. He/she also works in close collaboration with the District IRS Manager to manage the planning and coordination of IRS activities. The DC supervises all logistical operations such as store keeping and transportation. And he/she ensures all risk preventions and environmental compliance measures are fully implemented. The District Coordinator and the IRS Manager will coordinate all IRS activities. An operational spray plan (progress calendar), produced during the micro-planning and validated by the DCMOs, indicating all communities to be sprayed during the spray operations will be maintained by the DC. The District Coordinators will hold weekly meetings with the DCMOs to discuss operational issues and their solutions. During these meetings, the partners will assess the progress of spray operations, ensure that the planned work schedule is strictly adhered to, and make recommendations as necessary to the IRS project or IEC implementers.

The Base supervisor referred to as IRS manager evaluates the work of the spray teams and IEC activities in the field. He/she also inspects structures that have been sprayed to check quality of spraying and that proper protocols have been fully followed. Base supervisors mostly EHTs monitor the effectiveness on beneficiary populations of IEC campaigns by visiting sprayed houses to discuss beneficiary impressions,
and visiting unsprayed houses to discuss with heads of families why spraying is important. Regarding spray technique and spray operator discipline, monitoring will involve visiting the sprayed compounds and interviewing beneficiaries to ensure that spray operators respect household members, spray all eligible rooms, record the essential data in the relevant form, mix and apply insecticides at the right dosage, and pass the relevant health information to the household. Base Supervisors will provide oversight to ensure the goal of day-to-day achievement of environmental compliance. At the end of each day, team leaders at each operational site will meet with the IRS manager to discuss the day’s events, challenges faced, and recommendations for resolving problems.

The Team Leaders oversee spray operators to ensure spraying occurs according to best practices. They will also ensure sprayer equipment and PPE are properly cleaned daily, as well as review data collection for accuracy. They are also responsible for tracking insecticide sachets.

The Environmental Compliance Officer will visit each base during the spray operations and complete the Environmental Compliance Checklists. The Environmental Compliance Checklists are versions of those found in the PMI IRS BMP Manual (2015) for use in the field. The checklists ensure that all best management practices are being implemented and are effective, or that immediate action is taken to correct non-compliances.

The PMI IRS implementing partner will maintain records of program performance reports which will be able to demonstrate adherence to PMI IRS BMP, quality of training and supervision, procurement activities, and environmental compliance. Such reports include the pre- and mid-spray environmental compliance reports (checklists), reports on core IRS indicators and end-of-spray evaluation reports.

Good supervision will also require observing each spray team during implementation to ensure best practices for insecticide storage and solid waste management. Since the reports of the operators are the basis for all reporting and data collection, supervisors will ensure that they are completed accurately and promptly at the end of the spraying day.

The districts are divided into geographical bases to facilitate operation and implementation. Base teams develop their operational plans with support from the DCs and IRS Managers. To ensure that IRS operations are running smoothly, in each district, AIRS Zambia will have a district operations team made up of:

- District coordinator (full-time);
- Field IRS Consultants (Master Trainers)
- Stores Officer/Logistics assistants (Seasonal)
- Data entry clerks (seasonal); and
- M&E assistants (seasonal)
- A team of SOPs with one team leader per 5 SOPs
- One supervisor per 15 SOPs

In an effort to transfer more responsibilities to the NMCP and government entities, the team will continue to work with the DCMOs. However, the AIRS Zambia Environmental Compliance Officer (ECO) will remain responsible for the pre-spray assessments of every operational site (storeroom and wash areas) two months before spraying.
Prior to spray operations, the district teams will develop spray progress plans, in collaboration with health posts, health committee chairs, and other local officials who have greater knowledge of the villages and settlements targeted for spraying. To quantify the number of structures to be sprayed in 2015 (or any upcoming year), the project will use 2014 (the previous year’s) data for structures/rooms found by SOPs (spray operators).

Each site will have two to sixteen teams, each comprised of up to five SOPs and other staff as listed below:

Site IRS managers, to support spray operations in their respective site (40);
District Coordinators, (19)
EHT supervising spray techniques in each site, (120);
Team leaders (one for each team; four to five teams, (276);
   SOPs (five in each spray team, (1203);
   IEC community mobilizers;
   Storekeepers, (40);
   Washers, (80);
   Guards, (96);
   Data clerks, (50);
   M&E assistants, (40)

The SOPs will work six days per week with average hours of operation from 6AM to 5PM. The project will ensure SOPs transportation to and from spray villages with traditional vehicle transportation while exploring new ways to reduce higher operational cost and increased environmental risk. Examples include: organizing camp sites to reduce considerable transportation costs in remote areas. Every morning, spray personnel will receive PPE, insecticide for the day, spray pumps, and data collection materials.

To track daily results and promote competitive performance, the districts will be using the spray performance tracking sheet that was successfully introduced in 2013 as well as the mobile phone-based performance tracker (MPT) introduced in 2014. Additionally, this year the PMI AIRS Project will utilize a simple SMS platform to send helpful job reminders to hired seasonal workers. The objective of these job-aid text messages is to reinforce key behaviors for high-quality and environmentally sound spray implementation (i.e. proper use of PPE, proper data collection tips, etc.).

The AIRS Zambia operations manager will review the performance tracking sheet weekly (at least) for all operational sites. Spray teams’ performance will be shared periodically with DMOs, MCDMCH and the NMCP. The use of the MPT will allow the DMO, DCMOs, NMCP, and PMI to have daily access to spray data (including number of structures sprayed, number of people protected, insecticide use, and SOP attendance).

District storekeepers/Logistics assistants will be responsible for regular supervision of secondary site stores to ensure appropriate stock and waste recordkeeping.

The AIRS PMI project will continue enhancing efforts to increase women’s participation in IRS operations. Specifically, AIRS Zambia will use planning meetings and meetings with local leaders as a
venue to advocate for recruitment of women as SOPs, team leaders, store keepers, data entry clerks and M&E assistants. The project will also work with existing female SOPs and community-based organizations including women and youth associations to promote this job to other women. AIRS Zambia will work with the DCMOs to ensure the IRS program creates a safe working environment for female workers in securing toilet and dressing rooms for them. The project will review conditions of camps sites for operators to ensure the safety and protection of women. The project will also plan to advocate communities' participation for free sites. AIRS Zambia will offer SOPs tarpaulins or mattresses for better sleeping conditions in camping sites.

**INSECTICIDE SELECTION**

The insecticide selection and the timing of the spray cycle are generally dictated by MOH and are based on the results of annual entomological studies. The insecticide will normally be procured by PMI/USAID program.

**QUANTIFICATION OF PESTICIDE REQUIREMENTS**

PMI IRS IP will conduct an annual logistics assessment for all targeted districts for planning and procurement of the correct quantity of materials, including insecticides. Purchase of insufficient pesticide will lead to shortages, delays, and possibly the inability to spray all targeted areas. Purchase of too much pesticide may lead to expiration of the pesticide before it can be used up, which creates serious storage and disposal problems.

**PESTICIDE QUALITY ASSURANCE**

The procurement and use of pesticides that do not meet the necessary quality assurance standards can compromise the overall spray quality and desired vector action while at the same time could expose the residents and spray operators to hazards related to altered toxicological characteristics.

USAID PMI program will procure the insecticide from a reputable supplier. Pesticide batches will be analyzed for the concentration of the active ingredient prior to shipment to Zambia. Additional sampling and testing may be performed upon arrival. Delivery of all insecticide to the central warehouse in Lusaka will be supervised by PMI and NMCP before being dispatched to the districts where spray operations will be concentrated.

**QUALIFICATION OF WAREHOUSES (STORAGE FACILITIES)**

IRS pesticides can cause adverse impacts to human health, animals, and the natural environment if not properly stored according to PMI BMPs. Before insecticides are procured or transported to the spray areas, suitable warehouse(s) must be assessed to ensure that they can meet BMP standards. During the geographical reconnaissance and logistics assessments, the need for new or rehabilitation of previously used district warehouses to meet PMI IRS BMP standards for pesticide storage will be assessed. The standards include:

- Located as far as feasible from; flood plains, wetlands and water bodies, markets, schools, residential, beehives, and protected areas
- Spacious enough to store insecticides in bulk and to store other IRS commodities separately
- A separate space for the storekeeper’s office.
- Well ventilated and allowing for air circulation
- Built of concrete or other solid material
- Impervious flooring, or floor must be completely covered by a tarpaulin
• Watertight roofing
• Barred and screened windows
• Preferably 2 exits from the pesticide storage area for emergency purposes

In addition to the above, all facilities used for storage, distribution, and transportation of insecticide products should comply with relevant requirements of Zambian pesticide regulation. During the logistical needs assessment, the PMI IRS IP will identify warehouses at the district level that can meet these requirements. PMI cannot provide funds for the construction of new buildings, but can assist in the modification or renovation of existing facilities. In Zambia, IRS is implemented in partnership with the MoH/NMCP, therefore, some warehouses are located on District Health Office property for logistic and security purposes.

**QUALIFICATION OF LIQUID WASTE DISPOSAL FACILITIES (WASH AREAS, SOAK PITS AND EVAPORATION TANKS)**

Pyrethroids, OPs and carbamates degrade quickly when exposed to environmental action such as photolysis, hydrolysis, and bacterial action. If wash areas and soak pits are properly constructed in appropriate locations and used according to BMPs, liquid pesticide waste will be captured in the charcoal layer of the soak pit and held until it breaks down by these natural processes.

Cleanup from spray operations using DDT will be performed in a wash area that drains to an evaporation tank or other capture/treatment device, in order to prevent a gradual build-up of DDT concentrations near wash areas. At the end of the season, the evaporation tank dries up, and the solid residue is carefully collected for proper disposal in an approved incinerator.

Site considerations for locating IRS cleaning and waste facilities (progressive rinse, wash areas, soak pits, and tanks) include soil type, topography, vertical distance to ground water, and proximity to schools, lakes, streams, and other sensitive areas. Ideally, disposal facilities should be located adjacent to the storage facilities, where they can be more easily protected and monitored. However, the setting or the function of buildings provided for storage are not always appropriate for siting a wash area, so it may need to be placed some distance away. Due to access limitations and distance to some spray sites, it may be more feasible to locate a small wash facility in an appropriate area near the spray site.

Soak pits and evaporation tanks must be located at least 30 meters from any sensitive areas such as water bodies, flood plains, habitat, schools and other public buildings, areas protected by regulations, and areas of high groundwater. They should be located on relatively high ground to increase the vertical distance to groundwater. The general area should be level, but the wash area must be constructed to slope gently toward the soak pit or toward the collection point that is piped to the soak pit/evaporation tank.

Soil characteristics affect how pesticides move through the soil, and how they break down by environmental or micro-biological degradation. Clay soils have a high capacity to absorb many pesticides, but if hard-packed, may have limited percolation abilities. Sandy soils have a much lower capacity to absorb pesticides, but liquids percolate rapidly. Where possible, locate facilities on fine textured soils with organic content and good absorptive properties. Hard packed clay or rocky soils are not appropriate.

Pesticides may move in water runoff as compounds dissolve in water or attach to soil particles. Facilities should be located on high, level ground to minimize exposure to runoff. Avoid steep slopes or natural runoff flow lines. Where necessary, curbs or berms will be constructed around wash areas to divert...
stormwater runoff away from the soak pit/evaporation tank, and to contain any spills or overflows. In very rainy areas or seasons, it may be necessary to cover the soak pit/evaporation tank and wash area when not in use with a tarpaulin, to prevent flooding of the soak pit and subsequent runoff of pesticide-contaminated water.

**Supply Chain and Disposal Options**

The PMI IRS implementing partner will work with the relevant authorities and will employ the pesticide chain management as shown in Figure 6 in its Zambia IRS programs to ensure control. The chain of custody procedures are based on PMI IRS BMPs (and as previously mentioned, these BMPs include WHO, FAO and other international guidelines).

**FIGURE 6: PESTICIDE CHAIN OF CUSTODY AND MANAGEMENT**

<table>
<thead>
<tr>
<th>Manufacture: PMI IRS implementing partner supplements pesticides for PMI program as needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality Control: Pesticide samples will be tested for chemical properties and efficacy internationally.</td>
</tr>
<tr>
<td>Port of entry: Pesticides will be collected by PMI staff and ZEMA representative</td>
</tr>
<tr>
<td>Transportation: All drivers must be trained in proper pesticide handling and transportation safety measures as per the PMI IRS BMP. All vehicles must meet BMP requirements. A PMI and ZEMA representative will escort the pesticide to the central storage facility.</td>
</tr>
<tr>
<td>Central Storage: Pesticide will be stored in warehouses that meet the specifications detail in the BMP manual for storage and transport of pesticides</td>
</tr>
<tr>
<td>Spray Operators must sign out all pesticides received daily and return empty sachets at the end of the day as per the Insecticide Distribution Section below</td>
</tr>
<tr>
<td>District Storage: Empty containers will be stored in warehouses that meet the specification detailed in the BMP manual for storage and transport of pesticides</td>
</tr>
<tr>
<td>Disposal: All empty pesticide sachets will be incinerated in an approved incinerator. All plastic containers will be triple washed and recycled at an approved facility.</td>
</tr>
</tbody>
</table>

**Pesticide Transport**

After the receipt of insecticide at the central warehouse, insecticides are transported to the district warehouses by road, and in some areas, over water in boats. During transportation, there is a risk of vehicle accidents and consequent insecticide spillage. It is essential that the vehicle type and speed of transport be matched to the conditions. Drivers must take no chances.
A lockable box truck is the preferred vehicle to transport insecticides from central to district stores. All vehicles must be in good condition and pass the Pre-Contract Vehicle Inspection performed by the Environmental Compliance Officer or their qualified designate, using a smart phone. If during transport the pesticides are to be left unattended for any period of time, including lunch breaks or overnight stops, a lockable box truck is essential.

Prior to long-distance transport of the insecticide from the customs warehouse or PMI Zambia central storage facility, drivers will be informed about general issues surrounding the insecticide and how to handle emergency situations such as accidents or spillage. Training for long-distance transport will include the following information:

- Purpose of the insecticide (indoor usage for malaria protection, not for agricultural or any other outdoor use)
- Toxicity of the insecticide
- Security issues, including implications of the insecticide getting into public access.
- Hazardous places along the routes to be taken, and mitigation measures.
- Steps to take in case of an accident or emergency (according to BMP standards)
- Combustibility and toxicity of the combustion byproducts of insecticide

Drivers hired for intra-district transport of insecticide and spray team members during the spray campaign will receive training in:

- Operator transportation best practices and vehicle requirements from PMI IRS BMP #2, Worker and Resident Health and Safety.
- Health and safety as provided to spray operators, with the exception of sprayer operation and spray practice.
- Handling an accident or emergency according to BMP standards.
- Handling vehicle contamination.
- Vehicle decontamination procedures

Figure 7 below provides a list of key responses to mitigate the impact of the insecticide spills.
FIGURE 7: EMERGENCY RESPONSE TO A SPILL

IN CASE OF INSECTICIDE SPILLS

1. Control, contain and clean up the spill
2. Protective clothing should be donned prior to attempting to clean the spills.
3. It is imperative to avoid fire as a result of the accident and a fire extinguisher should be deployed just in case. The engine should be shut off and smoking in the area strictly prohibited.
4. Onlookers and bystanders should be cautioned against approaching the accident site.
5. If the crew has come in contact with the pesticides, they should remove contaminated clothing immediately and wash the pesticide off their skin.
6. For major spills send for help immediately; drivers must have cell phones and an emergency number for use in such cases.
7. People should be kept away and the spill covered with earth, sand, etc.; no attempt should be made to wash away the spill with water or other substances.
8. Vehicles that are used for transporting large quantities of pesticides should be equipped with a bucket of sand, sawdust or soil, a shovel, and fire extinguisher.

Because vehicles used for insecticides transportation can be used for the transport of other goods, including food, it is important to ensure that vehicles are decontaminated. The drivers will be responsible for cleaning and decontaminating the interior of the vehicle and exterior bed at the end of the spray campaign. Drivers will be provided with gloves, overalls, and rubber boots to wear for cleaning the vehicle. All cloths used in wiping down the interior and bed of the vehicle will be washed with soap and water.

If pesticide is transported over water, BMP #10, Water Transport (PMI IRS BMP Manual, 2015) must be followed in every detail.

HEALTH AND SAFETY IN THE WAREHOUSE

The following measures are required in all warehouses in order to reduce cases of pilferage, exposure through leakages and theft, and to ensure the health and safety of those accessing these facilities:

- Guarded 24 hrs./day
- Warehouse must be double-padlocked.
- All the storage facilities must have thermometers installed for daily temperature recording.
- Soap and clean water for washing must be available at all times.
- Trained storekeepers must be present and wear appropriate PPE when in the pesticide area of storage.
- Pallets are available for proper storage of insecticides and must be used
- Pesticide stacking position and height in the warehouses must not be above 2 meters in height
unless placed on sturdy shelves.

- Fire extinguishers must be available in the storage facilities and all workers trained on how to use them.
- Hazard warning notices must be placed in the outside of the store in pictorial form (skull and crossbones).
- First-aid kits must be fully stocked and available in all the central warehouses and secondary stores. Security and inventory management of first aid supplies is mandatory.

Inhalation of toxic fumes in the event of a storehouse fire is a major risk of IRS. The risk can be minimized, however, by following BMPs for storage, including prohibiting lighted materials in or near the warehouse or in the vicinity of pesticides during transport to/from vehicles, providing fire extinguishers, and proper ventilation of storerooms.

6.1.5 Fetal Exposure (Pregnancy Testing)

All female candidates for spray teams will be tested for pregnancy before being recruited into the spray operations and every thirty days until operations end. Females found to be pregnant will be re-assigned to positions that do not have the potential for exposure to insecticides. Women who are breastfeeding cannot have any contact with pesticides, and are thus prohibited from spraying of pesticide or washing contaminated items. Due to the possible bioaccumulation and teratogenic effects of DDT, women will not be exposed to this pesticide through duties such as spray operations or monitoring, overall washing, or pesticide storekeeping.

6.1.6 Spray Operator Exposure

The individuals recruited for IRS campaigns will receive intensive training on Insecticide Distribution and Management Process at District and Community Levels.

The PMI IRS implementing partner will use, or develop if necessary, standard requisition, tracking, and monitoring forms to be used for inventory, and record and track all the insecticides distributed and returned. These forms will be used in the program at all levels, and the store managers will receive training on how to use these forms. The steps below highlight the insecticide distribution process proposed including recording and tracking methods:

- Upon reception of the pesticide at the central warehouse (the import company is responsible to deliver the pesticide to a determined location) lot numbers and quantities of insecticide are registered on shelf inventory card by the PMI IRS implementing partner storekeeper. All copies are kept at the warehouse.
- District requisitions are approved at the PMI IRS implementing partner program office, where copies are maintained.
- Requisition then proceeds to district warehouses where distribution takes place. All pesticide inventories are signed for based on sachet numbers. Insecticides are distributed on a “first-expired, first-out” system, so that the insecticide with the earliest expiration date is distributed first. This avoids accumulation of expired stock.
- All sachets are counted and stamped with the relevant stamp and registered on a stock card. Boxes are then resealed with the correct original quantity of sachets inside until the sachets are issued.
- Every morning before the spray operations begin, store managers distribute only enough sachets for
the day’s work to the team operators. The team operator must sign for all pesticides received daily in a logbook.

- At the end of the day, empty and full sachets are returned and numbers checked against what was signed out. Returned empty and full sachets are logged into the logbook by the storekeeper or supervisor.

- Supervisor and team leaders examine spray operators’ performance by comparing number of structures sprayed to sachets used to determine whether there is an over or under application.

- Storekeeper must submit the following to the program office for data entry on a daily basis: 1) insecticide stock balances; 2) sign-in/sign-out results; and 3) structures sprayed per spray operator.

- The next day, all previously signed for but unused sachets are reissued and signed for by the relevant spray operator.

- At the end of each day and at the end of the spray round, stock remaining must equal the stock at start of the day minus the number of sachets distributed. Number of sachets distributed should be equal to number of sachets used if there is no returned full sachet.

**PERSONAL PROTECTIVE EQUIPMENT**

In accordance with PMI IRS BMP, all persons working on IRS must be adequately protected against potential harm due to exposure from pesticides. All persons with potential direct contact or exposure to pesticides during handling, transportation, storage, use and cleaning of pesticides or pesticide contaminated materials must wear appropriate personal protective clothing in accordance with the safety instructions on the pesticide label or material safety data sheet (MSDS). At a minimum, those handling pesticide will wear a dust mask, overalls, gloves, and rubber boots.

Each team leader, spray operator, and washer for both the district based and community based implementation models will be provided with the following safety equipment to be used during the spraying, in accordance with the PMI IRS BMPs specifications:

- Broad rimmed hat/helmet
- Face shield or goggles (face shield preferable)
- Dust mask or filtered mask
- Two or more cotton overalls per spray operator (appropriately sized)
- Nitrile rubber, neoprene, or butyl rubber gloves, without inside lining, and long enough to cover the forearm
- Rubber boots
- Cloth to protect the neck.
- Flashlights

For spray operators, safety precautions will depend on the proper use of PPE, and personal hygiene, including washing and daily changing of spray clothes. A schedule for carrying out and supervising personal hygiene, regular washing of protective clothes and cleaning of equipment will be organized along the following lines:

- Spraying staff will be provided with at least two uniforms to allow for frequent changes.
• Washing facilities with sufficient water and soap will be made available in the field at appropriate locations.
• All working clothes must be removed at the end of each day’s operations and a shower or bath taken—in circumstances where a full-body shower or bath is not feasible, face/neck and hands must be washed with soap and water.
• Working clothes will be washed daily by the wash-persons hired by the project.
• Particular attention will be paid to washing gloves, helmets, face shields, and boots, and to avoiding contamination of the inside of these items.
• Spray operators will wash before eating, drinking or smoking at the end of the daily spray operation.
• Eating, drinking and smoking during work will be strictly forbidden at all times during operations. If spray operators need to drink water in between spraying structures, they must receive assistance from the homeowner, such that they do not need to handle water containers with gloves or other PPE that has been exposed to pesticides during spray or mixing activities. Because in the field there are no proper disposal facilities for water contaminated by washing gloves and hands, it is recommended that homeowners assist the operator if hydration is needed (for example, holding a cup and straw for the operator).

**PROCUREMENT OF OTHER IRS EQUIPMENT**

The following IRS equipment will be procured alongside with the insecticides and PPEs including:

• Spray Nozzles. The program in Zambia will procure 8002E nozzles for the spray pumps, which are the standard size recommended by WHO for mud and brick walls.
• Spray pumps. Spray operators use Hudson X-PERT and Goizper compression sprayers and with shoulder- suspended tanks to apply a measured amount of insecticide on the interior walls of houses and structures. Insecticide is added to the sprayer according to the instructions in the spray operator’s pocket guide for the pesticide in use, the sprayer is agitated and pressurized, and the material is then applied to the interior walls of targeted house (structure). For liquid pesticide formulations, the container must be triple-rinsed during pesticide make-up. After the day’s spraying is complete, spray operators must clean the sprayer following the manufacturer’s recommendations to ensure their proper operation and calibration.

**TRAINING**

The objective of the trainings is to provide the knowledge and skills to the spray and supervisory teams, and to build the capacity of the host government at the national and district levels to implement, monitor and evaluate a well-organized IRS program.

Training in IRS implementation will be a key element of the PMI IRS program. The planning process for trainings will be carried out in coordination with the NMCP, and all MCDMCH, ZEMA malaria officers will be actively engaged from inception. The recruitment and training of spray operators are key elements in this process, and require vigorous involvement of implementing partner staff to ensure that when these activities are transferred to NMCP/DCMOs, there will be sufficient local capacity to continue IRS activities.

**Drivers**

Drivers are recruited by the transport vendor hired to offer transport services during IRS implementation. Drivers that will transport insecticide will be trained on methods and protocol for safe
driving, handling insecticides, and what to do in an emergency situation when transporting insecticides. Drivers will also be trained on insecticide-related security issues, handling vehicle contamination, methods for cleaning vehicles after transporting insecticide, and handling insecticide run-off. They will also be provided with emergency contact cards in the case of an accident.

**TOT Training for IRS supervisors:**

Participants include representatives from MOH/NMCP, MCDMCH/DCMOs and former trainers from past spray campaigns. Key topics that will be covered include the following:

- Malaria epidemiology
- IRS
- Storage of IRS commodities
- Environmental and safety issues concerning IRS campaigns
- IEC
- Spray pump use and maintenance
- Spray technique
- Data management and quality (correct use of forms)
- Basic entomological information
- Supervision, performance monitoring and auditing of spray activities

Graduates of the TOT training for supervisors then conduct the spray operator training with the support of the PMI IRS implementing partner. The training has both theoretical and practical sessions.

Training in IRS implementation and supervision is crucial to the overall capacity building strategy of the IRS program. In order to reduce training costs and reduce the facilitator trainee ratio, AIRS Zambia will work with NMCP and MCDMCH to conduct TOT trainings in provinces. With support from the PMI Zambia IP, NMCP will be responsible for organizing and coordinating trainings on IEC. In addition NMCP/MCDMCH will organize the trainings on IRS supervision with AIRS Zambia’s support.

**Training for District Staff on Environmental Compliance**

Participants will include district health staff identified by the District Coordinator, IRS Manager and the Environmental Compliance Officer (ECO). District health staff will be trained on measures taken during IRS operations to meet environmental compliance rules and regulations, based on the EMMP (Annex A). This will include best practices in Environmental Compliance, including pre- and post-spray assessments, inspections, and reporting. They will also receive training to understand proper hygiene, to recognize the signs and symptoms of poisoning, and to understand the referral procedure for any incidents involving poisoning. This training is conducted in accordance with PMI IRS BMP manual (2015).

**Training spray operators, team leaders and base supervisors:**

Participants include spray operators, team leaders and base supervisors identified by the local communities at the health post level. PMI AIRS staff will supervise the trainings sessions. Spray operators will initially be chosen based on their completion of primary school and must pass written and practical tests of their ability to read, write and record critical spray information, and make calculations. They will then undergo medical exams to determine their physical capability for providing appropriate application
of the insecticide. All female workers will be tested for pregnancy before training and recruitment as spray operators or washers. Pregnancy tests will then be conducted every 30 days during IRS operations. It is incumbent on the implementing partner to protect female spray operators’ privacy concerning pregnancy testing.

The training includes:

- Insecticide application technique
- Handling a spray pump
- Communication strategies in the field
- Spray operation organization
- Completing Daily Spray Operator forms for accuracy
- Team Leader protocols for checking Spray Operator data (physical and mathematical checks)
- Use of PPE to prevent toxic exposure, environmental compliance and avoidance of spraying in environmentally-sensitive areas

Following the training, a post-training exam is given, and only candidates that receive high scores will qualify as spray operators. The District Coordinator and IRS manager will identify outstanding trainees and designate them as team leaders to supervise a number of operators.

**Storekeepers**

Participants will include storekeepers. Training for all storekeepers includes IRS logistics and supply chain management, insecticide storage and security, inventory tracking (stock card use), spill control and management, and IRS waste storage and management. Following the training, an exam will be given, and only those who achieve a high enough score will qualify as storekeepers for the IRS spray campaign. The AIRS Zambia Logician will work with the ECO to train storekeepers to manage stock and IRS waste effectively.

**Pump technicians**

Technicians for each operations site will be trained on technical maintenance and repair of the spray pumps and progressive rinsing systems.

**Washers**

AIRS Zambia staff will lead training for washers on how to wash coveralls and other PPE to protect themselves, and prevent contamination.

**Data Clerks and District Data Manager**

Data clerks will be trained in IRS data entry; using the IRS database; and methods for reviewing data and assuring data accuracy and quality. The M&E Coordinators and Database Manager will complete the trainings.

**TOT for IEC Coordinators**

Participants will include IRS managers, DCs and IEC Coordinators. Training will include modules on the IEC communication protocol, and messaging for the IEC/BCC campaign. The PMI IRS implementing partner with the NMCP IEC department will complete the training.
The main purpose of mobilization is to remind beneficiaries about the positive benefits of IRS in controlling and preventing malaria and malaria-related deaths, and to remind them of their roles, responsibilities, and behaviors before, during, and after spray operations. Mobilizers are trained to conduct house-to-house mobilization during the first cycle of each IRS campaign. Once the risks and benefits of IRS have been explained, households have the option of declining to participate.

Door-to-door communication is the main strategy used for community outreach. PMI IRS implementing partner develops, prints, and distributes household IRS cards as well as IRS fliers and brochures with key IRS messages.

In 2014, PMI continued to support communication activities in areas targeted for IRS to inform potential beneficiaries about the timing of spray activities, what they can expect, the precautions they need to take, and the health benefits of IRS. Finally, tools to collect data on communications activities were revised and materials to support BCC activities (posters, training guides, and manuals) were produced.

**Health Workers in Poison Management**

Participants include health facility staff identified by the District Coordinator and the DMO. The AIRS Zambia Operations Manager will conduct the trainings. Health facility staff will be trained and prepared for handling insecticide poisonings, skin irritations, and other potential IRS spray campaign injuries. General poison control guidance will be provided. When new pesticides will be used, additional training specific to the symptoms and treatment for that chemical will be provided. Acute exposure can occur through dermal contact, which could lead to absorption into the blood stream as well as skin and eye irritation, inhalation or ingestion. The DCMO will be in charge of certifying intoxication cases reported in the field.
<table>
<thead>
<tr>
<th>Pesticide Class</th>
<th>Treatment Medicine(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organochlorine (DDT):</td>
<td>Activated Charcoal (priority)</td>
</tr>
<tr>
<td></td>
<td>Diazepam or Lorazepam (for seizure)</td>
</tr>
<tr>
<td></td>
<td>Phenobarbital</td>
</tr>
<tr>
<td></td>
<td>Cholestyramine resin</td>
</tr>
<tr>
<td>Organophosphates:</td>
<td>Atropine sulfate or Glycopyrolate (priority treatment)</td>
</tr>
<tr>
<td></td>
<td>Furosemide (less critical)</td>
</tr>
<tr>
<td></td>
<td>Diazepam or Lorazepam (for seizure)</td>
</tr>
<tr>
<td>Carbamates:</td>
<td>Cholestyramine Atropine (priority)</td>
</tr>
<tr>
<td></td>
<td>Furosemide (less critical)</td>
</tr>
<tr>
<td></td>
<td>Diazepam (for seizure)</td>
</tr>
<tr>
<td>Pyrethroids</td>
<td>Promethazine</td>
</tr>
<tr>
<td></td>
<td>Panadol</td>
</tr>
<tr>
<td></td>
<td>Diazepam</td>
</tr>
<tr>
<td></td>
<td>Lorazepam</td>
</tr>
<tr>
<td></td>
<td>Calamine cream</td>
</tr>
<tr>
<td></td>
<td>Vitamin E</td>
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<tr>
<td></td>
<td>Hydrocortisone cream</td>
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<tr>
<td></td>
<td>Salbutamol</td>
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<tr>
<td></td>
<td>Activated charcoal</td>
</tr>
<tr>
<td>Chlorfenapyr</td>
<td>Activated charcoal</td>
</tr>
<tr>
<td></td>
<td>Benzodiazepine (seizures)</td>
</tr>
</tbody>
</table>
Accidental Warehouse Fires

Human inhalation of toxic fumes in the event of a storehouse fire is also a risk for which storekeepers and site supervisors must be prepared. The risk can be minimized, however, by following PMI IRS BMPs for storage, including prohibiting lighted materials in the warehouse and in the vicinity of pesticides, providing proper ventilation, etc.

Information on the combustion of byproducts of pyrethroids can be found in Table 7 below, and the 2012 PEA. Fire-fighting instructions can be found in the Material Safety Data Sheet (MSDS) for the pesticide(s) in storage.
<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Combustion Byproduct</th>
<th>Extinguishing Instructions</th>
</tr>
</thead>
</table>
Extinguishing media, which must not be used for safety reasons: Do not use solid water stream as it may scatter and spread fire.  
Specific hazards during firefighting: As the product contains combustible organic components, fire will produce dense black smoke containing hazardous products of combustion. Exposure to decomposition products may be a hazard to health.  
Special protective equipment for firefighters: Wear full protective clothing and self-contained breathing apparatus.  
Further information: Do not allow run-off from fire-fighting to enter drains or watercourses. Cool closed containers exposed to fire with water spray. |
| Bendiocarb         | Fine dust may form explosive mixtures in air. The product is not flammable, but when heated above 125º C will evolve toxic fumes of methyl isocyanate. Water is the preferred extinguishing medium as it decomposes any methyl isocyanate. | Water fog or fine spray, carbon dioxide, dry chemical, foam. Fire fighters should wear full protective gear, including self-contained breathing apparatus (AS/NZS 1715/1716). Keep unnecessary people away and move all other personnel to windward side of fire. Bund area with sand or earth to prevent contamination of drains or waterways. Dispose of fire control water or other extinguishing agent and spillage safely later. |
| Delta-methrine     | Combustion and/or pyrolysis of deltamethrin can lead potentially to the production of compounds such as formaldehyde, acrolein, hydrogen cyanide, and hydrogen bromide (UK PID, 2006) | Suitable extinguishing media: Water spray jet, carbon dioxide (CO2), dry powder, foam.  
Extinguishing media which should Product itself is non-combustible not be used for safety reasons: Fire extinguishing measures to suit surroundings. |
| Bifenthrin         | Not available                                                                        | Suitable extinguishing media: Carbon dioxide (CO2), Foam; Powders  
Not suitable extinguishing media: Water (the product is hazardous for the environment - do not dilute it)  
Specific fire-fighting methods: Isolate fire area. Evacuate downwind. Contain the extinguishing fluids by bunding (the product is hazardous for the environment). Do not attempt to fight the fire without suitable protective equipment. Do not breathe fumes Protection of fire-fighters: Self-contained breathing apparatus and complete protective clothing. |
| Cyfluthrin         | Combustion and/or pyrolysis of cyfluthrin can lead potentially to the production of compounds such as formaldehyde, acrolein, hydrogen cyanide, hydrogen chloride, and hydrogen fluoride (UK PID, 2006) | Not available to-date. |
**PREVENTION OF RESIDENTIAL EXPOSURE**

NMCP, ZEMA and the PMI IRS implementing partner and other partners will work with relevant institutions at all levels to carry out an IEC campaign/BCC to sensitize residents to IRS activities, in accordance with WHO guidelines and also Zambia National Malaria Strategic Plan, 2011-2016 and PMI Malaria Operational Plans. The IEC campaign (as well as IRS project supervisors and health workers who will also instruct residents on best practices prior to spraying) should focus on the following elements of residential safety during an IRS program:

- Clear homes of mats or rugs, furniture, cooking implements and foodstuffs prior to spraying; if furniture cannot be moved out of the home, then move it to the center of the room and covered with impermeable material.
- Stay outside the home during spraying for two hours after spraying.
- Move and keep all animals outside the home during spraying, and for two hours after spraying.
- After two hours, open all windows and doors and air the house out for ½ hour before allowing re-entry by children and animals.
- Sweep up any insects killed from the spraying and drop them in latrine pits.
- Sweep floors free of any residual insecticide that may remain from the spraying and dispose of in pits or latrines.
- Do not re-plaster or paint over the sprayed walls after spraying.
- Keep using bed-nets for protection against malaria.
- If skin itches after re-entrance into home, wash with soap and water; for eye irritation, flush eyes with water; for respiratory irritation, leave the home for fresh air; for ingestion, if soap and water are unavailable, or if symptoms persist, contact program staff or go to nearest health facility which has the appropriate medical intervention.
- If spraying during the rainy season, the teams should follow the following Contingency Plan which will minimize exposure of household effects.

**During the rainy season:**

- Each spray operator must be given adequate covering material (3m by 3m minimum), which should be used to cover household effects moved to the center of the room (only if necessitated by rain, etc.) More than one sheet may be required, depending on the size of structures and the amount of belongings.
- Materials can also be moved into structures that are not targeted to be sprayed, e.g., an isolated kitchen or other domestic animal shelter.
- Move the household effects to one room which will not be sprayed on that particular day, but the next day.
- The spray teams should pay close attention to any signs of potential rains so that they prepare the communities accordingly.
- When it rains in the mid of spraying:
- Stop the spraying activities. After the rains stop and the weather is considered good spraying can continue.
• Cover the household effects with an impermeable material. These materials should have already been procured by the program and given to each operator.

6.1.7 **SPECIAL HEALTH AND SAFETY CONSIDERATIONS WHEN USING DDT**

**WORKER HEALTH AND SAFETY**

PPE used for DDT IRS activities should be washed every other day (to minimize contaminated effluent) in a cemented bay that is adjacent to and drains into a storage tank.

**PESTICIDE EXPOSURE AND TREATMENT**

Early symptoms may include paresthesia (tingling) of the tongue, lips and parts of the face, which in severe cases extends to the extremities. The patient may have a sense of apprehension and disturbance of equilibrium, dizziness, confusion, and a characteristic tremor. Remove contaminated clothing and wash the affected skin with clean water and soap, and flush the affected area with large quantities of clean water. Keep the patient calm and in quiet, shaded conditions and seek medical attention.

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**Medicines to be Administered by a Professional at the Hospital in Case of DDT Poisoning:**

- Activated Charcoal (priority): Phenobarbital.
- Diazepam or Lorazepam (for seizure): Cholesteryamine resin.

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**SAFETY OF WOMEN SPRAY PERSONNEL**

When using pyrethroids, carbamates, and organophosphates, PMI’s policy is to test all women for pregnancy, and if a woman is found to be pregnant, to only offer positions that do not entail any contact with pesticides. For spray campaigns lasting longer than 30 days, the pregnancy tests must be repeated once every month during the campaign, and to reassign any women found to be pregnant to a position that does not involve potential contact with pesticide. As there is some evidence that DDT is bioaccumulative, and may have an impact on fetal development, it is especially important for countries using DDT to ensure that women are not exposed to DDT. Therefore, if DDT is to be used, women may not occupy positions such as spray operator, washperson, or storekeeper, that have potential contact with DDT.

**PESTICIDE STORAGE AND STOCK CONTROL**

It is of increased importance that PMI BMPs regarding pesticide storage and stock control be implemented when using DDT. Strict mechanisms for retrieving empty sachets of DDT from the districts should be established and auditing should be frequent. Once retrieved, the empty sachets will be kept in a secured designated location until transported to a certified incinerator (see solid waste disposal). Punitive measures against pilferage and unauthorized use of DDT should be enforced.
6.2 PREVENTING ENVIRONMENTAL CONTAMINATION FROM END OF THE DAY CLEANUP

6.2.1 TRIPLE RINSE AND REUSE OF LEFTOVER PESTICIDE

USAID’s PMI IRS BMP Manual recommends that any remaining pesticide, as well as the water used to rinse out spray pumps at the end of each day must be re-used at the beginning of the next day’s work to save water, reduce the load on soak pits/evaporation tanks (for DDT only), and reduce the potential for pollution from leftover pesticide or contaminated rinse-water. This contaminated material should be considered as make-up water rather than pesticide, as it has degraded with exposure to air and sunlight, and so it must be mixed with new insecticide accordingly. This best practice for spray pump cleaning is called “progressive rinse.” As shown in Figure 8, seven barrels/drums/containers of approximately 200-litres each are placed in a line. Every other container is filled with water (e.g. the first container is empty, the second is filled with water, the third is empty, fourth is filled with water, fifth is empty, sixth is filled with water and the seventh container is empty). During the end-of-day cleanup, the remnants of the insecticide prepared in the field and remaining in the pump are emptied into the first container. This will be a limited volume, which should be much less than half of this container, as most sprayers should be returned empty from the field. It is important to train operators to manage this goal of minimizing leftover at the end of the day. The spray operator will then add two liters of water from the second container, close and shake the sprayer, and dump the rinse water into the third container.

The spray operator will repeat those steps with the fourth and fifth containers, then with the sixth and seventh containers. The spray operator then washes the outside of the sprayer using water from the sixth container on the impermeable wash area that drains to a soak pit. The following day, the spray pumps are filled with liquid from containers in the same sequential order: container one, then container three, then container five, and finally seven.
FIGURE 8: THE SEVEN BARREL TRIPLE RINSE SYSTEM

<table>
<thead>
<tr>
<th>Barrel #1</th>
<th>Barrel #2</th>
<th>Barrel #3</th>
<th>Barrel #4</th>
<th>Barrel #5</th>
<th>Barrel #6</th>
<th>Barrel #7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empty</td>
<td>Rinse water</td>
<td>Empty</td>
<td>Rinse water</td>
<td>Empty</td>
<td>Rinse water</td>
<td>Empty</td>
</tr>
</tbody>
</table>

Wash Operation Sequence

| Empty leftover pesticide from spray pump | Scoop 2 liters and add to pump. Cap, pressurize and shake pump. | Depressurize empty 1st rinse and 1st rinse into Barrel #3 | Scoop 2 liters and add to pump. Cap, pressurize and shake pump. | Depressurize empty 1st rinse into Barrel #5. | Scoop 2 liters and add to pump. Cap, pressurize and shake pump. | Depressurize and empty 3rd rinse into Barrel #7 |

Note: After this operation is complete, the outside of the pump is washed, along with the spray operators’ helmet, face shield, gloves, boots, and neck protection, in the central wash area, with the washwater directed to the soak pit.
**6.2.2 Effluent Disposal Facilities**

**Wash Areas and Soak Pits (Pyrethroids, Carbamates, OPs and Chlorfenapyr)**

Spray operators must completely wash their pumps, most of their PPE, and themselves after triple-rinsing their pumps. Overalls are washed separately by wash-persons provided with protective gear. In order to minimize possible ground contamination from washing spray equipment and PPE, wash operations are conducted on an impervious (plastic or concrete) wash area that continuously slopes to a soak pit. A soak pit is an in-ground filter that contains a layer of charcoal that adsorbs the insecticide from wash water.

Spray operators should never wash themselves, their overalls, or their PPE in any water bodies, or delay washing until they are home. Washing must be performed at designated sites, and all wash-water must be disposed of in a soak pit. Where necessary, construction of infrastructure for proper disposal of contaminated water will be financed by PMI. The site for the soak pits will be selected jointly with the implementing partner’s Operations Manager, Environmental Compliance Officer, District Coordinator and the representative of the District Health Office according to the criteria in 6.1.3.5. The soak pit site must be away from water bodies, bore holes, schools, and other sensitive areas.

The size of the soak pit depends on the number of spray operators that the soak pit supports. According to the USAID PMI IRS BMP Manual, to serve about 30 operators the soak pits should be 2 meters by 1 meter, excavated to a depth of one meter. The bottom of the pit is packed with sawdust followed by hard coal or charcoal, stone aggregates and gravels as shown in Figure 9. The entire soak pit area is fenced complete with a lockable access door to prevent unauthorized entry by children or animals. Soak pits are built by DCMOs with funding from PMI. New soak pits are constructed before spray operations commence. Existing soak pits are evaluated by the PMI IRS implementing partner and DCMOs annually and are renovated as needed before spray operations begin.

The soak pit as described can be used for pyrethroids, carbamates, organophosphates and chlorfenapyr. The principle of the soak pit, sometimes referred to as a bio-bed, is to absorb the toxic chemicals in the pesticide through a carbon filtration process, so that the water that finally exits the bottom of the soak pit has been purified and no longer contains the chemical components in any significant concentration. The gravel and stone layers work to exclude large particulates such as leaves and sticks that may eventually clog the soak pit, and they also help to distribute the influent across the soak pit bed so that it is not concentrated in one spot. As the wash-water flows through the charcoal layer, the organic chemical contaminants (pesticides) are adsorbed onto and held by the charcoal, where they are eventually degraded by environmental forces, including hydrolysis and microbial action. The sawdust at the bottom helps to regulate the flow rate so that there is enough contact time between the contaminated water and the coal. Research has shown that pesticides on the coal are degraded within three months in the soak pit. Unless the soak pit becomes clogged with foreign matter and will not drain, the soak pit should remain effective for three years, at which time it can be excavated so that the sawdust and coal can be replaced. As long as the foreign matter can be separated from the stone, the three stone layers can be reconstituted using the same material.
FIGURE 9: SOAK PIT LAYERS

Cross section: Soak Pit for Pyrethroids
Showing Filling materials

- Gravels
  Size about that for road construction

- Courser gravels/smaller stones

- Stone
  Size about average hall cement blocks and smaller

- Charcoal
  Quantity - about 1.5 - 2.0 maxi-bags

- Wood shavings/saw-dust
  Quantity - about 1 - 1.5 maxi-bags
6.2.3 Mobile Soak Pits (MSP)

To reach certain targeted spray areas, operators must travel a great distance, and they may not be able to return at the end of the day to a centralized wash area for clean-up. Sometimes the operators will spend several days in the field, finding lodging and food in the villages where they finish their work for the day. The next day, they either continue to work at the same village, or travel on to the next nearby targeted spray area. Working this way can reduce transportation requirements, shorten the working day, and result in greater productivity. However, operators need a different system for clean-up at the end of the day.

In this situation, the operators carry a MSP filter, wash barrels, and a tarpaulin with them, and construct a temporary wash facility at a suitable site within the village where they will stay. The mobile soak pit filter is a 20-25 L bucket with highly adsorbent activated carbon that removes pesticide contamination from the wash water, so that the water that exits to the ground is purified. In 2014-15, Abt Associates tested the MSPs and each MSP has the capacity to filter the rinses of 5 spray operators’ pumps for at least 40 days.

The MSP can use a four-barrel rinse system to minimize the number of barrels that the spray team must carry, and reduce the necessary size of the wash area constructed. The four-barrel rinse system uses three barrels for rinse water, but only one barrel to receive both the leftover pesticide, and the water from all three rinses. This system simplifies the reuse of all leftover pesticide and rinse-water the following day, as the operators draw from only one barrel, instead of four. See Figure 11.
FIGURE 11: MOBILE SOAK PIT FILTER LAYERS

Particulate Filter Material (e.g., sponge, mattress material.) (~5”)

Activated carbon (~7”)

Particulate Filter Material (e.g., sponge, mattress material.) (~3”)
This schematic shows a 4m x 4m (not to scale) wash area, sloped to the MSP filter at the center, and covered with a tarp. A hole is dug in the center of the area to receive the MSP filter. An X is cut in the center of the tarp to allow rinse-water to drain into the MSP. There is a rectangular boot wash at the entrance to the wash area, so that mud does not drain to and clog the MSP. There are two rows of rinse barrels so that two operators can wash up at one time. The large barrel on the left receives both leftover pesticide and all rinse-waters.
6.2.4 Special Considerations for the Disposal of DDT-contaminated Liquids

WASHWATER DISPOSAL

In the implementation of IRS activities, washwater is generated on a daily basis during the cleaning processes for spray pumps, PPE (helmet, face shield, gloves, boots), plastic sheets used to cover household good, and overalls. This wash water is contaminated with very small concentrations of DDT, but improper disposal could cause damage to human health or the environment. Because DDT is a persistent organic pollutant (POP) (meaning that it does not decompose quickly in the environment), even small amounts of discharge could build up to harmful concentrations in the local environment. For this reason, PMI does not use soak pits for the disposal of contaminated wash water. Instead, the washwater is collected and stored for subsequent evaporation or treatment and destruction.

STORAGE AND/OR EVAPORATION TANK

A PMI storage or evaporation tank is designed for the storage of non-biodegradable liquid pesticide waste such as DDT. It can be designed to evaporate the water collected, leaving the solid pesticide behind, or designed to facilitate other means of pumping, capture, treatment, or destruction.

Standard Design and Construction

An IRS holding tank should hold approximately 15,750 liters or 4,100 gallons, which should be sufficient to allow disposal of effluent from 20-30 DDT spray operators during the spray season. If a larger number of operators will be using the facility, it should be designed accordingly. The tank can be designed and engineered to maximize evaporation if that is the separation mechanism, or to accommodate various forms of treatment.

The tank should be constructed with an impermeable surface (e.g., concrete) and covered with a lockable wire mesh on top for physical strength, and a window screen below to exclude bees and other insects. It should be simple to connect a pump for treatment or evacuation.
FIGURE 14: EVAPORATION TANK AND WASH BAY FOR DDT OPERATIONS

Basic design of evaporation tank and wash bay for DDT-based IRS operations

Note: Size/volume of evaporate tank depends on # of spray personnel intending to use structure.

Estimating volume/size needed: Assume 3.0 - 4.6 liters per person-day. Multiply by # of spray personnel and trend # of spray days. Add 10% extra volume. The difference could be accommodated by increasing or decreasing depth of tank.

Fluidising hinge to allow opening of wire mesh for cleaning

Note: Top of tank is covered with wire mesh

Evaporation tank (5m x 3m x 0.8 m)
0.5 m below natural ground level
- 0.3 m above ground level

3.5 m from end

Evaporation tank (5m x 3m x 0.8 m)

Relative position of metal poles for cloth lines

0.5 m of tank below ground
Natural ground level

0.5 m of tank below ground
Natural ground level

Natural ground level

Edges painted with PVC pipes 6 cm diameter

3.5 m

Wash Bay
- Concrete slab (5m x 4m)
- Sloping gently towards tank
- Smooth finish

Raised edges 20 cm above natural ground

The whole structure will be surrounded with a 1-meter area of gravel chips.
Siting

Holding tanks should be constructed at least 100 meters away from flood prone areas, steep gradients and slopes, water sources (wells and springs), schools, habitat, protected areas under federal or local regulation. They may not be located within any buffer zone of any protected area. A berm may be required to prevent run-on of stormwater into the tank. The tanks should also be located downhill from the progressive rinse area so that run-off from this facility can be directed into the tank. The wash area must be covered when not in use to prevent overflow of the tank due to collected rainfall.

Precautions

During the spray round, the evaporation tank must be covered with a tarpaulin to prevent rainwater from flooding the tank and causing overflow. If water level in the tank comes within six inches of the drainage hole, liquid should be siphoned into plastic polytanks (around 4k L) for temporary storage, until they can be added back to the tank. Liquid wastes should be placed in double-bung plastic drums or other approved containers.

**DECOMMISSIONING**

After a spray round, the water is removed for treatment or induced to evaporate (while protected from rainfall influent), and all of the sand, sludge, and pesticide residue remaining in the tank is scooped out, placed into a sealed container, stored with empty sachets and other contaminated waste, and disposed of according to US, host-country, and international regulation and conventions. If evaporation is used, the dried residue is carefully collected while wearing full PPE, and is disposed of together with other DDT-contaminated waste. Airborne contamination can be generated during this final cleaning process, so it is essential that PPE is worn, including face shield, gloves, organic/particulate combination respirator, rubber boots, and overalls. This PPE should be wiped clean following use with alcohol-impregnated paper or cloth wipes (e.g., baby-wipes), which are also added to the contaminated waste.
For final decommissioning, the tank should be cleaned with a towel dampened with alcohol, which is then added to the residue container. All this hazardous waste must be disposed of according to all US and host-country regulations and international conventions regarding POPs and hazardous wastes.

Concrete storage or evaporation tanks should be broken up and buried in a secure location, or used as road bed material. The site should be restored back to its natural state as much as possible. Sampling and analysis of site soil and vegetation should be performed to ensure that DDT concentrations do not significantly exceed ambient concentrations in more distant surrounding soils.

DDT-contaminated solid waste must be sent to an incinerator that meets Basel Convention technical standards for POP destruction. See more complete instructions below. Considering the available facilities in Zambia, DDT waste will likely need to be shipped to an appropriate incinerator in another country. After incineration the remaining ash residue should be handled as a dangerous material. Mixing this ash with concrete for use in construction or road building is one of the safest and most useful methods of final disposal.

All wash-persons at the evaporation tank staging area will wear gloves, boots, and coveralls, and will wash overalls at the operational site while spray operators are in the field. Spray operators must completely wash themselves after each day’s operations using washbasins or shower areas constructed near the soak pits. Spray operators should never wash themselves, their overalls, or their PPE in any water bodies, or delay washing until they are home. Washing must be performed at designated sites, and all wash-water must be disposed of in the evaporation or storage tank.

6.2.5 IRS SOLID WASTES DISPOSAL

IRS solid wastes must be classified as contaminated with insecticide, or non-contaminated, according to the guidance below. Contaminated solid wastes should be stored with pesticide stocks, separated from non-contaminated wastes and IRS commodities. Empty pesticide sachets and bottles must be fully accounted for and stored in sealed containers labeled with the pesticide and item identity.

At the local site level, contaminated solid wastes are separately collected, counted, and stored in labeled and sealed boxes. Unusable gloves, plastic bags, boots and plastic sheeting are decontaminated, air-dried under the sun and packaged by washers in clean containers. All such decontaminated solid wastes are then transferred to the main provincial warehouse, where decontaminated gloves are disposed of properly as ordinary garbage. Decontaminated plastic wastes are recycled in facilities approved by ZEMA.

Other contaminated wastes, including empty insecticide sachets, plastic containers, and masks, will be temporarily stored in the District warehouse. At the end of the spray campaign, the material will be relocated to the central storage facility in the provincial capital (or other district capital if PMI IRS activities expand or move to other districts). All contaminated material will require disposal in an environmentally responsible manner as prescribed by the PMI IRS BMPs.

Incinerators recommended for disposal of contaminated wastes fall into two categories, those that meet:

- Basel Convention technical standards for all insecticides that do not contain greater than 1% chlorine
- WHO/FAO standards: to be used if we’re using DDT or insecticides which contain > 1% chlorine.

For wastes containing less than 1% chlorine:

- The recommended combustion temperature is >850 °C.
• An after-burner is required, with a residence time of at least two seconds.
• The incinerator must have emission control, including particulate matter filters.
• Ash and slag produced by high-temperature incineration of pesticides are best incorporated into concrete and buried in a secure location. In Zambia, as solid wastes are not incinerated in a PMI-owned incinerator and the implementing partner does not have control over the ash and slag, PMI AIRS can only recommend this disposition.

For wastes containing greater than 1% chlorine:
• The recommended combustion temperature is between 1100-1300 °C.
• An after-burner is required, with a residence time of at least two seconds.
• A quench rinse for the gas stream that causes a rapid temperature drop to below 250 °C
• The incinerator must have emission control, including particulate matter filters.
• Ash and slag produced by high-temperature incineration of pesticides are best incorporated into concrete and buried in a secure location. In Zambia, as solid wastes are not incinerated in a PMI-owned incinerator and the implementing partner does not have control over the ash and slag, PMI AIRS can only recommend this disposition.

Incineration is not recommended for polyvinyl chloride or other chlorinated wastes such as gloves and boots. Gloves and boots no longer usable for IRS can be easily decontaminated with soap and water and then offered to spray team members, or disposed of as normal non-hazardous waste.

Empty plastic containers should not be incinerated due to the difficulty inherent in burning them cleanly, and the nuisance and toxic emissions that may result. Once punctured to prevent reuse, plastic bottles can be triple rinsed and recycled at an appropriate facility, or landfilled.

Cardboard boxes previously containing intact insecticide sachets or bottles are not considered as contaminated waste. Incineration is not recommended for cardboard boxes unless they have been contaminated by pesticide leakage, or used for the storage of other contaminated wastes. In many cases uncontaminated boxes can be recycled, or can also be disposed of as normal non-hazardous wastes.

During data capture for a SEA, PMI AIRS Environmental Team held a meeting with ZEMA in which ZEMA made mention of a local company that did a pilot test on the recycling of agro pesticide packaging materials into plastic poles which was supported by Crop Life. Therefore, the company has not yet started operations but it’s in the process of soliciting for funds to set a plant to be handling huge quantities of pesticide waste plastics and convert them into plastic poles that may be used for fencing. If this comes to fruition, it will help minimize the environmental risk and cut down the cost associated with transporting compressed and baled empty Actellic bottles to South Africa for the recycling purposes. There will also be a need to review specifications and operations to ensure that it meets USAID requirements.

After the solid waste management process is completed, a notification form for contaminated solid wastes is developed according to the Basel Convention, and is jointly signed by all involved parties (producer, carrier and eliminator) and submitted for record keeping.

6.2.6 SPECIAL CONSIDERATIONS FOR DDT-CONTAMINATED SOLID WASTE DISPOSAL

As recommended by IRMTWG and TAC, DDT may be considered for use in IRS operations in Zambia so as to help manage insecticide resistance in the mosquito population. Disposal of DDT-contaminated
materials or of expired DDT pesticide is subject to numerous host-country, US, and international regulations. Any disposal of DDT pesticide must be approved by the implementing partner’s HQ staff, as well as the COR and GH BEO. If the decision is made by the NMCP to use DDT for IRS, masks and empty insecticide sachets will be shipped to approved facilities for incineration as Zambia does not have an approved facility to incinerate DDT-contaminated waste.

DDT-contaminated wastes will only be disposed of under the following conditions’ (drawn from WHO and FAO guidelines):

1. Commercially licensed facilities accredited by the host governments to dispose of POP toxic waste. The IP or GRZ must obtain a list of the approved and licensed facilities from the ZEMA. If there are no appropriate in-country incinerators, the GRZ or the IP must locate and contract with an appropriate facility outside of the country.

2. Facilities must be assessed by the IP and found to satisfy PMI and international requirements for toxic waste disposal

3. Incinerators constructed or procured by the implementing partner that meet international standards (WHO/FAO)

4. Incinerators that consistently burn between 1100 deg. C and 1300 deg. C, with a minimum 2 second residence time in the afterburner chamber (hot zone) with excess oxygen (>11%) and with high levels of induced turbulence in the gas stream to promote complete combustion. The gas stream is then rapidly cooled to eliminate the risk of dioxin and furan formation.

5. Incinerators with air scrubbers to ensure minimal impact to air quality,

6. In some cases incineration can be negotiated with the pesticide manufacturers, who are responsible for recapturing solid wastes and then disposing of those wastes in an environmentally sound manner.

7. Alternatively, cement kilns or furnaces can also be considered for disposal in countries where cement factories or copper furnaces that meet the above criteria are available.

Wastes consisting of, containing, or contaminated with DDT should be properly packaged before storage or transport. Empty containers should be punctured to ensure that they cannot be used for other purposes, particularly the storage of food or water for human or animal consumption. Ideally suppliers are required to dispose of all DDT waste, and provide a certificate of destruction as proof that the wastes have been disposed of in a certified facility.

Any disposal of DDT pesticide must be approved by the implementing partner’s HQ staff, as well as the COR and GH BEO. Should DDT solid waste be disposed of in an approved incinerator, the remaining ash residue from the incineration must be treated as toxic waste and be disposed according to the requirements for disposal of toxic ash residue. Ideally this ash will be mixed with concrete and buried in a remote location.

The main concerns when handling DDT contaminated wastes are human exposure, accidental release to the environment, and contamination of other waste streams with DDT. Such wastes must be handled separately from other waste types to prevent contamination of other waste streams.

All DDT wastes are considered hazardous wastes and must be properly disposed of. DDT solid waste can be disposed of in an approved incinerator that meets DDT disposal requirements. As no such
incinerator currently exists in Zambia, the waste must be transported out of the country to a certified facility. This can be complicated due to inter-country transport/export/import laws, and must meet Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their disposal requirements as there are stringent requirements for notice, consent and tracking for movement of wastes across national boundaries. Once incinerated, the remaining ash residue from the must be treated as toxic waste and be disposed according to the requirements for disposal of toxic ash residue. Because of the small number of qualified incinerators worldwide, PMI AIRS will be unlikely to have control over the disposition of ash from the incineration of DDT wastes.

The use of DDT is subject to the following additional requirements:

- Notify Stockholm Secretariat and WHO of production and/or use of DDT
- Restrict production and/or use to disease vector control
- Produce and/or use DDT in accordance with WHO recommendations and guidelines
- Use DDT only when locally safe, effective, and affordable alternatives are not available
- Report on production and/or use of DDT every three years (reporting requirements found at www.pops.int).

**Stockholm Convention Recommendations on DDT**

The Stockholm Convention also lays out the following recommendations, “with the goal of reducing and ultimately eliminating the use of DDT”:

- Each Party using DDT should develop and implement an action plan as part of its National Implementation Plan (NIP). That action plan should include:
  a) Development of regulatory and other mechanisms to ensure that DDT use is restricted to disease vector control
  b) Implementation of suitable alternative products, methods, and strategies, including resistance management strategies to ensure the continuing effectiveness of these alternatives
  c) Measures to strengthen health care and to reduce the incidence of the disease.
- All Parties to the Stockholm Convention, within their capabilities, should promote research and development of safe alternative chemical and nonchemical products, methods, and strategies for vector control

As a signatory to the Stockholm Convention, the U.S. Government is committed to ensuring that its support for DDT use in developing countries is consistent with Stockholm Convention requirements and recommendations, as well as NIPs prepared by the host countries. Thus, USAID will support the following planning, program, and environmental compliance activities where it supports DDT use in disease vector control:

- USAID will base its support of insecticides used in disease vector control on a rational selection process considering the insecticide’s effectiveness in reducing or repelling the vector; risk to human health, the environment, and the agricultural and trade sectors; acceptability in the host country; cost; the need for resistance management; and other considerations.
• USAID will only provide support of DDT to Parties that have notified the Stockholm Secretariat and the WHO of their production and/or use of DDT, and that restrict DDT use to disease vector control.

• All USAID support of DDT use will follow WHO recommendations and guidelines.

• USAID will assist host-country governments in re-examining the need for DDT based upon the best available information and in identifying the best choice for IRS chemicals, considering safety, effectiveness, and affordability in accordance with the Stockholm Convention. The selection of alternatives or combination of alternatives for malaria control will take into consideration human health risks and environmental implications; viable alternatives to DDT should pose less risk to human health and the environment, be suitable for disease control, and be supported with monitoring data.

• USAID will review and revise SEAs pertaining to DDT every year, to ensure that USAID support remains consistent with stipulations in the Stockholm Convention, the host-country NIP, and Stockholm Convention Party reporting requirements for DDT use.

• When local capacity is insufficient, USAID will assist host-country governments in conducting activities to fulfill Stockholm Convention reporting requirements. To receive USAID support for use of DDT in IRS, the host country must demonstrate concerted effort in developing and following a NIP as well as reporting to the Stockholm Secretariat.

• USAID will support the monitoring of DDT in the environments where it is sprayed. According to CFR Title 22 Section 216, “to the extent feasible and relevant, projects and programs for which Environmental Impact Statements or Environmental Assessments have been prepared should be designed to include measurement of any changes in environmental quality, positive or negative, during their implementation.”

• When local capacity is insufficient, USAID will facilitate appropriate disposal of DDT-contaminated waste resulting from IRS operations in accordance with the Basel Convention and other relevant regional and international treaties.

**Conclusion**

Using the foregoing Best Management Practices and procedures, IRS can be performed safely and provide substantial benefits to the beneficiaries. The EMMR Annual Reporting Form and Certification in Annex A will be submitted to the USAID as part of the annual report.
6 Public Consultation & Preparation Methodology

The first draft of this SEA was prepared by the AIRS Zambia Environmental Compliance Officer (ECO), with guidance from AIRS headquarters environmental staff. Instructions and a SEA template were sent to the ECO prior to a short-term technical assistance trip by the headquarters Environmental Compliance Coordinator (ECC), Albert Acquaye. The ECC and ECO first attended meetings with the NMCP and ZEMA, and then traveled to several provinces to meet with provincial and district health officers. These visits enabled them to evaluate the past performance of IRS and identify sensitive areas and resources, and to determine needed improvements, areas of special concern, and how best to protect sensitive areas while conducting IRS in an environmentally sound manner.

In all the provinces visited, meetings were first held with the Provincial Medical Office (PMO) at provincial level and the District Community Medical Office at district level. In these meetings malaria came out to be the number one disease with higher disease burden in all the districts visited. As such, all the DCMOs welcomed IRS and hope to see the reduction in malaria incidences after the 2015 spray campaign. Another matter that surfaced had to do with high rate of refusals, which was attributed to poor quality community mobilization especially in such areas that may be referred to as urban areas in a rural setup. Other factors that were mentioned were the following comments that DCMOs get from community members after IRS implementation, which may contribute to unacceptability of the program;

- Insecticides used do not work because they do not kill mosquitoes, rather, it brings mosquitoes
- A few days after their houses are sprayed the mosquitoes density increases
- The chemical used brings dirt or soils in their homes
- The pesticide itches after the structures are sprayed
- Chemicals kill their domesticated animals
- Chemicals are meant to kill them by reducing their lifespan

After these consultations, in most cases, these officials arranged for and accompanied the ECC/ECO on visits to sites of interest regarding the SEA.

After the field trips, the ECC and ECO worked together to prepare the first draft of this SEA, which was submitted to headquarters for editing by the DECS, followed by submission to PMI. Comments and edits were received and incorporated into the final draft, which was submitted for all appropriate approvals.

The table below comprises the names of the people who were interviewed during the time the SEA was conducted.
<table>
<thead>
<tr>
<th>S#</th>
<th>Name</th>
<th>Organization</th>
<th>Position</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>ZEMA</td>
<td>Senior Inspector</td>
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<td>2</td>
<td></td>
<td>ZEMA</td>
<td>EIA Senior Inspector</td>
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<td>3</td>
<td></td>
<td>ZEMA</td>
<td>Senior Inspector</td>
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<td>4</td>
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<td>ZEMA</td>
<td>Acting Director General</td>
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<td>5</td>
<td></td>
<td>MOH</td>
<td>Principle IRS Officer</td>
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<tr>
<td>6</td>
<td></td>
<td>MCDMCH</td>
<td>Principle IRS Officer</td>
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<tr>
<td>7</td>
<td></td>
<td>MOH</td>
<td>CEHO Luapula Province</td>
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<tr>
<td>8</td>
<td></td>
<td>MoH</td>
<td>CEHO Northern Province</td>
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<td>9</td>
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<td>MOH</td>
<td>CEHO Western Province</td>
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<td>10</td>
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<td>MCDMCH</td>
<td>EHO/ Kaputa</td>
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<td>MCDMCH</td>
<td>EHT/ Numbai</td>
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<td>EHT/ Kaoma</td>
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<td>MCDMCH</td>
<td>EHT/ Mongu</td>
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<td>14</td>
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<td>MOH/Mansa</td>
<td>Senior Hop. Admin. Mng</td>
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<td></td>
<td>MOH</td>
<td>EHT /Mansa</td>
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<td>16</td>
<td></td>
<td>MOH/Mansa</td>
<td>Acting PMO /Luapula</td>
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<td>17</td>
<td></td>
<td>MCDMCH</td>
<td>EHT/ Senanga</td>
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<td>MCDMCH</td>
<td>DMO/ Senanga</td>
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<tr>
<td>19</td>
<td></td>
<td>MCDMCH</td>
<td>EHO/Kasama</td>
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<tr>
<td>20</td>
<td></td>
<td>MLNREP</td>
<td>ZAWA</td>
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<tr>
<td>21</td>
<td></td>
<td>PMI</td>
<td>PMI Advisor for Zambia</td>
</tr>
<tr>
<td>22</td>
<td></td>
<td>MCDMCH</td>
<td>Malaria Specialist</td>
</tr>
</tbody>
</table>
ANNEX A: ENVIRONMENTAL MITIGATION & MONITORING PLAN

Please See the EMMP next page
<table>
<thead>
<tr>
<th>Category of Activity</th>
<th>Describe specific environmental threats of your organization's activities</th>
<th>Description of Mitigation Measures</th>
<th>Who is responsible for monitoring</th>
<th>Monitoring Indicator</th>
<th>Monitoring Method</th>
<th>Frequency of Monitoring</th>
</tr>
</thead>
</table>
| **Use of insecticides** | 1. Occupational risks for workers involved in IRS campaigns (e.g., risks from insecticide exposure and vehicular accidents), especially women of child-bearing age | a. Inspect and certify vehicles used for pesticide or spray team transport prior to contract.  
  b. Train drivers  
  c. Ensure that driver has cell phone, personal protective equipment (PPE) and spill kits during pesticide transportation (Phone must be provided by rental company).  
  d. Initial and 30-day pregnancy testing for female candidates for jobs with potential pesticide contact.  
  e. Health test all spray team members for | a-d. Abt Environmental Compliance Officer (ECO).  
  e-g. Abt Operations Manager (OM).  
  h. ECO  
  i. Chief of Party (COP), Technical Project Managers (TPM) and headquarters environmental staff. | a. Transport vehicles have a valid inspection certificate on-board.  
  b. Drivers have a certificate of training completion.  
  c. Transport vehicles are equipped with cell phone, spill kit, and PPE.  
  d. Storekeeper has records of pregnancy testing for all female team members.  
  e. Storekeeper has medical exam results for all | a-c. ECO inspection of vehicles in the field.  
  d-e. ECO inspection of health records at IRS operational sites.  
  f-h. ECO performs pre-spray inspections of inventories and training records, and mid-spray inspections of PPE use and spray operator performance.  
  i. Monitoring of on-line database for submission of inspection reports. | a-c. 2 inspections per week.  
  d-e. One inspection per campaign, additional inspection if new hires or more than 30 spray days.  
  f-h. ECO pre-spray inspections 2/campaign, ECO mid-spray inspections 5 times/week.  
  i. Weekly |
<table>
<thead>
<tr>
<th>Duty Fitness</th>
<th>Team Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>f. Procure, distribute, and train all workers with potential pesticide contact on the use of PPE.</td>
<td>f. Spray operators wear complete PPE during spraying and clean-up.</td>
</tr>
<tr>
<td>g. Train operators on mixing pesticides and the proper use and maintenance of spray pumps.</td>
<td>g. Operators mix pesticide properly, and the pump does not leak.</td>
</tr>
<tr>
<td>h. Provide adequate facilities and supplies for end-of-day cleanup.</td>
<td>h. All facilities are compliant, and materials required for clean-up are present.</td>
</tr>
<tr>
<td>i. Enforce clean-up procedures.</td>
<td>i. Inspections are performed as scheduled, corrective action is taken as needed.</td>
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2. Safety risks for residents of sprayed houses (e.g., risks from inhalation and ingestion of...

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<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
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</thead>
<tbody>
<tr>
<td>2. Safety risks for residents of sprayed houses (e.g., risks from inhalation and ingestion of...</td>
<td>a. IEC campaigns to inform homeowners of responsibilities and precautions.</td>
<td>a-b. IEC officers, OM, ECO</td>
<td>a. Pre-spray IEC campaigns were executed. Homeowners know</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>a. Inspect work records</td>
</tr>
</tbody>
</table>
### 3. Ecological risk to non-target species and water bodies from use of insecticides (during mixing and spraying)

|  |  |
|-----------------|------------------|-----------------|------------------|------------------|
| **insecticides)** | houses that are not properly prepared.  
  c. Two-hour exclusion from house after spraying  
  d. Instruct homeowners to wash itchy skin and go to health clinic if symptoms do not subside. | operators (SO) and Team Leaders (TL) responsibilities.  
  b. All houses being sprayed are properly prepared.  
  c. Homeowners observe 2 hour exclusion.  
  d. Lack of incident reports, or incident reports with proper response noted. | b-d. ECO mid-spray inspections  
  3/wk. |
| a. Spray indoors only.  
  b. Train operators on proper spray technique.  
  c. Maintain pumps.  
  d. Conduct baseline and ongoing monitoring of DDT in the area of operations | a-c. TL, Abt District Coordinator (DC), OM, ECO  
  a. Operators spray only inside of houses.  
  b. Operators are trained and know and use proper spray techniques.  
  c. Pumps are maintained and operated to eliminate leaks and erratic spraying. | a. ECO mid-spray inspections.  
  b. ECO inspection of training records 1/campaign.  
  b-c. ECO mid-spray inspections 5/wk. |
| 4. Environmental risk from disposal of insecticide (both liquid and solid waste) | a. Choose sites for disposal of liquid wastes according to PMI BMPs.  
   b. Construct soak pits with charcoal to adsorb pesticide from rinsewater.  
   c. Maintain soak pits as necessary during season.  
   d. Inspect and certify solid waste disposal sites before spray campaign.  
   e. Monitor waste storage and management during campaign.  
   f. Monitor disposal procedures post-campaign. | a-c. Abt OM, ECO, DC  
   b. Soak pits are constructed according to the AIRS BMP manual.  
   c. Soak pits perform properly throughout the spray season.  
   d. Disposal sites have the capacity and policies to properly dispose of wastes.  
   e. Wastes are stored and managed according to PMI BMPs.  
   f. Waste disposal has taken place as agreed and certificates of disposal received. | a-b. ECO Pre-spray inspections  
   c-f. ECO mid- and post-spray inspections and monitoring. | a.2/campaign  
   b.1/campaign  
   c. 5/week  
   d. 1/campaign  
   e. 3/week  
   f. Continuous during disposal |
<table>
<thead>
<tr>
<th>5. Risk of diversion of insecticides for unintended or uncontrolled use</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Maintain records of all pesticide receipts, issuance, and return of empty sachets/bottles.</td>
</tr>
<tr>
<td>b. Reconcile number of houses sprayed vs. number of sachets/bottles used.</td>
</tr>
<tr>
<td>c. Examine houses sprayed to confirm spray application.</td>
</tr>
<tr>
<td>d. Perform physical inventory counts during the spray season.</td>
</tr>
<tr>
<td>e. IP will assist host country, as needed, with DDT international reporting requirements.</td>
</tr>
<tr>
<td>a-d. Storekeepers, District coordinators, sector managers, logistics coordinator, OM, ECO</td>
</tr>
<tr>
<td>a-d. All pesticide management records are reconciled.</td>
</tr>
<tr>
<td>a-b, d. Inspection of pesticide management records. Storekeeper performance checklists.</td>
</tr>
<tr>
<td>c. ECO mid-spray inspections.</td>
</tr>
<tr>
<td>a-b, d. Daily monitoring by storekeeper or site supervisor. Weekly monitoring by District Coordinators</td>
</tr>
<tr>
<td>c. 1/campaign by country headquarters. 2/campaign by ECO</td>
</tr>
<tr>
<td>d. 2/campaign/store-room</td>
</tr>
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</table>
## Annex B: Summary of Acute Exposure Symptoms & Treatment of WHOPES Pesticides

### Summary of Acute Exposure Symptoms and Treatment of WHO-recommended Carbamate

<table>
<thead>
<tr>
<th>Carbamates</th>
<th>Human side effects</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bendiocarb</td>
<td>Excessive sweating, headache, nausea, blurred vision, chest pain, vomiting, excessive salivation, and slurred speech. Severe intoxication causes narrowed pupils, muscle twitching, spasms, intestinal convulsions, diarrhea, and labored respiration.</td>
<td>The affected person should stop work immediately, remove any contaminated clothing and wash the affected skin with soap and clean water. The whole contaminated area (including the eyes, if necessary) should be flushed with large quantities of clean water. The patient should be kept at rest and immediate medical aid obtained. Administer Atropine.</td>
</tr>
<tr>
<td>Propoxur</td>
<td>Excessive sweating, headache, nausea, blurred vision, chest pain, vomiting, excessive salivation, and slurred speech. Severe intoxication causes narrowed pupils, muscle twitching, spasms, intestinal convulsions, diarrhea, and labored respiration.</td>
<td>The affected person should stop work immediately, remove any contaminated clothing and wash the affected skin with soap and clean water. The whole contaminated area (including the eyes, if necessary) should be flushed with large quantities of clean water. The patient should be kept at rest and immediate medical aid obtained. Administer Atropine.</td>
</tr>
</tbody>
</table>
### Summary of Acute Exposure Symptoms and Treatment of WHO-recommended organophosphates

<table>
<thead>
<tr>
<th>Organophosphate</th>
<th>Human side effects</th>
<th>Treatment</th>
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</thead>
<tbody>
<tr>
<td>Malathion</td>
<td>Malathion is an indirect cholinesterase inhibitor. The primary target of malathion is the nervous system; it causes neurological effects by inhibiting cholinesterase. Exposure to high levels can result in difficulty breathing, vomiting, blurred vision, increased salivation and perspiration, headaches, and dizziness. Loss of consciousness and death may follow very high exposures to malathion.</td>
<td>Oral exposure to malathion should be treated with rapid gastric lavage unless the patient is vomiting. Dermal exposures should be treated by washing the affected area with soap and water. If the eyes have been exposed to malathion, flush them with saline or water. People exposed to malathion who exhibit respiratory inefficiency with peripheral symptoms should be treated via slow intravenous injection with 2–4 mg atropine sulfate and 1,000–2,000 mg pralidoxime chloride or 250 mg toxogonin (adult dose). Exposure to high levels of malathion that result in respiratory distress, convulsions, and unconsciousness should be treated with atropine and a re-activator. Morphine, barbiturates, phenothiazine, tranquilizers, and central stimulants are all contraindicated.</td>
</tr>
<tr>
<td>Fenitrothion</td>
<td>Fenitrothion is the most toxic to man of the insecticides recommended for residual house spraying, and has a relatively low margin of safety. Absorbed through the gastrointestinal tract as well as through intact skin and by inhalation. It is also a cholinesterase inhibitor.</td>
<td>Dermal exposure to fenitrothion should be treated by removing contaminated clothing, rinsing the skin with water, washing the exposed areas with soap and water, then seeking medical attention. If fenitrothion gets into the eyes, they should be rinsed with water for several minutes. Contact lenses should be removed if possible and medical attention should be sought. Ingestion of fenitrothion should be treated by rinsing the mouth and inducing vomiting if the person is conscious. Inhalation exposures require removal to fresh air and rest in a half-upright position. Artificial respiration should be administered if indicated and medical attention should be sought.</td>
</tr>
<tr>
<td>Organophosphate</td>
<td>Human side effects</td>
<td>Treatment</td>
</tr>
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</tr>
<tr>
<td>Pirimiphos-methyl</td>
<td>Pirimiphos-methyl is also a cholinesterase inhibitor. Early symptoms of poisoning may include excessive sweating, headache, weakness, giddiness, nausea, vomiting, stomach pains, blurred vision, constricted pupils, slurred speech, and muscle twitching. Later there may be convulsions, coma, loss of reflexes, and loss of sphincter control.</td>
<td>OP poisoning is a medical emergency and requires immediate treatment. All supervisors and individual sprayers (in the case of dispersed operations) should be trained in first-aid and emergency treatment of OP intoxication.</td>
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<tr>
<td></td>
<td></td>
<td>The affected person should stop work immediately, remove any contaminated clothing, wash the affected skin with soap and clean water and flush the skin with large quantities of clean water. Care must be taken not to contaminate others, including medical or paramedical workers.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Automatic injectors loaded with atropine sulfate and obidoxime chloride can be made available in the field whenever relatively toxic OP insecticides are used in areas without easy access to medical care.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Atropine sulfate. Administer atropine sulfate intravenously or intramuscularly if intravenous injection is not possible.</td>
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<td>Glycopyrolate has been studied as an alternative to atropine and found to have similar outcomes using continuous infusion.</td>
</tr>
</tbody>
</table>
## Summary of Acute Exposure Symptoms and Treatment of WHO-recommended organophosphates

<table>
<thead>
<tr>
<th>Pyrethroids</th>
<th>Human side effects</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bifenthrin</td>
<td>Acute exposure symptoms include skin and eye irritation, headache, dizziness, nausea, vomiting, diarrhea, excessive salivation, fatigue, irritability, abnormal sensations of the face and skin, and numbness. No skin inflammation or irritation observed; however can cause a reversible tingling sensation. Incoordination, irritability to sound and touch, tremors, salivation, diarrhea, and vomiting have been caused by high doses.</td>
<td>Depends on the symptoms of the exposed person. Casual exposures require decontamination and supportive care. Wash affected skin areas promptly with soap and warm water. Medical attention should be sought if irritation or paresthesia occurs. Eye exposures should be treated by rinsing with copious amounts of water or saline.</td>
</tr>
<tr>
<td>Deltamethrin</td>
<td>Acute exposure symptoms include skin and eye irritation, headache, dizziness, nausea, vomiting, diarrhea, excessive salivation, fatigue, irritability, abnormal sensations of the face and skin, and numbness.</td>
<td>If exposed immediately remove any contaminated clothing. Soak any liquid contaminant on the skin clean affected area with soap and warm water. Rinse copiously with water when eye exposures occur or 4 percent sodium bicarbonate. Vomiting should not be induced following ingestion exposures, but the mouth should be rinsed.</td>
</tr>
<tr>
<td>Lambda-Cyhalothrin</td>
<td>Skin exposure leads to transient skin sensations such as periorbital facial tingling and burning. Can irritate the eyes, skin, and upper respiratory tract. Oral exposure can cause neurological effects, including tremors and convulsions. Ingestion of liquid formulations may result in aspiration of the solvent into the lungs, resulting in chemical pneumonitis.</td>
<td>Dermal exposure should be treated by removing contaminated clothing and washing the exposed areas with soap and water. Eyes should be rinsed with water for several minutes. Vomiting should not be induced following ingestion. Inhalation exposures require removal to fresh air and rest.</td>
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<tr>
<td>Pyrethroids</td>
<td>Human side effects</td>
<td>Treatment</td>
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<tr>
<td>Alpha-Cypermethrin</td>
<td>Acute exposure symptoms include skin rashes, eye irritation, itching and burning sensation on exposed skin, and paraesthesia. Acute inhalation exposures may cause upper and lower respiratory tract irritation. Ingestion of alpha-cypermethrin is also harmful</td>
<td>Dermal exposure should be treated by removing contaminated clothing and washing the exposed areas with soap and water. Eyes should be rinsed with water for several minutes. Vomiting should not be induced following ingestion. Inhalation exposures require removal to fresh air and rest.</td>
</tr>
<tr>
<td>Cyfluthrin</td>
<td>Acute occupational or accidental exposure results in burning, itching, and tingling of the skin. Reported systemic symptoms included dizziness, headache, anorexia, and fatigue. Vomiting occurs most commonly after ingestion of pyrethroids. Less commonly reported symptoms include tightness of the chest, paresthesia, palpitations, blurred vision, and increased sweating. In serious cases, coarse muscular fasciculations (twitching), convulsions, and coma.</td>
<td>If exposed immediately remove any contaminated clothing. Soak any liquid contaminant on the skin clean affected area with soap and warm water. Rinse copiously with water when eye exposures occur or 4 percent sodium bicarbonate. Vomiting should not be induced following ingestion exposures, but the mouth should be rinsed.</td>
</tr>
<tr>
<td>Etofenprox</td>
<td>Acute occupational or accidental exposure results in burning, itching, and tingling of the skin. Reported systemic symptoms included dizziness, headache, anorexia, and fatigue. Vomiting occurs most commonly after ingestion of pyrethroids. Less commonly reported symptoms include tightness of the chest, paresthesia, palpitations, blurred vision, and increased sweating. In serious cases, coarse muscular fasciculations (twitching), convulsions, and coma.</td>
<td>If exposed immediately remove any contaminated clothing. Soak any liquid contaminant on the skin clean affected area with soap and warm water. Rinse copiously with water when eye exposures occur or 4 percent sodium bicarbonate. Vomiting should not be induced following ingestion exposures, but the mouth should be rinsed.</td>
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### Summary of Acute Exposure Symptoms and Treatment of WHO-recommended organochlorines

<table>
<thead>
<tr>
<th><strong>Organochlorines</strong></th>
<th><strong>Human side effects</strong></th>
<th><strong>Treatment</strong></th>
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<tr>
<td><strong>DDT</strong></td>
<td>Acute poisoning by DDT is very rare, particularly when used for IRS. Nevertheless, it could potentially occur if there is gross mishandling. Early symptoms may include paresthesia (tingling) of the tongue, lips and parts of the face, which in severe cases extends to the extremities. The patient may have a sense of apprehension and disturbance of equilibrium, dizziness, confusion, and a characteristic tremor.</td>
<td>Remove contaminated clothing and wash the affected skin with clean water and soap, and flush the affected area with large quantities of clean water. Keep the patient calm and in quiet, shaded conditions and seek medical assistance. Do not give the patient oils and fats.</td>
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</table>
### Summary of Acute Exposure Symptoms and Treatment for Chlorfenapyr

<table>
<thead>
<tr>
<th>Human side effects</th>
<th>Treatment</th>
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<tbody>
<tr>
<td>As chlorfenapyr is a rather new product, there are not many cases of poisonings where the symptoms were described. One patient first exhibited general fatigue, hyperperspiration, nausea and vomiting. He was initially diagnosed as being dehydrated. Another patient initially presented diaphoresis, headache and cough. Symptomatic management is initiated, but after seven days she presents neurological and respiratory deterioration, causing her death.</td>
<td>Symptoms following exposure should be observed in a controlled setting until all signs and symptoms have fully been resolved. If ingested, control any seizures first. Chlorfenapyr can produce abnormalities of the hematopoietic system, liver, and kidneys. Do not use emetics. Monitoring complete blood count, urinalysis, and liver and kidney function tests is suggested for patients with significant exposure. If respiratory tract irritation or respiratory depression is evident from inhalation, monitor arterial blood gases, chest x-ray, and pulmonary function tests. Significant esophageal or gastro-intestinal tract irritation or burns may occur following ingestion. Consider gastric lavage after ingestion of a potentially life-threatening amount of poison if it can be performed soon after ingestion (generally within 1 hour). Protect airway by placement in Trendelenburg and left lateral decubitus position or by endotracheal intubation. Activated charcoal binds most toxic agents and can decrease their systemic absorption if administered soon after ingestion. Immediate dilution with milk or water may be of benefit in caustic or irritant chemical ingestions. Rinse mouth and administer 5 ml/kg up to 200 ml of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool. Observe patients with ingestion carefully for the possible development of esophageal or gastrointestinal tract irritation or burns. If signs or symptoms of esophageal irritation or burns are present, consider endoscopy to determine the extent of injury. Carefully observe patients with inhalation exposure for the development of any systemic signs or symptoms and administer symptomatic treatment as necessary. If exposure is to the eyes, immediately irrigate exposed eyes with copious amounts of room temperature water (better with 0.9% saline) for at least 15 minutes. If irritation, pain, swelling, lacrimation, or photophobia persist, the patient should be seen in a health care facility. For dermal exposure remove contaminated clothing and wash exposed area thoroughly with soap and water. A physician may need to examine the area if irritation or pain persists.</td>
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</table>
### Mitigation Measure

<table>
<thead>
<tr>
<th>Mitigation Measure</th>
<th>Status of Mitigation Measures</th>
<th>Outstanding issues relating to required conditions</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a. Pre-contract inspection and certification of vehicles used for pesticide or spray team transport.</td>
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<tr>
<td>1b. Driver training</td>
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<tr>
<td>1c. Cell phone, personal protective equipment (PPE) and spill kits on board during pesticide transportation.</td>
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<tr>
<td>1d. Initial and 30-day pregnancy testing for female candidates for jobs with potential pesticide contact.</td>
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<tr>
<td>1e. Health fitness testing for all operators</td>
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<tr>
<td>1f. Procurement of, distribution to, and training on the use of PPE for all workers with potential pesticide contact.</td>
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<td>1g. Training on mixing pesticides and the proper use and maintenance of spray pumps.</td>
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<tr>
<td>1h. Provision of adequate facilities and supplies for end-of-day cleanup.</td>
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<tr>
<td>1i. Enforce clean-up procedures.</td>
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<tr>
<td>2a. IEC campaigns to inform homeowners of responsibilities and precautions.</td>
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<td>2b. Prohibition of spraying houses that are not properly prepared.</td>
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<td>2c. Two-hour exclusion from house after spraying</td>
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<td>2d. Instruct homeowners to wash itchy skin and go to health clinic if symptoms do not subside.</td>
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<td>3a. Indoor spraying only.</td>
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<td>3b. Training on proper spray technique</td>
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<tr>
<td>3c. Maintenance of pumps</td>
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<tr>
<td>4a. Choose sites for disposal of liquid wastes according to PMI BMPs.</td>
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<td>4b. Construct soak pits with charcoal to adsorb pesticide from rinsewater.</td>
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<td>4c. Maintain soak pits as necessary during season.</td>
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<tr>
<td>4d. Inspection and certification of solid waste disposal sites before spray campaign.</td>
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<td>4e. Monitoring waste storage and management during campaign.</td>
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<td>4f. Monitoring disposal procedures post-campaign.</td>
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<tr>
<td>5a. Maintain records of all pesticide receipts, issuance, and return of empty sachets/bottles.</td>
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<td>5b. Reconciliation of number of houses sprayed vs. number of</td>
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<tr>
<td>sachets/bottles used.</td>
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<td>5c. Visual examination of houses sprayed to confirm pesticide application.</td>
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<tr>
<td>5d. Perform physical inventory counts during the spray season.</td>
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</tbody>
</table>
Annex D: References

Abt Associates. August 2012. Assessment and Recommendations: Storage, Stock Control, and Inventory Management. USAID.


Autman Tembo (2010). Supplemental Environmental Assessment: Indoor Residual Spraying for Malaria Control in Zambia, Amendment to include additional Districts in Northern Region, Zambia. Using Pyrethroids, Carbamates or Organophosphates.


