The PMI Africa IRS (AIRS) Project

Indoor Residual Spraying (IRS)

Task Order Six

SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT COUNTRY-WIDE

BENIN

INCLUDED PESTICIDE CLASSES: PYRETHROIDS, CARBAMATES, ORGANOPHOSPHATES AND CHLORFENAPYR (WHEN RECOMMENDED BY WHOPES)

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ACRONYMS

AIRS	Africa Indoor Residual Spraying Project
ABE	*Agence Beninoise pour l'Environnement* (Benin Environmental Agency)
BMP	Best Management Practice
CARDER	*Centre d'Action Regional pour le Developpement Rurale* (Regional Action Centre for Rural Development)
CENAGREF	*Le Centre National de Gestion des Réserves de Faune* (National Center of Management of Fauna Reserves**)**
CDC	Center for Disease Control and Prevention
CNAC	Comité National d'Agrément et de Contrôle des Produits Pharmaceutiques
COP	Chief of Party
COR	Contracting Officer's Representative
CREC	*Centre de Recherche Entomologique de Cotonou* (Cotonou Entomological Research Center)
DECS	Director of Environmental Compliance and Safety
DDE	*Direction Departementale de l'Environnement* (District Environment Center)
DDEGCC	*Direction Départementale de l'Environnement et de la Gestion des Changements Climatiques)*
DDT	Dichlorodiphenyltrichloroethane
DDS	*Direction Departementale de Santé* (District Health Center)
EC	Environmental Compliance
ECC	Environmental Compliance Coordinator
ECO	Environmental Compliance Officer
FAO	Food and Agriculture Organization
EEM	Enhanced Entomological Monitoring
EOSR	End of Spray Report
IP	Implementing Partner
IRS	Indoor Residual Spraying
LLIN	Long-lasting insecticide-treated nets
M&E	Monitoring and Evaluation
MAEP	Ministry of Agriculture **(***Ministère de l'Agriculture de l'Elevage et de la Pêche*)
MOH	Ministry of Health (*Ministere de Santé*)
MOE	Ministry of Environment (*Ministere d'Environnement et Protection de la Nature*)

MSP	Mobile Soak Pit
NMCP	National Malaria Control Program (*Programme National pour la Lutte contre le Paludisme*; PNLP)
OP	Organophosphate
PMI	President's Malaria Initiative
PPE	Personal protective equipment
PSECA	Pre-Spray Environmental Compliance Assessment
SEA	Supplemental Environmental Assessment
SOP	Spray Operator
SPV	Service de Protection des Végétaux
USAID	United States Agency for International Development
USG	United States Government
WHO	World Health Organization
WHOPES	World Health Organization Pesticide Evaluation Schemes

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EXECUTIVE SUMMARY

This document has been prepared to serve as a Supplemental Environmental Assessment (SEA) for Indoor Residual Spraying (IRS) in Benin for the period 2016-2020. Previous environmental documentation for PMI-supported IRS in Benin authorized the use of the pyrethroid, carbamate and organophosphate classes of the WHOPES-recommended pesticides for the whole country, from 2010-2015, and was prepared in accordance with the provisions of USAID 22 CFR (216) regarding the use and application of pesticides. This SEA proposes to reauthorize the use of the same three classes of WHOPES-recommended insecticides, and to expand the authorization to include the use of chlorfenapyr (when recommended by WHOPES). This SEA also seeks to maintain the geographic coverage of authorized PMI-supported IRS to the entire country, and 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.

In FY 2007, the USG selected the Republic of Benin as one of the eight PMI countries. For the past nine years, PMI has supported IRS in Benin as its sole donor. PMI has worked with the National Malaria Control Program (NMCP) and *the Centre de Recherche Entomologique de Cotonou* (CREC) for capacity building in entomological monitoring, and will continue with a contract issued directly by USAID/Benin to complete entomological surveillance and provide recommendations for insecticide selection.

The FY 2016 Malaria Operational Plan presents a detailed implementation plan for Benin, based on the USG malaria strategy and the National Malaria Control Program's (PNLP) strategy. It was developed in consultation with the NMCP, and with the participation of national and international partners involved in malaria prevention and control in the country. The activities that PMI is proposing to support fit in well with the National Malaria Control Strategy and Plan and build on investments made by PMI and other partners to improve and expand malaria-related services. Benin's National Strategic Plan (NSP) for 2011-2015 has been revised to extend through 2018.

Malaria is a major public health problem in Benin. Although dramatic progress in malaria control has been made in recent years with the scale-up of malaria prevention and treatment interventions, nearly all 10 million residents in Benin are still at risk of infection.

Changing or rotating insecticides of different classes over time is a leading way to manage vector resistance. In Benin, entomological monitoring with the CREC has demonstrated that local mosquitoes have developed 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.

The proposal to include chlorfenapyr is prompted by the need to increase the options of recommended 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 for IRS in Benin outlines the monitoring and mitigation measures that will be employed by PMI Implementing Partner (IP) to minimize or reduce any unintended adverse impacts of pesticide application. Those measures are found in the Safer Use Action Plan (Section 7), and summarized in the

Environmental Mitigation and Monitoring Plan (EMMP) found in Annex A. All PMI IRS operations in Benin 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, in order to implement response protocols. Biomonitoring is not routinely required for the use of pirimiphos methyl formulations for IRS at the present time, but increased vigilance is essential.
2. Pirimiphos-methyl formulations are supplied in plastic bottles, which if not controlled carefully may be used inappropriately once emptied of the insecticide 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 insecticide make-up procedure, whereby the insecticide 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 insecticide 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 insecticide 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 Benin National Malaria Control Program (NMCP) the Implementing Partner (IP) will ensure that the plastic remains segregated from other materials, and is recycled appropriately.

The PMI IP will implement the EMMP in Annex A, with guidance from PMI 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 PMI along with the annual end of spray report.

On an annual basis, a letter report will be submitted to the Contracting Officer's Representative (COR) and Bureau Environmental Officer (BEO). It must contain information regarding program changes, entomological/resistance monitoring results and data, and program response to those results. It should also contain the results of the environmental monitoring and how the program will improve any areas of deficiency.

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

1. PRINCIPAL PROPOSALS & CLEARANCE

1. The Benin Supplemental Environmental Assessment (SEA) (2008), as amended in 2010 (amendment #1) was valid for implementing PMI-supported IRS in all selected regions nationwide, using all WHO-recommended pesticides in the pyrethroid, carbamate and organophosphate classes for the period 2011-2016.
2. In order to continue with PMI IRS, PMI is seeking approval for a new SEA for a further 5 years (2016-2020) and for the SEA to be nationwide in scope.
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, and organophosphates.
4. 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.
5. This SEA contains the condition that spraying will not be performed by PMI IPs within national parks or reserves, or within 30 meters of natural water bodies, wetlands or marshes, organic farming areas, or beekeeping areas.
6. The Safer Use Action Plan in Chapter 7 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 key required mitigation measures, as well as the monitoring and reporting requirements and schedule.
7. The preparation of this SEA renders a Letter Report unnecessary for 2016. In subsequent years, provided there are no changes to the program outside the scope of this SEA, a Letter Report will be submitted annually that will discuss significant changes in the IRS program for that particular year's spray campaign.
8. 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 Benin since 2013, BEO signatures are not required on the annual Letter Reports.
9. This SEA contains an updated Pesticides Procedures section, which, together with the Safer Use Action Plan, constitute the elements of a PERSUAP.

APPROVAL OF ENVIRONMENTAL ACTION RECOMMENDED
2016-2020 SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT FOR PRESIDENT'S MALARIA INITIAVE- INDOOR RESIDUAL SPRAYING (IRS) FOR MALARIA CONTROL IN BENIN

The United States Agency for International Development, Global Health Bureau has determined that the proposed IRS effort, as described in the 2016-2020 Supplemental Environmental Assessment: Indoor Residual Spraying for malaria control in Benin responds to the needs of the community and country as it relates to managing malaria in Benin, 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 Benin's and USAID's goal of reducing malaria incidence in Benin while minimizing negative impact to the environment and to human health.

The proposed actions recommended for approval in this 2016 SEA are:

1. The continuation of IRS implementation using pyrethroids, carbamates, organophosphates, and/or chlorfenapyr (when recommended by WHOPES), where appropriate, based on 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. This SEA will extend coverage to all geographical areas in Benin 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 2016 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 WHOPES evaluation and country-level required documentation has been submitted and approved.
4. Due to the need to protect the population in buffer zones of protected areas from malaria, and given the successful record of PMI in implementing IRS in Africa 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. However, spraying in these areas will not be done unless approved by the Beninese environmental authorities and all other competent agencies. PMI does not currently have the approvals from the Beninese authorities to spray within these buffer zones.

The Safer Use Action Plan (Section 7) and the updated Environmental Mitigation and Monitoring Plan (EMMP) for Benin (Annex A) provide 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:
Country Representative
USAID/ Benin Jonathon Richter Date: 4/28/16

CONCURRENCE: see e-clearance (annex) : 8 April 2016
Bureau Environmental
Officer/GH: Rachel Dagovitz Date: _____

ADDITIONAL CLEARANCES: (Type Name under Signature Line)

Bureau Environmental
Officer/AFR: Brian Hirsch Date: _____

PMI Advisor:
PMI/ Benin Peter Thomas Date: 04/25/2016

Mission Environmental Officer:
USAID/Benin Harriet Ahokpossi Date: 04/22/2016

Regional Environmental Compliance Advisor:
USAID/West Africa Henry Aryeetey Date: 04/25/2016

2. BACKGROUND & PURPOSE

2.1 PRESIDENT'S MALARIA INITIATIVE

When it was launched in 2005, the goal of PMI was to reduce malaria-related mortality by 50% across 15 high-burden countries in sub-Saharan Africa through a rapid scale-up of four proven and highly effective malaria prevention and treatment measures: insecticide-treated mosquito nets (ITNs); indoor residual spraying (IRS); accurate diagnosis and prompt treatment with artemisinin-based combination therapies (ACTs); and intermittent preventive treatment for pregnant women (IPTp). With the passage of the Tom Lantos and Henry J. Hyde Global Leadership against HIV/AIDS, Tuberculosis, and Malaria Act in 2008, PMI developed a U.S. Government Malaria Strategy for 2009–2014. In 2015, PMI launched the next six-year strategy, setting forth a bold and ambitious goal with specific objectives. The PMI Strategy for 2015-2020 takes into account the progress over the past decade and the new challenges that have arisen. PMI will assist Benin 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.

2.2 HISTORY AND SCOPE OF IRS IN BENIN

In December 2007, the USG selected Republic of Benin to be included as a PMI country, initiating IRS activities in 2008. For the past nine years, PMI has supported IRS in Benin and in 2016, the PMI AIRS project will have completed a tenth round of IRS and its sixth round in the Atacora Department in close collaboration with Beninese government partners; namely, the NMCP; Ministry of Health (MOH); Ministry of Agriculture, Livestock and Fisheries (MOAEP); Ministry of Environment, Habitat and Urbanization; Benin Environmental Agency; National Directorate of Agriculture; National Directorate of Hygiene; Department Administrative Authorities of Atacora; and Department Directorate of Health of Atacora.

Prior to 2011, IRS activities were implemented in the Oueme Plateau, protecting up to 636,000 residents per year in 4 communes. When the regional change was made to Atacora Region in 2011, the number of residents protected dropped to 426,000, but increased to 7 communes of coverage. Over the subsequent years of IRS implementation in the Atacora Region from 2011-2015, IRS coverage has progressively increased, almost doubling the amount of protecting residents, to 802,600 covered in 9 communes in 2015.

One reason for the regional switch, is that the North of the country (Atacora) is better suited to IRS because of higher child mortality rates, and only one seasonal transmission peak (as opposed to two seasonal transmission peaks in the South). The malaria transmission season in Oueme region outlasted the duration of the IRS insecticidal effect and subsequently hindered the effectiveness and efficacy of IRS. In the formerly sprayed areas in the South (Oueme), PMI has supported efforts to ensure universal coverage and adequate use of ITNs. The PMI has also continued supporting the NMCP entomological and malaria case surveillance system in Ouémé-Plateau.

Another notable change over the course of PMI IRS implementation was the switch to a more expensive, but longer lasting pirimiphos-methyl Actellic CS (organophosphate). The switch is in keeping with the NMCP adoption of World Health Organization (WHO) guidance that calls for insecticide rotation prior to development of resistance. Entomological monitoring in 2014 confirmed continued resistance to pyrethroid- and carbamate-class insecticides in malaria vector populations from the eastern side of Atacora. Future IRS will continue to rely on organophosphate-class insecticides, and other susceptible insecticides, if/when recommended by WHOPES and included in the PEA.

While an integral component of the National Malaria Strategic Plan, implementation of IRS in Benin is limited, as PMI is the sole donor supporting the intervention. The 2016 spray round targets nine communes (~252,000 structures, population ~800,000) in the department of Atacora, which has a seasonal malaria transmission pattern. Recent monitoring results suggest that in some areas of Atacora, perennial transmission is more present than previously assumed. Since 2014, PMI has supported capacity building of the NMCP to play a greater role in the planning and implementation of IRS. In 2015, the NMCP increased its IRS implementation area from one to three communes. Given limited resources and to maximize the public health impact of IRS, PMI convened national vector control partners to reassess current approaches and consider medium-, and long-term plan for the future of IRS in Benin. Using available epidemiologic, entomologic, and environmental data, the gathering of experts and stakeholders reached a consensus on continuing IRS in Atacora in 2016. Beginning in 2017, the Ministry of Health will relocate spraying to the departments of Alibori and Donga.

Table 1: Spray Performance in Benin 2008-2016

Year	Month	Department	Communes	Structures Found	Insectides Used		Structures Sprayed	Population Protected
					Carbamates	Organophosphates		
2008	July-Aug	Ouémé	4	151,782	X		142,813	521,698
2009	March-Apr	Ouémé	4	157,146	X		156,223	512,491
2010	March-Apr	Ouémé	4	168,010	X		166,910	636,448
2010	Aug-Sept.	Ouémé	4	200,095	X		200,036	623,904
2011	May-June	Atacora	7	170,598	X		145,247	426,232
2012	May- June	Atacora	9	221,937	X		210,380	652,777
2013	May-June	Atacora	9	239,112	X	X	228,951	694,729
2014	May	Atacora	9	265,907		X	254,072	789,883
2015	May	Atacora	9	270,141		X	252,706	802,597
2016	May	Atacora	9	270,141		X	N/A	N/A

According to the most recent national annual health statistics report of 2014 from the MOH, malaria is the leading cause of mortality among children under five and the leading cause of morbidity among adults in Benin. In 2014, malaria was also the leading cause of hospital visits, representing 39.8 percent of outpatient visits for the overall population and 54.2 percent for children under 5 years old. In the same year, malaria comprised 25.3 percent of all inpatient deaths in Benin, and for children under 5 years old 36.2 percent. Trends for admissions and deaths have steadily increased over the past four years, although this trend might reflect better overall testing and reporting of malaria infections in Benin. The 2015 Malaria Indicator Survey reported 38.8% malaria prevalence in children less than five years of age. Results from Benin's two most recent DHSs revealed a substantial decrease in the prevalence of anemia (malaria likely being a major cause) among children 6–59 months old: from 78 percent in 2006 (25 percent mild, 46 percent moderate, and 8 percent severe) to 58 percent in 2012 (26 percent mild, 29 percent moderate, and 3 percent severe). The 2015 MIS showed that anemia in children less than five

years of age continues to decline, reaching 51 percent (35 percent mild, 15 percent moderate, and 1 percent severe).

ORGANIZATION OF THE BENIN HEALTHCARE SYSTEM

- Central: The MOH and its central Directorates, including the Directorate of Public Health to which the NMCP directly reports, along with one National Referral Hospital (*Centre National Hospitalier Universitaire*);
- Intermediate: The six Departmental Health Directorates, including an NMCP cell of dedicated staff and the corresponding six Departmental Referral Hospitals (*Centres Hospitaliers Départementaux*)
- Peripheral: There are 34 health zones, including the following levels of clinical facilities in decreasing order of capacity: Zonal Hospitals (*Hôpitaux de Zone*); Commune Health Centers (*Centre de Santé de la Commune*), which includes inpatient services; accredited private health facilities; Community Health Centers (*Centres de Santé d'Arrondissement*), and village health units including Community Health Workers (CHWs).

3. PROPOSED ACTION AND ALTERNATIVES

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, and organophosphate classes and 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 Benin.
3. **Spraying in alternative geographic regions:** This alternative would use different criteria to select alternative districts and sectors to spray.
4. **Using alternative pesticides:** This alternative would consider pesticides other than those recommended by WHO.
5. **Alternative technologies:** This alternative would consider methods other than IRS to achieve the stated goals of reduction in malaria mortality and morbidity.

DESCRIPTION OF PROPOSED ACTION

The preferred action is to implement an IRS program in selected communities in consensus with the NMCP, choosing among the pyrethroid, carbamate, and organophosphate classes, as well as chlorfenapyr when recommended, considering current entomological, epidemiological, logistical, environmental, and economic conditions. The pesticide to be used will be determined by a process explained in Pesticide Procedures part b.

NO PROJECT ALTERNATIVE

Indoor Residual Spraying 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 goals of the Benin National Malaria Control Program or the President's Malaria Initiative, which are to:

- 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.

ALTERNATIVE IRS GEOGRAPHICAL SITES CONSIDERED

In IRS implementation in Benin, 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. Using different criteria for selecting geographical sites would reduce the effectiveness and impact of IRS, decreasing progress towards the goals of the Benin National Malaria Control Program and the PMI program.

USE OF ALTERNATIVE INSECTICIDE(S)

For IRS to be implemented by PMI, a pesticide approved by World Health Organizations (WHO) under the World Health Organization Pesticide Evaluation Scheme (WHOPES) must be selected for use. WHOPES is an international institution that analyses and recommends pesticides to be used in IRS based on their effectiveness, cost, and toxicity to human health and the environment. The USEPA regulates and registers pesticide products and uses thereof in the United States, and provides guidance for foreign health interventions.

To date WHOPES has recommended the use of pesticides within the following four classes of pesticides: pyrethroids, carbamates, organochlorines and organophosphates. In addition, if approved in this SEA, PMI may use chlorfenapyr when it is recommended by WHOPES. Therefore, the proposed action for Benin includes the use for IRS of recommended organophosphates, carbamates, pyrethroid and pyrrole formulations. The proposed action excludes the use of DDT.

PMI and their implementing partner will monitor WHOPES proceedings towards recommendation of new pesticides, but will seek to amend this SEA before there is any decision to use new WHOPES recommendations.

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 other technologies.[1] The specific focus of this PMI project is IRS, and the role that PMI plays in Benin includes IRS. If other, viable approaches were to arise that would replace or improve upon the role that IRS plays, the National Malaria Control Program, PMI and its partners would evaluate them and proceed accordingly.

[1] PRESIDENT'S MALARIA INITIATIVE Malaria Operational Plan (MOP) Benin, 2016

4. AFFECTED ENVIRONMENT

4.1 OVERVIEW OF COUNTRY

Benin is a slim, rectangular country situated in West Africa. Benin has a narrow 100-kilometer coastline along the Bight of Benin, in the Atlantic Ocean. The country is bordered to the west by Nigeria, to the north by Niger and Burkina Faso, and to the east by Togo. Benin has a land area of 112,622 square kilometers. Both the capital, Porto-Novo, and Cotonou, the largest city, are located on the coast in the southeast of the country.

Figure 1: Administrative Map of Benin

4.2 ADMINISTRATIVE AND POLITICAL UNITS – INCLUDING IRS STRUCTURE AND PARTICIPATION

Benin is divided into 12 departments and subdivided into 77 communes. In 1999, the previous six departments were each split into two halves, forming the current 12. Each of the six new departments was assigned a capital in 2008.

Table 2: Benin Population by Department 2013

Department	Capital	Population	Area kms	Former Department	Region
Alibori	Kandi	867 463	26,242	Borgou	North
Atakora	Natitingou	772 262	20,499	Atakora	North
Atlantique	Ouidah	1 398 229	3,233	Atlantique	South
Borgou	Parakou	1 214 249	25,856	Borgou	North
Collines	Savalou	717 477	13,931	Zou	North
Kouffo	Dogbo-Tota	745 328	2,404	Mono	South
Donga	Djougou	543 130	11,126	Atakora	North
Littoral	Cotonou	679 012	79	Atlantique	South
Mono	Lokossa	497 243	1,605	Mono	South
Ouémé	Porto-Novo	1 100 404	1,281	Ouémé	South
Plateau	Sakete	622 372	3,264	Ouémé	South
Zou	Abomey	851 580	5,243	Zou	North
Total		10 008 749			

Table 3: Departments and Communes in Benin

Département (Nombre de commune)	Communes (nombre d'arrondissements)
Alibori (6)	Banikoara (10), Gogounou(6), Kandi(10), Karimama(5), Malanville(5), Ségbana(5)
Atacora (9)	Boukoumbé (7), Cobly(4), Kérou(4), Kouandé(6), Matéri(6), Natitingou(9), Péhunco(3),Tanguiéta(5), Toucountouna(3)
Atlantique (8)	Abomey-Calavi(9), Allada(12), Kpomassè(9), Ouidah(10), So-Ava(7), Toffo(10), Tori Bossito(6), Zê(11)
Borgou (8)	Bembérèkè (5), Kalalé(6), N'Dali(5), Nikki(7), Parakou(3), Pèrèrè(6), Sinendé(4), Tchaourou(7)
Collines (6)	Bantè(9), Dassa-Zoumè(10), Glazoué(10), Ouèssè(9), Savalou(14), Savè(8)
Couffo (6)	Aplahoué(7), Djakotomey(10), Dogbo(7), Klouékanmey(8), Lalo(11), Toviklin(7)
Donga (4)	Bassila(4), Copargo(4), Djougou(12), Ouaké(6)
Littoral (1)	Cotonou (13)
Mono (6)	Athiémè(5), Bopa(7), Comé(5), Grand-Popo(7), Houéyogbé(6), Lokossa(5)
Ouémé (9)	Adjarra(6), Adjohoun(8), Aguégué(3), Akpro-Missérété(5), Avrankou(7), Bonou(5), Dangbo(7), Porto-Novo(5), Sèmè-Podji(6)
Plateau (5)	Adja-Ouèrè(6), Ifangni(6), Kétou(6), Pobè(5), Sakété(6)
Zou (9)	Abomey (7), Agbangnizoun (10), Bohicon(10), Covè(8), Djidja(12), Ouinhi(4), Zagnanado, Za-Kpota(8), Zogbodomey(11)

4.3 PHYSICAL ENVIRONMENT

Benin is predominantly flat in topography, however there is much rigorous terrain as you travel northwards. There are five notable topographical regions:

- A Coastal Band; low and sandy, mostly surrounded by lagoons (and coconut palms);

- A Central Plain; hilly and monotonous, which rises gradually from 200 to 400 m from south to north around Nikki then descends to the Niger valley and Kandi Basin; The Kandi Basin Northeast is as a plain drained by Sota River and its tributaries, which flow in very flared valleys;
- The Atacora chain in the Northwest, Mount Aledjo (658m) is the highest peak;
- The vast plains of Gourma in the extreme northwest, between Atakora and the border with Burkina Faso and Togo.
- The Wet Savannah occupies most of the country. Some primary forest patches remain in the south and center. Aquacultures, swamps and huge palm plantations predominate the southernmost part of Benin territory.

4.3.1 CLIMATE

Benin is located in West Africa on the Guinea Coast. At latitudes of 6 to13°N, the climate of Benin is tropical, and strongly influenced by the West African trade winds.

There are two climatic zones in Benin; Southern and Northern. The Southern climatic zone has an equatorial type of climate which has two seasons – wet and dry; each season occurs twice in a year. The hot and dry seasons occurs from January to April and during the month of August. The rainy seasons occur from May to July and then September to December. The average monthly temperature in southern Benin ranges from 20° to 34° Celsius. The rain amount increases rapidly in east side. Sea breezes temper the climate during much of the year. The Northern climatic zone the wet and dry seasons occurs only once. Hot and dry season is between November and June; cooler and very wet weather between July and October. These areas experience highly elevated temperatures during dry season.

June is the wettest month in all districts in Benin. Cotonou, its metropolis, and the coast is broadly hot and humid during this time. In the dry season, the Harmattan (hot dry wind from the northeast or east of Sahara) blows from December to March creating a haze over the city. On average about 890 mm (about 35 in) of rain falls yearly in northern Benin, mainly from May to September.

Benin is characterized by unusually dry conditions. This is due primarily to two very important factors. First, the situation of the coast which is rather well protected from the western winds; second, the Atacora Barrier in the West and North West which decreases the amount of rainfall.

4.3.2 RAINFALL PATTERNS

Rainfall patterns vary all over Benin. Benin's rainfall azonality is remarkable, given the difference that is observed between the North and the South. The total average rainfall levels per annum fall symmetrically into the following two patterns: High rainfall level in the North-west (Djougou and Atacora) and South-east (Porto-Novo, Oueme and surrounding areas) - (1 500 – 1 400 mm); and Low rainfall level in the North and North-east (the Niger valley) and low Mono valley in the South-west (1 000-850 mm).

Within these two extreme regions is a vast area including the Zou, Middle Ouémé and Central Borgou basins where annual average rainfall levels oscillate between 1 100 and 1 200 mm. The configuration of the annual isohyets shows an indigent rainfall zone located in the areas bordering the sea which extends diagonally inland towards the SW-NE in a downward curve.

Benin is characterized by the following two rainfall gradients; a littoral gradient extending from Sèmè (1 500 mm) towards the "thalweg" of the diagonal on the Grand-Popo-Bopa-Zagnanado axis, and a

Northern sub-meridian gradient extending from Djougou to the piedmont south-east of the Atacora mountain range (1 400 mm), towards Malanville in the Niger valley (900 mm). Between the 7° 30 ' and 9° parallels, a rainfall "marsh" extends with some localised "poles" onto the inselbergs (island-mountains) of the Idaca – Cabè country.

The rainy seasons in these areas are defined:

- a bimodal pattern with four seasons including two dry and two rainy seasons to the south of parallel 7° 45';
- a unimodal pattern with two seasons, one of which is a dry season and the other a rainy season to the north of parallel 8°30 ' and;
- an intermediate pattern alternating between bimodal and unimodal between these two parallels.

Figure 2: Average Rainfall in Oueme Department from 1982- 2012, depicting bimodal rainfall peaks in June and October (climate-data.org)

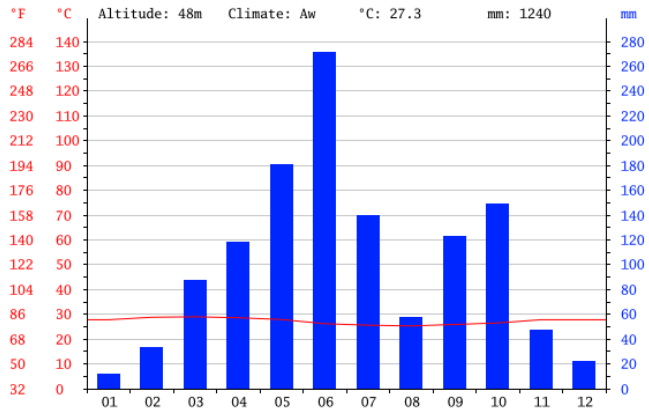
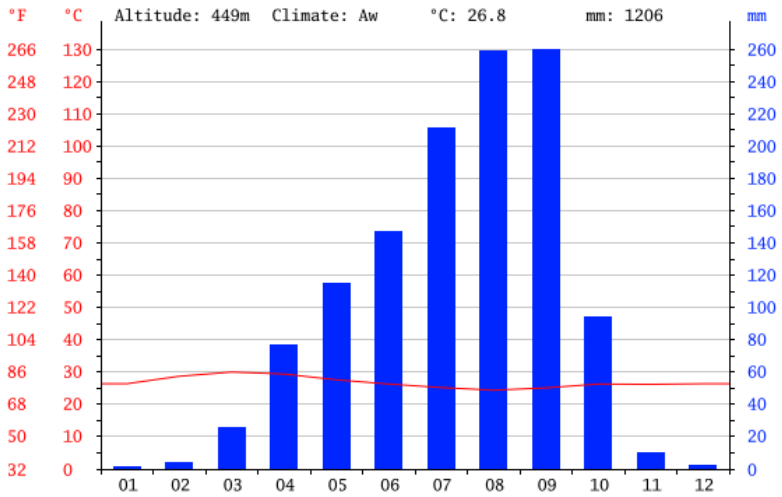


Figure 3: Average Rainfall from 1982-2012 : Atacora Department, depicting one peak in August (climate-data.org)



4.3.3 TOPOGRAPHY, GEOLOGY AND SOILS

Topography

Benin can be divided into five natural regions:

- A coastal area, low, sandy and about 2 to 5 kilometers wide, bounded by lagoons;
- A plateau zone called "La terre de barre" made of iron clay cut with marshy dips;
- A silica clayey plateau with wooded savannah extending North of Abomey to the foothills of the Atacora hills; -
- A hilly region in the Northwest, the Atacora, with elevation ranging from 500 to 800 meters and constituting the water reservoir for Benin and Niger Republics.

Soils

A large variety of soils can be found in Benin. Fersialitic soils with high gravel contents are dominant on the crystalline basement, while ferralitic and hydromorphic soils prevail in the sedimentary basins in the south of Benin. In general, small scale variability of the soils is very high, and many soil types are associated with other soil types. Five major sol types can be identified in Benin and they include;-granitto gneissiques; ferralitic soils; hydromorphic soils; vertic green soils: and rough undeveloped mineral soils.

Geology

The geology of Benin broadly includes the North-Northeast trending Proterozoic Dahomenyide orogeny in the north and a range of Cretaceous to Holocene sedimentary rocks in the south. Neogene alluvial deposits extend across Benin's northeastern border with Niger.

4.3.4 BIOLOGICAL ENVIRONMENT

VEGETATION AND AGRO-ECOLOGICAL ZONES

The original rain forest, which covered most of the southern part of the country, has now largely been cleared, except near the rivers. In its place, many oil palms and rônier palms have been planted and food crops are cultivated. North of Abomey the vegetation is an intermixture of forest and savanna (grassy parkland), giving way farther north to savanna. Apart from the oil and rônier palms, trees include coconut palms, kapok, mahogany, and ebony.

In spite of the apparently favorable geographical position, Benin is not a forest country like neighboring Nigeria, Ghana and Ivory Coast. However, about 65 % of the whole territory is covered by bushy vegetation. Out of this brushy vegetation Benin has 93.1 % grassland area, making it the highest grassland covered country in Sub-Saharan Africa. Generally, the types of natural formations found in Benin, depending on the various climatic conditions are: the South, North Central region, North, and Guinea zone:

The South has a sub-equatorial type climate has a Brazilian-type Ipomoea lawn, that consists of *Remirea maritima, Ipomoea asarifolia* on the old offshore bar; a clear forest with *Lophira lanceolata* (false karité tree), *Carissa edulis, Byrsocarpus coccineus* on the old offshore bar; a marshy formation in the West made up of *Mitragyna inermis, Cola grandiflora, Ceiba pentandra, Lonchocarpus sericeus, Andropogon gayanus,* etc. In brackish areas, a mangrove formation made up of *Rhizophora racemosa* (mangrove), *Avicennia germinans* and *Dalbergia ecastaphyllum*. The disappearance of this woody vegetation gave way to *Paspalum vaginatum, Philoxerus vermicularis, and Sesuvium portulacastrum*; a marshy formation in the East made up of *Raphiale (Raphia hookeri, Raphia vinifera), Ficus congensis, Anthocleista vogelii, Alstonia boonei, Cyrtosperma senegalense, Cyperus papyrus, Eleocharis spp*., etc; more prevalent on clayey soil in *Elaeis guineensis* (Oil-palm) plantations.

North-central region has a Guinea-Sudan type climate located between parallel 8° Niger River (NR), the Savè – Savalou line, and parallel 9° 30 Niger River, the Koura - Partago-Bori - Guinagourou line, this zone consists of: dry thick forests (between Savalou and Djougou) with *Isoberlinia doka, Isoberlinia tomentosa, Pterocarpus erinaceus, Afzelia africana, Antiaris africana, Chloptelea grandis, Milicia excelsa, Cola gigantea, Celtis zenkeri, Khaya senegalensis, Khaya grandifolia, Amblygonocarpus andongensis, Swartia madagascariensis, Erythophleum guineense*; clear forests and savannas with *Anogeissus leiocarpa, Butyrospermum paradoxum, Daniellia oliveri, Isoberlinia doka, Parkia biglobosa, Combretum micranthum, Guieria senegalensis, Boscia salicifolia, Albizia chevaileri;* and forests galleries with *Ceiba pentandra, Milicia excelsa, Khaya senegalensis, Diospyros mespiliformis and Vitex doniana*.

The North is characterized with a Sudan-Sahel type climate. Located between 10° N and 12° 30 N, it has shrubby and wooded savannahs with *Lophira lanceolata, Acacia ataxacantha, Acacia.macrostachya, Butyrospermum paradoxum, Parkia biglobosa, Entada africana, Burkea africana, Terminalia spp, Combretum spp, Pterocarpus erinaceus, Detarium microcarpum, Sterculia tomentosa Acacia seyal, Balanites aegyptiaca, Guieria senegalensis*; clear forests with *Anogeissus leiocarpa* (deep soils) or with *Isoberlinia doka* (siliceous soils); and forest galleries with *Khaya senegalensis, Diospyros eliottiti, Kigelia africana, Diospyros mespiliformis, Vitex chrysocarpa, Cola laurifolia, Syzygium guineense, Mimosa pigra and Daniellia oliveri.*

The vegetation in the Guinea Zones is dominated by moist woodlands and savannas. The separation between a northern and a southern part coincide with the northern boundary of bimodal rainfall in southern Benin. The Northern Guinea Zone is characterized by woodlands, tree and shrub savannas with abundant *Isoberlinia spp*. and *Butyrospermum paradoxa*. In the Southern Guinea Zone moister types

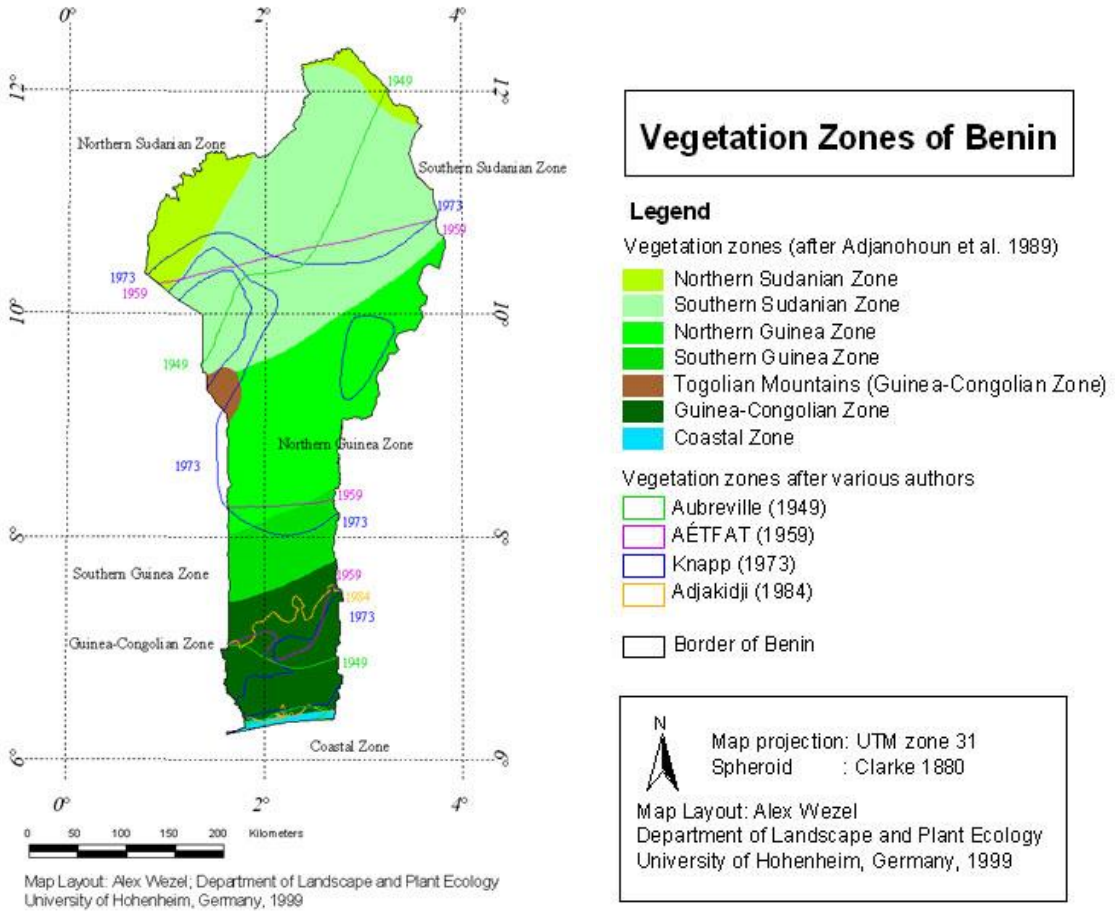
of woodland and savannas with abundant *Daniella oliveri* are found. In the Guinea-Congolian and Coastal Zone a mosaic of forests and savannas exists. In the two zones most of the original vegetation has been replaced by secondary grasslands or savannas due to human impact. This fact was emphasized by vegetation studies on bush and grass fallows.

The separation between a northern and a southern part coincide with the northern boundary of bimodal rainfall in southern Benin. The prevailing vegetation types in the Sudanian Zone are woodlands and savannas. Along rivers, gallery forests can be found. In the Northern Sudanian Zone, vegetation is dominated by *Combretaceae* and *Mimosaceae* woodland or single trees with perennial grass layers of *Andropogon gayanus* (sandy soils), *Loudetia spp*. (laterite, glacis) and *Hyparrhenia spp.* (in moister sites).

Table 4: Characteristics of the Agro-ecological Zones in Benin

Agro ecological zone	Relative area %	Annual rainfall (mm)	Climate	Soil type	Natural vegetation	Main crops	Land holding
Southern Zone	13	1 000–1 400	Subequatorial, with two rainy and two dry seasons	Ferralitic	Relics of forest	Maize, cassava, cowpea, oil palm, vegetables	Inheritance, purchased
Transition Zone	15	1 000–1 200	Transitional (no clear distinction between the two rainy seasons)	Tropical ferruginous	Woody savannah	Maize, cashew, cassava, cotton, groundnut, yam	Inheritance, rented
Southern Borgou Southern Atacora Zone	32	900–1 300	Sudano- Guinean. One rainyand one dryseason	Tropical ferruginous	Woody savannah	Sorghum, cotton, maize, yam	Inheritance
Northern Borgou Zone	24	600–800	Soudano-Sahelian. One rainy and one dryseason	Tropical ferruginous	Shrubby savannah	Cotton, maize millet, sorghum	Inheritance
Atacora Zone	16	900–1200	Sudanian. One rainy and one dry season	Tropical ferruginous	Treed savannah	Sorghum, cowpea maize, millet	Inheritance

Figure 4: Map Depicting Vegetation Zones in Benin



ANIMAL LIFE

Among the mammals in Benin are the elephant, lion, panther, monkey, and wild pig, as well as many kinds of antelope. Crocodiles and many species of snakes (including python, puff adder, and mamba) are widely distributed. Partridge, guinea fowl, and wild duck, as well as many kinds of tropical birds, are common. Insects include varieties of tsetse fly and other vectors of epidemic disease.

Factors which contribute to the endangerment of the wildlife in Benin are the same as those which threaten the forests. As of 2002, there were at least 188 species of mammals, 112 species of birds, and over 2,500 species of plants. According to a 2006 report issued by the International Union for Conservation of Nature and Natural Resources (IUCN), the number of threatened species included 6 types of mammals, 2 species of birds, 1 type of reptile, 8 species of fish, and 14 species of plants. Threatened species include the cheetah, the sandbar shark, the green turtle, and the roan antelope.

Benin has fields of lying fallow, mangroves, and remnants of large sacred forests. In the rest of the country, the savanna is covered with thorny scrubs and dotted with huge baobab trees. Some forests line the banks of rivers. In the north and the northwest of Benin the Reserve du W du Niger and Pendjari National Park attract tourists to see elephants, lions, antelopes, hippos, and monkeys. Pendjari National Park together with the bordering Parks Arli and W in Burkina Faso and Niger are among the most important strongholds for the endangered West African lion. With an estimated 356 (range: 246–466) lions, W-Arli-Pendjari parks harbor the largest remaining population of lions in West

Africa. Historically Benin has served as habitat for the endangered painted hunting dog, *Lycaon pictus*; however, this canid is thought to have been locally extirpated.

4.3.5 MAJOR WATER BODIES

Benin has a diverse and dense network of surface and underground water resources and basins that form the hydrological network described in detail in the section below. Four large sets of water basins exist in Benin including: the Niger basin, hydrographic basins of the Volta, coastal watershed basin including west of Mono-Couffo and all of the Ouémé-Yéwa basin. The entire coastal watershed empties into a lagoon system that connects the two Western sets of basins.

LAKES

Lake Nokoué is a lake in the southern part of the West African nation of Benin. The lake is 20 km wide and 11 km long and is located, north of Cotonou. On the northern edge is the famous water town of Ganvié. Lake Nokoué is an important site for the birds.

Lake Nokoue, which is South of the Oueme Valley, is connected to the sea through the Cotonou Channel (Cotonou lagoon) which separates the eastern and western parts of the town. Otherwise, the Lake Nokoue is surrounded by a system of lagoons and shallows to which it was initially connected, and which presently are shut off from one another due to the urban development. The fluctuations of the lagoon water levels are related not only to the rainfalls but also to the groundwater dynamics depending on the hydraulic continuity existing among them.

RIVERS

Ouémé River

The Ouémé River is Benin's longest fluvial basin (length: 510 km, surface: 50,000 km2). It springs out of the Tanéka hills (about 9°51 NS) in the Atacora Mountains and flows into the Atlantic Ocean by the Cotonou channel. Its two important tributaries are the Zou River (150 km) and the Okpara River (200 km). The Ouémé River drains the largest part of Bénin's cotton belt.

The upper basin of the Ouémé River has a sub-humid tropical climate characterized by one humid season, with 5 months of rainfall (from April–May to September–October) and one dry season per year. Average annual rainfall amounts range between 1180 mm (Kpassa) and 1380 mm (Donga).

The lower basin is characterized by a sub-equatorial climate with 6 to 8 months of rain per year, divided over two rainy seasons per year. The amount of rainfall in the lower basin is rather variable from one year to another.

The Ouémé basin, with an area of 50,000 square kms, is the largest river catchment area in Benin. It drains part of the northern, the central and the southern regions of the country. The Ouémé River provides drinking water, water for domestic use and irrigation water. It also is an important means of transportation for people of the area. It is used for commercial transport and business between the neighboring country Nigeria and Benin.

Biodiversity of the Ouémé River is remarkably high, with a large diversity of fish, mollusks, shellfishes, insects, amphibians, reptiles and birds. The Ouémé River contains more than 120 fish species, of which approx. 90 percent are used for human consumption.

The Oti River

The Oti River begins in the Atakora hills of Benin at an altitude of about 600 m and flows through Togo and Ghana. In Benin, the Oti River is referred to as the Pendjari River. Tributaries include the

Koumongou, Kéran, Kara, Mô, Kpanlé, Wawa, Ménou, and Danyi Rivers. Due to the regulation by the Kompienga Dam in Burkina Faso, the Oti River has a permanent flow with an annual average flow of 100 to 300 m3/s, and can reach more than 500 m3/s. Virtually all the tributaries stop flowing during the dry season, however, and their annual average flows are only in the range of 5 m3/s. In Ghana, the Black Volta, the White Volta and the Oti join the main Volta at Volta Lake, which was created by the Akosombo Dam.

The Niger River

The Niger River is shared by nine countries in West and Central Africa— Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Guinea, Mali, Niger, and Nigeria.

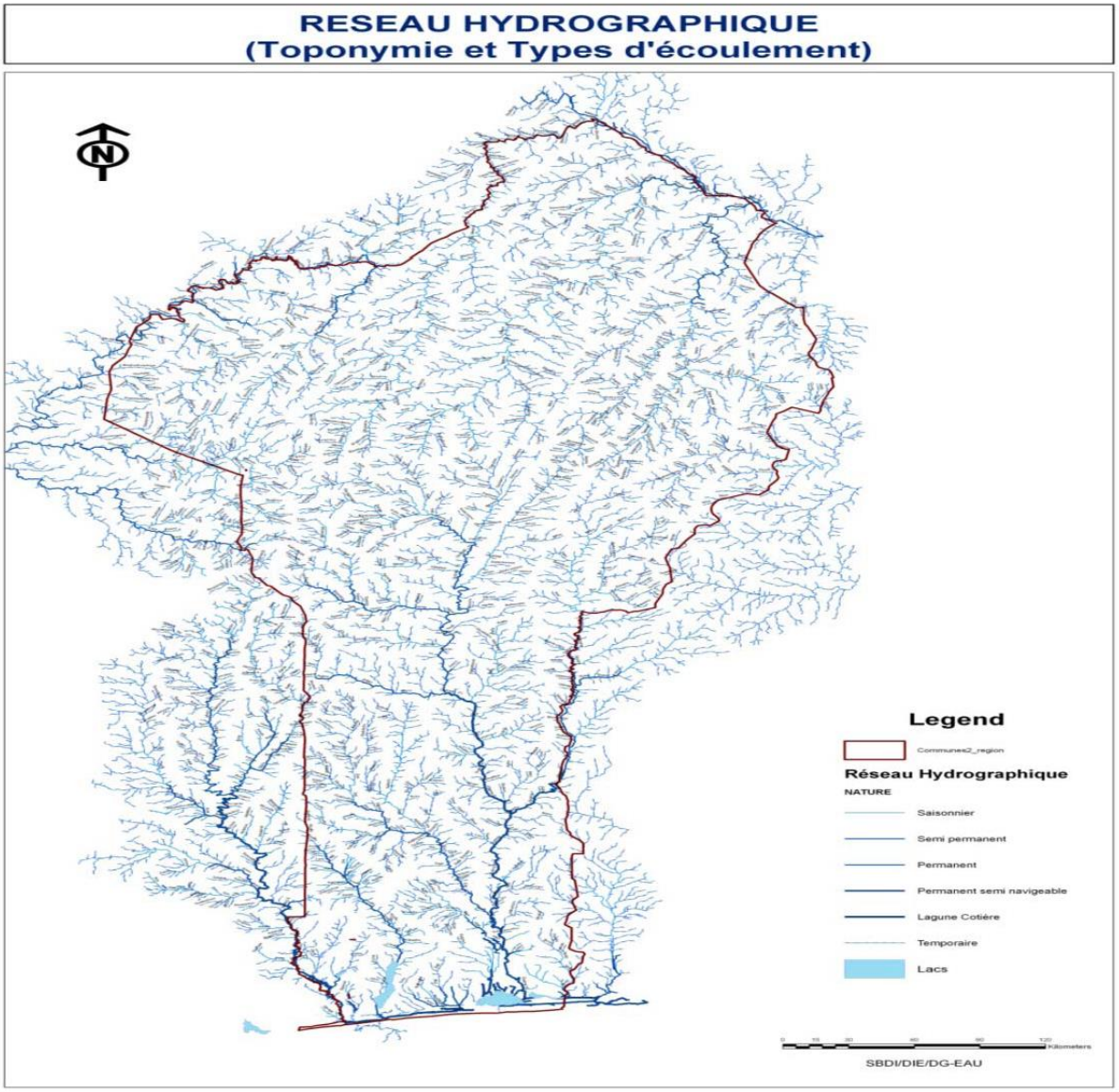
The Niger River's hydrologically active basin covers a surface area of nearly 1.5 million square kilometers shared among the nine countries according to the following approximate percentages: Benin (2.5 percent), Burkina Faso (3.9 percent), Cameroon (4.4 percent), Chad (1.0 percent), Côte d'Ivoire (1.2 percent), Guinea (4.6 percent), Mali (30.3 percent), Niger (23.8 percent), and Nigeria (28.3 percent).

The catchments of several right-bank tributaries of the Middle Niger River are situated in northern Benin, occupying 2.5 percent of the total area of the Basin (37,500 square kilometers). Benin is densely populated, with 65 inhabitants per square kilometer, on average. More than 1.95 million people live in the Niger Basin in Benin. The land within the Basin is used primarily for grazing and livestock, although there are areas, once used for groundnut farming, that are now used for cotton farming. Cotton farming in this area now contributes one-third of the national production. The Mekrou River, a tributary of the Niger, crosses the "W" International Park, an extensive protected sanctuary for flora and fauna, shared by Benin, Burkina Faso, and Niger.

The Volta River Basin

The Volta River basin is shared by six riparian countries, of which Burkina Faso (46 percent) and Ghana (39 percent) share the major portion, and the remaining 15 percent are shared by Togo (6 percent), Benin (4 percent), Mali (3 percent), and Cote d'Ivoire (2 percent). The Volta River Basin is the 9th largest in sub-Saharan Africa with an estimated area of 400,000 km2.

Figure 5: Hydrographical Network of Benin



WETLANDS

The Ramsar Site of the *Complexe W* (895,480 hectares) is a very large wetland complex comprising the W Benin National Park and related protected areas along the national borders with Burkina Faso and Niger, much of which is part of the UNESCO Man and Biosphere Transboundary Biosphere Reserve called "'W' Region". The 'Zone humide de la rivière Pendjari (144,774 hectares) also a National Park and also a UNESCO Biosphere Reserve, is one of the most important humid ecosystems in the sub-Sahelian zone of West Africa, characterized by gallery forests, savannah and swampy meadows, alluvial plains, ponds, rivers, and dense dry forests within floodplains.

The beaches along the coast are sandy and dune ridden, dotted with small mangrove stands in the lagoons in and around the Lake Nokoue. This usually is described as a swampy strip, inundated during the rainy seasons and measuring up to 5 km in width, surrounded by the lagoons and extends along the entire coast immediately to landward of the low coastal dunes. Zones of periodic inundation extend

inland from this strip, up minor streams for distances of up to 23 km, while swamps occur around the several small lakes on the coastal plain, and extensive swamps occur in the delta of the Oueme River, on the Couffro River at the head of Lake Aheme, and on the lower course of the Mono River.

On the interior plateau, in the central eastern district, extensive permanent swamps occur in the headwaters of tributaries of the Okpara River, some 50 km east of Parakou. In the northeast, floodplains and permanent swamps occur all the way along the Niger River where it forms the boundary between Benin and Niger. In the northwest, floodplains and permanent swamps occur on the Pendjari River and many of its influents, both to the east and west of the Atacora Mountains.

There are numerous small agricultural impoundments in the interior and northern parts, and a major dam on the Mono River, at Nangheto in Togo.

4.3.6 Coastal and Marine Environments/Ecoregions

Benin's coastal zone consists of a sea front 125 km long, and an area stretching 50-69 km inland from the Atlantic Ocean that covers about eight percent of the country's land area, but harbors 50 percent of the population. The ecological functions and the natural and biological processes that take place at the interface between the rivers, lagoons, lakes and swamps, on the one hand, and the marine areas on the other, make the Benin coastal zone one of the more productive of the Gulf of Guinea. In particular, water bodies in the coastal inland harbor important and unique biodiversity assets. The variety of geological, topographic and hydrological conditions of the coastal zone combined to create a diversity of ecosystems and habitats for rare animal species. Wetlands, lagoons and rivers cover 40% of the Benin coastal zone, and these water bodies encompass eight different ecosystems that provide irreplaceable ecological functions, and breeding, feeding and nurturing grounds for fish and other aquatic organisms.

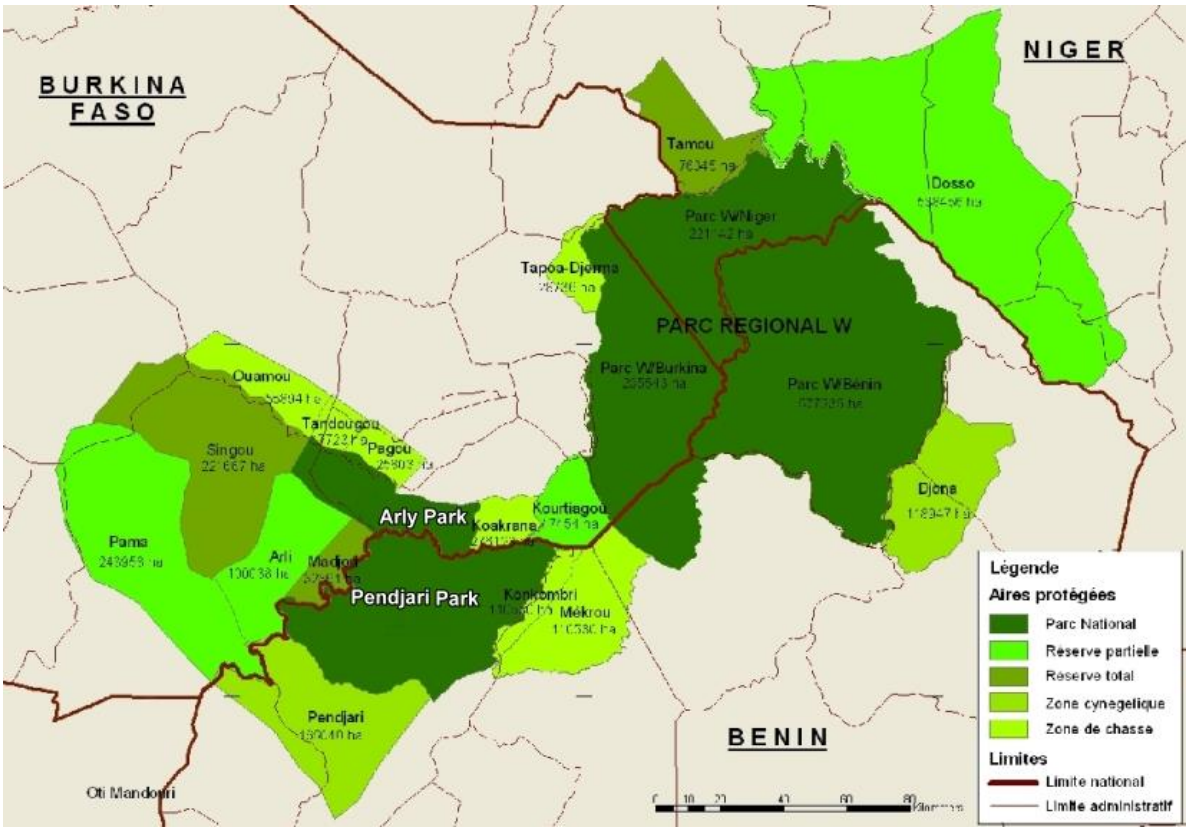
4.4 Protected Areas

Benin has two main national parks (protected) in the entire country and the flora, fauna and birdlife in these habitats are described below.

The Pendjari National Park (French: *Parc National de la Pandjari*) was initially classified as a National Forest and partial Wildlife Reserve on December 13, 1954. In May of 1961 it became a National Park, acquiring the status of Biosphere Reserve in June 1986. It was listed as a Ramsar Site in February 2007.

The W National Park ("*W*" *du Niger*) is a major national park in Niger which meanders around the Niger River shaped like a "W," hence its name. While the greatest area of the park is in Niger it also extends through the extreme northern section of Benin (1,938 sq mi or 5,020 sq km) and into Burkina Faso (733 sq mi or 1,901 sq km). The area was declared a faunal reserve and state forest in 1953 and designated a national park on August 4, 1954. In 1996, a 850 square mile section of the park lying within Niger, between Sudan and Guinea Savannas, was named a UNESCO World Heritage Site.

Figure 6: Map depicting Trans-border National Parks in Benin, Niger and Burkina Faso



4.4.1 PENDJARI NATIONAL PARK

The Pendjari National Park lies in northwestern Benin up to the international border with Burkina Faso. It is part of the largest group of protected areas in West Africa, the complex of Park W-Arli-Pendjari. This complex is a transboundary park comprised within three nations: Niger, Benin and Burkina Faso. The Park W-Arli-Pendjari Complex covers a total area of 19,305 square miles (50,000 sq km), of which 4,633 sq mi (12,000 sq km) is in Benin. Pendjari National Park covers approximately one tenth of the complex (1930 sq mi or 5000 sq km).

The Pendjari National Park is known for its wildlife, including monkeys, hippopotami, and a prominence of birds. There are also large stocks of game animals including elephants, lions, leopards, buffalo and various antelopes.

The quartzite cliffs of the Atacora Hills form the southeastern boundary of the park. The Pendjari River bounds the park on three sides and forms the international border with Burkina Faso along the park's northern edge. The hills and cliffs of the Atacora range provide a dramatic backdrop to the Park, which, in its isolation, remains one of the most diverse in West Africa. The rocky cliffs of the area are sparsely wooded with *Burkea africana*, *Detarium microcarpum*, *Lannea acida*, *Sterculia setigera* and *Combretum ghasalense*. On the deep soils of some of the summits and the Atacora escarpment one finds a greater variety of plant species with *Isoberlina doka* and *Afzelia africana*. The Pendjari River has an impressive gallery forest. The park includes both Sudan and Northern Guinea savannas, with areas of grassland dominated by *Acacia sieberiana* and *Mitragyna inermis* or *Terminalia macropter*.

4.4.2 W National Park

The W National Park contains important areas of high biodiversity and significant natural habitats for threatened species. It is home to major populations of hoofed mammals (ungulates) and wild plant species, valuable to both conservation and genetic research. The wetland area of the Park is of international importance for the conservation of birds as a Ramsar site.

The considerable hydrological resources found in W National Park has earned its listing under the Ramsar Convention, which provides for international cooperation for the conservation and wise use of wetlands and their resources.

The rugged landscape consists of gallery forests, rivers, ponds, meadows and floodplains, with widespread shrub savanna, crucial to the populations of African Elephant and the Cheetah. Other animal populations include aardvarks, antelopes, baboons, buffalo, caracal, crocodiles, hippopotamuses, leopards, lions, monkeys, serval and warthogs. There are many species of snakes, including pythons and puff adders. Significant numbers of water birds have been recorded. Birdlife includes guinea fowl, wild duck, and partridge, as well as many tropical species of snakes, including pythons and puff adders. Significant numbers of water birds have been recorded. Birdlife includes guinea fowl, wild duck, and partridge, as well as many tropical species.

4.5 Agriculture and Organic Farming

Benin is predominantly a rural society and more than 70 percent of the population depends on employment in the agricultural sector. Agriculture contributes around 35 percent of the Country's GDP and 80 percent of export income. While the Government of Benin (GoB) aims to diversify its agricultural production, Benin remains underdeveloped and its economy is underpinned by subsistence agriculture. 93 percent of total agricultural production goes into food production. The proportion of the population living in poverty is about 35.2 percent, with more rural households in poverty (38.4 percent) than urban households (29.8 percent). 36 percent of households depend solely upon agricultural (crop) production for income, and another 30 percent depend on crop production, livestock or fishing for income.

Cotton is the principal cash crop and accounts for nearly 40 percent of GDP and roughly 80 percent of official export receipts, therefore cotton exports are vital to Benin's economy and an integral part of the country's development plans and poverty reduction strategies. Cotton seed production is concentrated in the north and center of Benin in an area known as the cotton belt. About two-thirds of the farmers of Borgou department grow cotton, 37 percent of those in Atacora department and 64 percent of those in the central department of Zou. By contrast, in the three departments in the south (Atlantique, Mono, and Ouémé), the percentage ranges from zero to 25 percent. Cotton is grown by small scale farmers and sold to ginning companies, which transform it into cotton lint and/or produce other by products such as cotton seed, cake and oil, etc. whose export has developed strongly in the last few years. After rising to become one of the 20 leading global producers of cotton lint between 2004 and 2006, Benin experienced a sharp fall in production and exports and has not been able to recover its former output levels (which reached a peak of 268,630 mt in 2007/08). For example, in 2010/2011 production was less than one third of the installed ginning capacity of 620,000 tons.

Cashews, shea nuts and shea butter, pineapples, palm products, and some cocoa and coffee also are export crops. Animal and meat exports to nearby countries contribute a significant amount to the agricultural economy, but remains mostly outside official recorded statistics. Corn, beans, rice, peanuts, cashews, pineapples, cassava, yams, other tubers, and vegetables and fruits are grown for local subsistence and for export to neighboring countries through informal cross-border trading activities.

Top commodities produced by quantity are cassava, yams, corn, pineapples, tomatoes, rice, cottonseed, cashew nuts, fresh fruit, and groundnuts. Top commodities produced by value are yams, cassava, cotton lint, cashew nuts, pineapples, corn, tomatoes, cattle, hot peppers, and rice.

Almost all ruminant livestock in Benin feed off of natural pasture. Most pastoralists graze their herds on seasonal pasture lands. The main feed sources available to grazing animals are natural pasture, cut forage from forests, some additional fodder and crop residues. The presence of the grass *Andropogon gayanus*, and the dicotyledons *Indigofera secundiflora* (in Atacora) and *Chromolaena odorata* (in Savè) are recognized as indicators of fertile soil, whereas *Hyptis* spp., *Striga hermonthica* and*Spermacoce filifolia* (in Atacora) indicate infertile soils.

Pasture production is traditionally unknown in Benin, but forage cultivation is done on national farms. Cultivated fodders have been experimented with but are of little importance in smallholder stock rearing. There are a number of grass and legumes species in Benin to support the nutrition of ruminant livestock. Some common pastures grasses and legume species and plant-communities are: Guinea grass (*Panicum maximum*); Elephant grass (*Pennisetum purpureum*), *Brachiaria ruziziensis, Andropogon gayanus* and *Hyparrhenia*; *Stylosanthes guianensis, Pueraria phaseoloides*, *Mucuna pruriens*, and *Centrosema*. Feeding them as single feed or as mixtures serve as feed resources for ruminant animals. Early in the rainy season, *Brachiaria ruziziensis* and *Panicum maximum* are the most common forage grasses grazed by most animals.

Organic Farming
Organic Farming is almost non-existent in Benin. However, there are initiatives to further the dependence on pesticide use in agriculture. The intense use of pesticides is prevalent in agriculture, especially in the North of Benin, where cotton cultivation is highest.

Bee Keeping
In Benin, honey producers are mostly found in the Northwest regions. These producers practice either honey hunting or have small beekeeping units often limited to few hives that are generally made using traditional techniques. 70 percent of honey production in Benin is honey hunting, using fire hunting or honey harvest methods in the holes of trees, caves and on trees, much of the time resulting in destroying the beehives. Beekeeping is still a very underdeveloped practice.

MARINE AND ARTISANAL FISHERIES

The subsector of fishery includes three main areas of activity: marine fisheries, continental fisheries and aquaculture. Benin has a coastline of approximately 121 km, which stretches from the Nigerian to the Togolese border. The exclusive economic zone (EEZ) has an area of almost 27,750 square kms. The continental shelf has a sandy bottom and covers a surface of approximately 2,800 square km between isobaths 10 and 100 m, but reaches 3 100 square km between 10 and 200 m. Upwellings occur rarely and are weak. The average width of the continental shelf reaches 27 km. In spite of this narrowness of the shelf, the ichthyologic fauna is quite diverse, presenting more than 257 species including 43 *Elasmobranchii* and 214 *Teleosts*.

Marine Artisanal Fishery
Marine artisanal fishery is done by fishers from 80 fishing-villages distributed over four coastal departments of Benin. Currently there are 4,345 artisanal fishermen operating at sea including 2,234 Beninese (51.4 percent), 1993 Ghanaians (46 percent), 115 Togolese (2.54 percent) and 3 Nigerians (0.06 percent). They usually use gillnet, purse seine, beach seine and hook and line. The marine artisanal fishing fleet is comprised of 816 operational canoes, of which approximately 46

percent are powered by outboard engines, according to the results of the socio-economic survey of 1999. Inland fishery annually produces a large quantity of fish. The great number of reservoirs, rivers, brooks, etc. yield a production estimated at 30,000 tons per year. There is little data on inland fishery.

Artisanal Inland Fishery

Inland fishery is a very important activity for the riverside communities, given that it generates employment and provides a reliable source of proteins. Approximately 57,500 fishermen and approximately 100 women, who compete with these men, work on Lake Ahémé and on the coastal lagoon, fishing for crabs and oysters. Approximately 40,000 women are employed in the fish processing sector. In addition, activities related to inland fishery provide livelihoods to another 300,000 people, such as fishing gear salesmen, dugout canoe manufacturers and those employed in cutting, scaling and storage of the catch.

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 and significant 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 6 in section 6.5 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 accidently 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 Best Management Practices (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 6 in Section 6.5 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 Benin is mainly conducted away from the household and the sale of honey provides significant income to the residents, particularly in the Northwest of Benin in the Atacora region. 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.

SPECIAL NOTE ON NATIONAL PARKS

According to Beninese law, and upon discussion with the CENAGREF (government body in charge of national park management), IRS will not be conducted within the 5km buffer zone of the park. While the IP following strict protocol has led to positive results in other countries in the past, ultimately it is the decision of the CENAGREF on whether or not the populations that live within these areas will receive IRS. In the Pendjari park, there are no more than 500 people that live within the 5 km buffer zone. Within the W Park, however, approximately 45,000 people live in the buffer zones. As an alternative to IRS, the households will receive ITNs.

5.2.2 Indirect Adverse Effects

Upon termination of the IRS program, PMI 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 GoB, 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 PMI and/or the PMI IP, requires that PMI and/or the PMI IP provide environmental training to the GoB in the PMI IRS BMPs Manual, 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 GoB these activities must be mentioned in the annual Letter Report, in addition to this SEA. These activities do not require environmental compliance monitoring, however, PMI and/or the PMI IP must provide environmental training in the PMI IRS BMP. These requirements relate to the use of non-DDT insecticides by the GoB. The conduct of IRS by District Medical Officers with communities, using properly working equipment left behind by PMI 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 Medical 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 un-intentional 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 and agitating it to ensure ample mixing with the water. The process of mixing the pesticide can lead to exposures via inhalation, dermal contact, and incidental ingestion, from releases of pesticide vapors and liquids. 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 droplets 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. Once the pesticide gets into the soil, it can migrate to groundwater, which may be used as a water supply via household wells. In this manner, ingestion exposure can occur from drinking contaminated surface water. Residents may also be exposed to this contaminated water by dermal contact when it is used for cleaning or cooking 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- and Process-specific Potential Health 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 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, especially if disposal sites are well-chosen and BMPs are followed. There are indications[2] that the capsule suspension form of Actellic is more resistant to environmental degradation than either Actellic EC, or the other WHOPES-recommended pesticides.

Repeated exposures to organophosphates can 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, and that team leaders, site supervisors and other staff monitor spray operators and others with potential contact with organophosphates for the signs of cholinesterase depression. 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.

[2] Mitchell, David, and Chandonait, Peter (2015)

6. 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 Benin 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 Benin.

6.1 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 6.1-6.12 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 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 the Ministry of Health and the NMCP, provides the assessment, notification and mitigation requirements of US regulations. PMI is therefore empowered, upon acceptance of this document and the receipt of formal authorization from a competent Benin authority, to use in Benin all WHOPES-recommended pesticides (except DDT) in the pyrethroid, carbamate, and organophosphate classes, and chlorfenapyr when recommended by WHOPES.

6.2 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.

- PRIMARY CRITERIA FOR CHOOSING PESTICIDES

Approval by the World Health Organization Pesticide Evaluation Scheme: Only insecticides recommended by WHOPES or by USEPA can be used in IRS. Certain pesticides in the organophosphate, carbamate, pyrethroid and organochlorine classes are WHOPES-recommended for use in IRS. Table 5 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 hut trials, and for IRS when and if it receives WHOPES-recommendation.

Table 5: WHOPES Recommended Pesticides with Effective Duration

Updated: 2 March 2015

WHO recommended insecticides for indoor residual spraying against malaria vectors

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

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://who.int/whopes/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/whopes/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 = pyrethroids.

Registration for use in Benin: In the case where the insecticide proposed for use in IRS is not registered in Benin, PMI will work with manufacturers and distributors, as well as the NMCP, MOH, MOE, MAEP, and the CNAC (Comité National d'Agrément et de Contrôle des Produits Pharmaceutiques) to obtain special authorization for the use of the pesticide.

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.

Pesticide must be appropriate for use on the wall surfaces of the selected location: In Benin, the majority of the houses in rural settings are still made up of mud wall surfaces, mud bricks and burnt bricks. Pyrethroids, carbamates, and organophosphates are known to function well on these surfaces, and are therefore appropriate for use.

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 Benin, vector susceptibility studies have confirmed the effectiveness of pirimiphos methyl in all the targeted districtst.

Monitoring Vector Susceptibility to Insecticides in Benin (2015)

CREC manages 11 entomological surveillance sites nationwide, including four sites in the current sprayed areas in Atacora Department (sites: Natitingou, Tanguieta, Kouande, and Pehunco) and a control site in Copargo in Donga Department. The remaining six sites are based in Adjohoun in Ouémé Department; Pobe in Plateau Department; Ouidah in Atlantique Department; Dassa in Collines Department; Parakou in Borgou Department, and Kandi in Alibori Department. These surveillance sites provide routine data on mosquito population dynamics and insecticide resistance in Benin. The level of vector resistance is mapped and regularly documented with the support of national research institutions and universities. The NMCP collaborates with the national research centers, notably CREC, to monitor resistance to inform insecticide selection. Coordination across all ministries implicated in vector control remains a priority area for improvement in the National Strategic Plan.

The three-month entomological surveillance from CREC report after the 2015 IRS campaign showed high mortality rates respectively 100% (June), 96% (July) and 87% (August). CREC reported that the malaria vector in Atacora continues to have high susceptibility to pirimiphos-methyl (organophosphate). CREC noted that pirimiphos-methyl CS formulation was effective on both susceptible and wild strain of the malaria vector, as well as on cement and mud walls. During the period from June to August, the monthly entomological monitoring showed also a high decrease of *An. gambiae* density in treated districts compared to control. The decrease was higher indoor treated houses compared to outdoor. The duration of effectiveness on the primary wall surface types will continue to be researched and considered when selecting insecticide class and active ingredient.

Ecological impact: Benin 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 6.5 and 6.7 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). PMI has evaluated various approaches for monitoring sprayer exposure to OPs, and has determined that biomonitoring is not routinely required when using pirimiphos-methyl. Exceptions as outlined in the new PEA (approval anticipated Aug 2016) will be followed.

- ### 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

6.3 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."[3]

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 insecticide-treated nets and indoor residual spray. 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

[3] [3] http://www.ipm.ucdavis.edu/IPMPROJECT/about.html

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. PMI supports an evidence-based approach and will continue to review health management information systems and entomologic data to determine where best to deploy IRS.

6.4 The Proposed Method or Methods of Application, Including Availability of Appropriate Application and Safety Equipment

IRS involves spraying an 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.

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. Spray operators are trained in and use spray patterns that have proven effective for providing long-lasting toxicity toward the malaria vector mosquito. 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.

6.5 Acute and Long-Term Toxicological Hazards Associated with the Proposed Use and Measures Available to Minimize Such Hazards

The 2012 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 6: Pesticide Toxicity

IRS Insecticide	Mammal	Bird	Fish	Other Aquatic	Bee	Persistence	Bioaccumulate
Alpha-cypermethrin (P)							
Bendiocarb (C)							
Bifenthrin (P)							
Cyfluthrin (P)							
DDT (OC)							
Deltamethrin (P)							
Etofenprox (P)							
Fenitrothion (OP)							
Lambda-cyhalothrin (P)							
Malathion (OP)							
Pirimiphos-methyl (OP)							
Propoxur (C)							
Chlorfenapyr (PR)							

Source: IVM PEA 2012

Key

High Toxicity	
Medium to High	
Medium Toxicity	
Low to Medium	
Low Toxicity	
Data Not Found	

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.

6.6 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 6.2 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/limit the development of 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 CREC in collaboration with the PMI supported AIRS Benin 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). The primary malaria vector in Benin is Anopheles gambiae s.s., but secondary vectors are also important to transmission. For example, the widespread distribution and continuous breeding of An. gambiae s.l. in the south, and more seasonal breeding in the north, results in a nationwide endemic transmission pattern with three distinct regions. In the coastal region that has many lakes and lagoons, there are two vectors: An. gambiae s.s. (particularly An. coluzzii: the M form) and An. melas only in localities along Lake Oueme, Lake Aheme and Lake Porto-Novo. In the central region of the country, malaria is holoendemic, and An. gambiae s.s. (An gambiae: the S form and An. coluzzii) is the primary vector.

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 will be taken prior to shipment to Benin, 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.

6.7 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 5). 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 solid 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 given away, disposed of in a landfill, or contaminated solid wastes are incinerated in an approved incinerator that will destroy the pesticide and prevent environmental contamination (see section 7.1.11). 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 7).

6.8 The Conditions under Which the Pesticide is to be Used

Chapter 4 of this document provides a detailed account of the environmental conditions in Benin 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 4, 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 NMCP, the MOE, the ABE and the CENAGREF 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.

6.9 The Availability and Effectiveness of Other Pesticides or Non-Chemical Control Methods

In Benin, 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 Benin 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.[4,5] 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 recommended pesticide classes (including chlorfenapyr in 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] Najera JA, Zaim M (2002). Malaria vector control – Decision-making criteria and procedures for judicious use of insecticides. WHO, Geneva, WHO/CDS/ WHOPES/2002.5. (Document available at: www.who.int/ctd/whopes/docs/JudiciousUseRev.pdf)

[5] 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.

6.10 THE REQUESTING COUNTRY'S ABILITY TO REGULATE OR CONTROL THE DISTRIBUTION, STORAGE, USE, AND DISPOSAL OF THE REQUESTED PESTICIDE

6.10.1 RELEVANT INSTITUTIONS (MINISTRIES OF ENVIRONMENT, AGRICULTURE, HEALTH (AS APPROPRIATE)

The institutional framework surrounding pesticide management lies within four main ministries: the **Ministry of Agriculture, Livestock and Fisheries (MAEP)**, **the Ministry of Environment**, the **Ministry Water and Energy** and the **Ministry of Health**.

The Ministry of Environment (Ministère de l'Environnement Chargé de la Gestion des Changements Climatiques du Reboisement et de la Protection des Ressources Naturelles et Forestières) is in charge of environmental legislation and regulation across all sectors in Benin.

The Benin Environmental Agency (ABE) is responsible for the enforcement of environmental regulations in the form of monitoring and effective mitigation of the negative impacts of projects including conducting Environmental Impact Assessments. This agency is responsible for managing the National Observatory of the Environment, enforcing some ratified international conventions including national environmental regulations, conducting and documenting activity reports and leading impact assessments on several activities that pose potential environmental risk in country.

The National Centre of Management of Fauna Reserves (Centre National de Gestion des Réserves de Faune, or CENAGREF) is in charge of national park management in Benin. Its mission is to conserve and manage nature reserves, national parks, wildlife reserves, special reserves and their buffer zones. CENAGREF is active in the Pendjari National Park and the W National Park. CENAGREF reports to the Ministry of Environment and Nature Protection.

The Ministry of Agriculture (Ministère de l'Agriculture de l'Elevage et de la Pêche) is in charge of all chemicals and substances that are used in pest control. The national strategy for management of plant protection products, to reduce the share of pests and pests and increase production while protecting human health and ecosystems. They actively engage in three main activities with respect to pesticides: stopping the introduction, distribution and use of plant protection products banned active ingredients; ensuring the sale of approved plant protection products (ie. Pesticides, herbicides and fertilizers) and ensuring that the application of these products is regulated only by authorized companies.

In Benin, the strategic actions related to the management of pests and pesticides is primarily the competence of the **Direction of Agriculture** (DAGRI) of the Ministry of Agriculture, including the **Plant Protection Service** (SPV). This service is responsible for monitoring the professional amenities and imported and distributed plant protection products. Inspections are carried out by plant protection inspectors at land borders, port and airport, and by VPD officers from the **Regional Action Centers for Rural Development** (CARDER).

The **CNAC** (Comité National d'Agrément et de Contrôle des Produits Pharmaceutiques); is the committee in charge of all pesticide registration and regulation in Benin.

The Ministry of Energy and Water sets general water sector policies and supervises their application. National sanitation policies are defined by the Hygiene and Basic Sanitation Authority (DHAB) under the Ministry of Health.

6.10.2 LAWS AND REGULATIONS

There are a number of existing laws, regulations, policies and institutions that identify requirements as well as highlight gaps and conflicts of the relevant legal and institutional arrangements that govern IRS activities. Environmental protection is under the Ministry of Environment and Protection of Nature which has created the Benin Environmental Agency (ABE) responsible for the technical management of environmental issues including the implementation of monitoring and enforcement of the SEA.

Apart from the Government of **Benin Environmental Act** (*Loi- Cadre sur l'Environnement en Republique du Benin*) (no. 98-030 of February 12th 1999) and the *Guide General de Realisation d'une Etude d'Impact sur l'Environnement* (from February 2001), which gives the format and requirements for the Environmental Impact Assessment required by the Beninese Environmental Agency (ABE), there are other regulations that need to be considered and respected for the implementation of the IRS program. These include:

Law No 91-004 of 11 February 1991 on phytosanitary regulations in the Republic of Benin: the provisions concerning health protection of plants and plant products, for the prevention and fight against pests both including their introduction to their spread in the country, in order to safeguard and ensure a satisfactory environment favorable to sustainable development. *Article 1: "The authorization of plant pharmaceutical products including importing, marketing and their use is done in order to provide sound quality products that are appropriately adapted to agriculture both technically and economically, to ensure the efficient use and with non-negative impact on the end user, the consumer and the environment." Article 2: "Plant Health Protection is the purview of the Minister in charge of Agriculture."*

Decree No 92-258 of September 8th 1992 Establishes the application modalities of the law No 91-004 on February 11th 1991 on Phytosanitary Regulation. Furthermore, in addition to being responsible for the registration of pesticides in Benin, the Ministry of Agriculture provides for the Plant Protection Service (Service de Protection de Vegetaux) whose role is to ensure surveillance of the pesticide's use, transport, and disposal, as outlined in the excerpts below: *Article 1: In application of the article 2 of the law 91-004 of February 1991, the Plant Protection Service within the Directorate of Agriculture of the Ministry of Rural Development is charged with phytosanitary protection across the territory of the Republic of Benin.*

Decree No 2001-235 from 12th of July 2001 This decree touches on the organization of the procedures of the Environmental Impact Assessment for the Government of Benin. This decree outlines the projects in Benin that require a "simple" EIA, and the projects that require an "In Depth" EIA. In the context of PMI IRS in Benin, IRS will not require an "In Depth" EIA, because spraying will not take place within wetlands or biodiversity of international significance, for example: RAMSAR sites. Article 3: Projects that are subject to an "In Depth" EIA are projects that are of great importance, outlined in Annex 1 and those that are described in Article 2, but are taking place in ecologically sensitive zones that are described in Annex 2.

Article 5: All promoters of the project are subject to the approval of the Benin Environmental Agency (ABE) and their terms of reference of the Environmental Impact Assessment relative to the project.

Law No 98-004- on Labor Code from January 27th 1998 The Beninese Workers conduct and safety law outlines that there must be security and heads of establishment. All personnel will be managed and supervised such that risks are minimized as much as possible and that they follow safety guidelines approved by the WHO, which will be outlined in cascade trainings.

Law No 87-015 of 21 September 1987 on Public Hygiene Code: legislation on housing, noise, water, environmental pollution, industrial facilities, beaches, classified establishments, animal health.

Law No 2010-44 of October 21st 2010 on Water Management in Benin: Governs the management of water and water resources in quantitative and qualitative terms. It replaces the previous Water Code and includes participatory management and basin management. The new law comprises arrangements for water pollution actions prohibition and preservation of its quality.

Law No 2002-016 of 18 October 2004 on the regime of wildlife in Benin: Lays down the provisions for the rational and participatory management of wildlife and its habitats, creation and management of protected areas in the protection of endangered species, vulnerable or endemic, and finally to the offenses and penalties. This law is a fundamental element that reinforces the objectives of the program include the conservation of biodiversity across biological reserves managed by the grassroots communities.

Decree no. 2011 – 394 of 28 May 2011 governs the conservation of nature in Benin, specifically with regards to the buffer zone around protected areas. Title 4, Article 36: the buffer zone is the bandwidth of at least 5 km belt which is intended to buffer a protected area, in this case, the Pendjari National Park and the W National Park. Only the governing body of this protected area is authorized to change these parameters, keeping in mind the concerned local populations. This was the case for the two aforementioned parks, where the parks themselves are amenable to the idea of allowing IRS within the 5 km buffer zone, however, it has not been permitted at the national level governing body, the CENAGREF.

Law No 93-009 from 02 July 1993 governing forests in Benin: lays down the provisions on "the management, protection, forestry, trade and industry of forestry and related products." The Forest Code defines the different types of forest regime (federal, private, community, assigned), their management and wildlife reserves and hunting issues. The provisions of punishment of offenses related to poaching and unsustainable logging; Article 11 has a favorable provisions in the Project shall be decided that "[...] the necessary forest [...] to the preservation of sites and nature conservation" may be classified.

Benin is also a signatory to a number of International Conventions and has ratified various multilateral agreements. Please see table below.

Table 7: International Conventions / Ratified Multilateral Agreements Relevant to Pesticide use and Management

N°	Convention / accord	Ratification Date (or signature)
01	United Nations Framework Convention on Climate Change	30 June1994
02	United Nations Framework Convention on Desertification	30 June 1994
03	Convention on Biological Diversity	30 June 1994
04	Convention on cooperation for the protection and enhancement of the marine environment and coastal areas of West and Central Africa	16 January 1997
05	Kyoto Protocol	25 February 2002
06	Convention on wetlands, habitats of water birds - Ramsar Convention	20 January 2000
07	UNESCO World Heritage Convention	14 September 1982
08	Bonn Convention- Conservation of Migratory Species	1st April 1986
09	Inter-African Phytosanitary Council IAPSC	1st April 1974
10	Stockholm Convention on POPs	23 May 2001
11	Basel Convention	12 April 1997

6.10.3 Strength and Ability of Enforcement

- **ABE/ Ministry of Environment**: National expertise and availability of funds is lacking at the national, regional and district levels. This problem involves both technical personnel and other players (research department, NGOs, and so on), in that there is not enough capacity to conduct inspection visits and environmental biomonitoring of the IRS areas. The AIRS IP has taken measures to have ABE and Ministry of Environment personnel accompany IP staff (the ECO) on environmental scoping and inspection visits, before, during and after IRS activities.
- **SPV/Ministry of Agriculture**: There is still a very large black market for unapproved pesticides in Benin and for reasons of lacking capacity to conduct the monitoring and inspections.

6.11 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 *Manual on Sound Management of Pesticides and Diagnosis and Treatment of Pesticide Poisoning,*[6], 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.

[6] WHO-UNEP Sound Management of Pesticides and Diagnosis and Treatment of Pesticide Poisoning: A Resource Tool. World Health Organization, Geneva. 332 Pages. Document also accessible at: http://www.who.int/whopes/recommendations/IPCSPesticide_ok.pdf

PMI will support the training of spray operators and supervisors, and provide overall guidance and logistical support to the IRS operations in Benin. The IP 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:

- A training of trainers program, in which potential supervisors[7], 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.

6.12 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. Direct methods measure the efficacy of the pesticide, that is, the degree to which the pesticide is able to kill the targeted mosquito vectors, and involve 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 primary goal of reducing the local disease burden. These efforts 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 Benin, this characteristic may be critical to the success of IRS. Therefore pirimiphos-methyl in the CS

[7] These are usually health-related government staff within the targeted district (health assistants/educators/ inspectors, nursing assistants, and community development assistants).

formulation has been used for PMI spraying in the Northern Region of Benin since 2013, and will continue to be used in 2016 in the Atacora Region.

7. Safer Use Action Plan

This section outlines the safer use action plan proposed to mitigate the potential adverse impacts outlined in Section 5. 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 and facilities for the storage and disposal of pesticides and contaminated waste. The mitigation measures, along with monitoring and reporting information, are compiled in the EMMP found in Annex A.

7.1 Implementation Conditions

During implementation, PMI/Benin 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 assessment.

7.1.1 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.

7.1.2 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.

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

7.1.3 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 recommended vehicle to transport insecticides from central to district stores. If box trucks are not available, the IP will notify the COR 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 required.

Prior to long-distance transport of the insecticide from the customs warehouse or AIRS Benin central storage facility, drivers will be trained 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 the wrong hands.
- 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 of insecticide and toxicity of the combustion byproducts

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. Don protective clothing 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 must be shut off and smoking in the area strictly prohibited.
4. Onlookers and bystanders must be prevented from approaching the accident site.
5. If anyone has come in contact with the pesticides, they must remove contaminated clothing immediately and wash the pesticide off their skin.
6. For a spill involving more than two boxes of pesticide, send for help immediately. Drivers must have cell phones and an emergency number for use in such cases. In Benin you dial 118.
7. People must 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 pesticides are required to 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, it is important to ensure that vehicles are decontaminated after use. 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.

7.1.4 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, warehouse(s) must be assessed to ensure that they can meet BMP standards. During the geographical reconnaissance, logistics and pre-spray environmental compliance assessments, the need for new or rehabilitation of previously used pesticide and commodity storehouses will be assessed. The standards include:

- Located at least 30 meters from flood plains, wetlands and water bodies, markets, schools, dwellings, beehives, and protected areas. Warehouses may not be located in the buffer zones of protected areas, or in schools.
- 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 leak-free tarpaulin
- Watertight roofing
- Barred and screened windows
- Preferably 2 exits from the pesticide storage area for emergency purposes
- Fire extinguisher

In addition to the above, all facilities used for storage, distribution, and transportation of insecticide products should comply with relevant requirements of Benin CNAC pesticide regulations. 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 Benin, IRS is implemented in partnership with the MoH/NMCP, therefore, some warehouses are located on District Medical Office / District Health Centers' property for logistical and security purposes.

7.1.5 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.

Site considerations for locating IRS cleaning and waste management 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, soak pits 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 that exist within facilities that do not have controlled access to their vicinity should be fenced off with danger signs with skull and crossbones pictogram posted in the appropriate language, in this case French.

Soak pits 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.

Although the soak pit captures the majority of pesticide from washwaters, small amounts may pass through and enter the soil below. Soil characteristics affect how pesticides move through the soil, and how they break down by environmental or microbiological 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 to capture and degrade trace amounts of pesticide. 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 and wash area with a tarpaulin when not in use, to prevent flooding of the soak pit and subsequent runoff of pesticide-contaminated water.

7.1.6 Warehouse/Storage Risk Management

In order to mitigate risks associated with pesticide storage, the following will serve as warehouse/storage best management practices:

- A trained storekeeper will manage each facility and will wear gloves, mask, overalls, and boots when in the pesticide area of storage.
- No smoking or eating will be allowed within 30 meters of the pesticide storeroom.
- Pesticide storage facilities must have thermometers installed for daily temperature recording.
- Soap and clean water will be available at all times in all the facilities.
- Recommended pesticide stacking position and height in the warehouse as provided in the FAO Storage and Stock Control Manual will be followed.
- A fire extinguisher will be available in the storage facilities and all site workers will be trained on how to use this device.
- Warning notices will be placed outside of the store with skull and crossbones pictogram, and warnings in the local language
- Insecticides must be lifted off of the floor via pallets or shelves.
- 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.

Accidental Warehouse Fires

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. Security guards must be trained on how to extinguish fires and instructions must be posted on the warehouse wall with important phone numbers.

7.1.7 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. Provided their work history has been acceptable, females who have been hired and later 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.

7.1.8 Spray Operator Exposure

The individuals recruited for IRS campaigns will receive intensive training on the use, operation, calibration and repair of the spray pumps, including hands-on exercises prior to the beginning of the spraying campaign. They will also be trained 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 will be conducted in accordance with the IRS Training Guide for Spray Operations (USAID, 2009) and the 2015 IRS BMP manual. Potential spray operators must also pass written and practical tests at the end of training.

Training for monitoring spray operators for symptoms of pesticide exposure will be mandatory for team leaders and supervisors, as well as for storekeepers and other senior personnel. Any case of an operator or beneficiary displaying symptoms of exposure will require the immediate completion of a standard Incident Report Form by the district coordinator, who will submit to the PMI (COR) Team and the PMI IRS Activity Manager in Benin within 48 hours.

For malathion and fenitrothion OPs, it may be necessary to monitor the level of acetyl cholinesterase in any worker who may have been exposed to contamination. Occupational exposures to OP insecticides are measurable using blood cholinesterase and urinary excretion of chemical biomarkers. PMI has evaluated various approaches for monitoring sprayer exposure to OPs, and has determined that biomonitoring is not routinely required when using pirimiphos-methyl. Exceptions as outlined in the new PEA (approval anticipated Aug 2016) will be followed."

In addition, the WHOPES Working Group recommendations state that, "provided that operational guidelines are followed, routine cholinesterase monitoring of spray men during IRS programs is not required" for Actellic CS.

7.1.9 Beneficiary Exposure

Residential exposure will also be monitored. During the IEC campaign, residents are made aware of the steps to take to prevent exposure, and the protocol to follow if exposed. If acute symptoms are encountered, the advice is to report to the nearest health facility. Thus reported cases at health facilities or by IEC mobilizers will serve as the principal monitoring strategy for beneficiary exposure incidents.

NMCP, Chief District Doctors (Medecins Chefs), and the PMI IRS IP 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 Benin National Malaria Strategic Plan 2014-2020 and PMI Malaria Operational Plans. The IEC campaign (as well as IRS project leaders and MOH/NMCP Officers) 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.
- Children and adults must stay at least 10 meters from the home during spraying, and for two hours after spraying.
- Move and keep all animals at least 10 meters from 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.
- Sweep up any insects killed from the spraying and drop them in latrine pits before allowing re-entry by children and animals.
- Do not re-plaster or paint over the sprayed walls after spraying.
- Keep using bed-nets for additional 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 can provide the appropriate medical intervention.
- If spraying during the rainy season, the teams should follow the instructions below to 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 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 middle of spraying:

- Stop the spraying activities.
- Cover the household effects with an impermeable material. These materials should have already been procured by the program and given to each operator.
- After the rains stop and the weather is considered good spraying can continue.

7.1.10 Pesticide Exposure and Treatment

All spray operators, team leaders, and supervisors will receive detailed training on the emergency steps to take if accidental exposure of the chemical occurs including ingestion, inhalation, eye or dermal contact with the chemical. This training will be conducted by the District and Sector Coordinators and will include drills to test knowledge of the operators. Team leaders must check the health of their spray operators each morning, especially looking for signs of pesticide exposure.

Most interventions for acute exposure will have to be provided by medical professionals at the nearest health clinic, so transporting the exposed person to the health clinic will be the priority. PMI IPs will confirm that all the health facilities around the spray sites have in their store the recommended treatment drugs, and that all the staff responsible for administering emergency treatment to pesticide

exposure receive appropriate training. Annex F provides additional information on symptoms and treatment protocols.

7.1.11 Solid and Liquid Contaminated Waste Management

Non-contaminated wastes, or those that can be cleaned thoroughly with soap and water will be given away (overalls, boots, and gloves) or recycled whenever possible, or disposed of in a municipal landfill if there is no appropriate recycling outlet.

Liquid contaminated wastes will be disposed of on a daily basis in soak pits that are carefully sited and designed according to the criteria in this SUAP and the PMI BMP manual. The soak pit is designed so that pesticides are adsorbed by the charcoal layer, and held until environmental processes result in the degradation of the pesticide. Thus, there should be no contaminated liquid waste to deal with at the end of the spray season.

Contaminated solid wastes are incinerated in incinerators that are capable of destroying the pesticide and preventing environmental contamination.

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 for DDT or insecticides which contain > 1% chlorine (FAO 1996).

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 Benin, ash and slag will be incorporated into cement blocks and buried.

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 Benin, the implementing partner will work with the appropriate authorities to ensure that the ash and slag are disposed of according to Beninese law.

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. The EMMP in Annex A gives details on the steps and measures that will be taken to prevent negative impacts on the non-target ecosystems from liquid and solid IRS waste materials and disposal practices.

8. Annex A: Environmental Mitigation & Monitoring Plan

Please See the EMMP next page

Category of Activity	Describe specific environmental threats of your organization's activities	Description of Mitigation Measures	Who is responsible for monitoring	Monitoring Indicator	Monitoring Method	Frequency of Monitoring
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

Category of Activity	Describe specific environmental threats of your organization's activities	Description of Mitigation Measures	Who is responsible for monitoring	Monitoring Indicator	Monitoring Method	Frequency of Monitoring
		duty fitness. f. Procure, distribute, and train all workers with potential pesticide contact on the use of PPE. g. Train operators on mixing pesticides and the proper use and maintenance of spray pumps. h. Provide adequate facilities and supplies for end-of-day cleanup. i. Enforce clean-up procedures.		team members. f. Spray operators wear complete PPE during spraying and clean-up. g. Operators mix pesticide properly, and the pump does not leak. h. All facilities are compliant, and materials required for clean-up are present. i. Inspections are performed as scheduled, corrective action is taken as needed.		

Category of Activity	Describe specific environmental threats of your organization's activities	Description of Mitigation Measures	Who is responsible for monitoring	Monitoring Indicator	Monitoring Method	Frequency of Monitoring
	2. Safety risks for residents of sprayed houses (e.g., risks from inhalation and ingestion of insecticides)	a. IEC campaigns to inform homeowners of responsibilities and precautions. b. Prohibit spraying 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.	a-b. IEC officers, OM, ECO c. ECO d. Spray operators (SO) and Team Leaders (TL)	a. Pre-spray IEC campaigns were executed. Homeowners know 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.	a. OM- IEC work records, ECO- mid-spray inspections. b-d. ECO mid-spray inspections	a. Inspect work records 1/campaign, b-d. ECO mid-spray inspections 3/wk.
	3. Ecological risk to non-target species and water bodies from use of insecticides (during	a. Spray indoors only. b. Train operators on proper spray	a-c. TL, Abt District Coordinator (DC), OM, ECO	a. Operators spray only inside of houses. b. Operators are	a. ECO mid-spray inspections. b-c. Training records, ECO mid-	a. ECO inspections 3/wk. b. ECO inspection of

Category of Activity	Describe specific environmental threats of your organization's activities	Description of Mitigation Measures	Who is responsible for monitoring	Monitoring Indicator	Monitoring Method	Frequency of Monitoring
	mixing and spraying)	technique. c. Maintain pumps. d. Monitor spraying in sensitive sites. Maintain required spray distance from bee keeping, wetlands, surface water. No spraying in forested areas per Benin Forest Act.		trained and know and use proper spray techniques. c. Pumps are maintained and operated to eliminate leaks and erratic spraying.	spray inspections	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 and secure 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	a-c. Abt OM, ECO, DC d-f. Abt ECO	a. Operations sites meet PMI BMPs. b. Soak pits are constructed according to the AIRS BMP manual. c. Soak pits perform properly throughout the	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

Category of Activity	Describe specific environmental threats of your organization's activities	Description of Mitigation Measures	Who is responsible for monitoring	Monitoring Indicator	Monitoring Method	Frequency of Monitoring
		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.		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.		
	5. Risk of diversion of insecticides for unintended or uncontrolled use	a. Maintain records of all pesticide receipts, issuance, and return of empty sachets/bottles. b. Reconcile number	a-d. Storekeepers, District coordinators, sector managers, logistics coordinator, OM,	a-d. All pesticide management records are reconciled.	a-b, d. Inspection of pesticide management records. Storekeeper performance	a-b, d. Daily monitoring by storekeeper or site supervisor. Weekly monitoring by District

Category of Activity	Describe specific environmental threats of your organization's activities	Description of Mitigation Measures	Who is responsible for monitoring	Monitoring Indicator	Monitoring Method	Frequency of Monitoring
		of houses sprayed vs. number of sachets/bottles used. c. Examine houses sprayed to confirm spray application. d. Perform physical inventory counts during the spray season. e. Maintain secure transport of pesticides by using a lockable box truck , or equivalent security mechanism approved by the COR.	ECO		checklists. c. ECO mid-spray inspections.	Coordinators c. 1/campaign by country headquarters. 2/campaign by ECO d. 2/campaign/ store-room

9. ANNEX B: EMMR FORM

Mitigation Measure	Status of Mitigation Measures	Outstanding issues relating to required conditions	Remarks
1a. Pre-contract inspection and certification of vehicles used for pesticide or spray team transport.			
1b. Driver training			
1c. Cell phone, personal protective equipment (PPE) and spill kits on board during pesticide transportation.			
1d. Initial and 30-day pregnancy testing for female candidates for jobs with potential pesticide contact.			
1e. Health fitness testing for all operators			
1f. Procurement of, distribution to, and training on the use of PPE for all			

Mitigation Measure	Status of Mitigation Measures	Outstanding issues relating to required conditions	Remarks
workers with potential pesticide contact.			
1g. Training on mixing pesticides and the proper use and maintenance of spray pumps.			
1h. Provision of adequate facilities and supplies for end-of-day cleanup,			
1i. Enforce clean-up procedures.			
2a. IEC campaigns to inform homeowners of responsibilities and precautions.			
2b. Prohibition of spraying houses that are not properly prepared.			
2c. Two-hour exclusion from house after spraying			
2d. Instruct homeowners to wash itchy skin and go to health clinic if symptoms do			

Mitigation Measure	Status of Mitigation Measures	Outstanding issues relating to required conditions	Remarks
not subside.			
3a. Indoor spraying only.			
3b. Training on proper spray technique			
3c. Maintenance of pumps			
4a. Choose sites for disposal of liquid wastes according to PMI BMPs.			
4b. Construct soak pits with charcoal to adsorb pesticide from rinsewater.			
4c. Maintain soak pits as necessary during season.			
4d. Inspection and certification of solid waste disposal sites before spray campaign.			
4e. Monitoring waste storage and management during			

Mitigation Measure	Status of Mitigation Measures	Outstanding issues relating to required conditions	Remarks
campaign.			
4f. Monitoring disposal procedures post-campaign.			
5a. Maintain records of all pesticide receipts, issuance, and return of empty sachets/bottles.			
5b. Reconciliation of number of houses sprayed vs. number of sachets/bottles used.			
5c. Visual examination of houses sprayed to confirm pesticide application.			
5d. Perform physical inventory counts during the spray season.			

10. Annex C: Public Consultation & Preparation Methodology

This SEA was prepared by, Jeanne Chabrier, a short term environmental compliance consultant. A short-term technical assistance trip was made to Benin, in order to meet with major stakeholders and gather the information necessary for the SEA preparation. The EC Consultant first attended meetings with the NMCP, Ministry of Environment, ABE, CENAGREF in Cotonou, where she discussed the need for the SEA to meet US regulatory requirements, and the parallel Benin requirements. Accompanied by Abt Associates and NMCP staff, she then traveled to several regions to meet with regional and district health officers and other relevant stakeholders. 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 regions visited, meetings were first held with the Regional Health Centers DDS (Direction Departemental de Sante) at the regional level and the District Medical Office at district level. In these meetings, malaria came out to be the number one disease with high disease burden in all the districts visited. As such, all the RMOs and DMOs welcomed IRS.

Several medical officers and others commented that a frequently heard complaint from beneficiaries was that during the initial round of IRS in 2013, when they used pirimiphos-methyl EC (Emulsifiable Concentrate), that it made the households smell bad. The next spray round, the product was switched to pirimiphos-methyl CS (capsule suspension), and the problem was resolved according to public discussion. There were no other issues mentioned by beneficiaries relating to the performance of IRS.

After these consultations, in most cases, the SEA scoping team arranged for visits to storerooms and soak pits to observe the conditions and status. Also, the current incinerator being used at the Commune Hospital of Tanguieta was visited, and confirmed that it does meet the WHOPES specifications for incinerating contaminated wastes.

After the field trips, the consultant and the DECS prepared the first draft of this SEA, which was submitted to PMI. Comments and edits were received and incorporated into the final draft, which was submitted for all appropriate approvals.

The table in Annex D comprises the names of the people who were interviewed during the preparation of the SEA.

11. Annex D: Names of Participants

NAMES AND POSITIONS OF THE STAKEHOLDERS INTERVIEWED

S#	Name	Organization	Position
1	Thursday, January 14th, 2016	Abt Offices in Cotonou with Bertille Onambele and Damien Kodjo Meeting with PMI Peter Thomas and Harriet Ahokpossi	Bertille +229 21325224 +229 67199583 Bertille_onambele@africairs.net Damien Kodjo +229 671995884 Damien_Kodjo@africairs.net
2		ABE with Dr Edmond Sossoukpe – Directeur General – Biologiste et Amenagiste des milieu Aquatiques (Universite d'Abomey-Calavi)	Dr Edmond Sossoukpe (PhD) +229 97999010 esossoukpe@yahoo.fr
3		PNLP with Directeur Mariam S. Okè et Evelyne Akakpo , Environment and Sustainable Development Liaison at PNLP	Evelyne Akakpo - +229 97808062 /+229 95613501 jeannlyna@yahoo.fr
4	Friday, January 15th, 2016	CREC with Prof Martin Akogbeto	Professeur Akogbeto +229 97330825 akogbeto@leland.bj
5		AGRI – CNAC with Agricultural Engineer , Protection of Plants	Desire Jesunoukon + 229 97197883 ; +229 99659695 ; +229457846 desireligan@yahoo.fr
6		CENAGREF - Dr. Ferdinand Claude	Dr. Ferdinand Claude Kidjo, Technical Director +229 21

S#	Name	Organization	Position
		Kidjo, Technical Director	380692 / +229 971771 11 / 95426810 / 90065403 lkidjo@yahoo.fr / claudekidjo@gmail.com
7	Monday, January 18th, 2016	Director of Health Center in Natitingou Dr. Mahamoud Zongo, Director	Dr. Mahamoud Zongo, Director +229 94230191 mahamoudz@yahoo.fr / kewoulere@gmail.com
8		Djougou Health Center Lead Dr Orou Yari Mohamed	Dr Orou Yari Mohamed +229 96706781
9		Health Center in Oake – Lead Dr Moutoama Doumitou	Dr Moutoama Doumitou +229 95808084; +229 97601188 mdoumitou@yahoo.fr
10	Tuesday, January 19th, 2016	Director of Pendjari Park	Meryas Kouton +22997588768/95549398
11	Wednesday, January 20th, 2016	Kouande – Community Coordinator	Lafia Seke +229 97352551
12		CARDER Kouande – Plant Pollution Technician	Richard Mayaba +22962909030
13		Pehunco – Head Doctor	Dr. Prisca Djekete +22995957555
14		Kerou CARDER – Koi-Innocent Tsiec – Technician specialized in Cooperative Edication	Koi-Innocent Tsiec +229 642244739
15	Thursday, January 21st, 2016	Kandi Health Center – Head Doctor Brice Aho-Glele	Dr. Brice Aho-Glele +229 94224105 /94734283
16		Segbana – Head Nurse Constant	Constant Tamou - +229 94611594

S#	Name	Organization	Position
		Tamou	Head Doctor - +229 94687006
17		Kandi – Director of the W Park Theophile A. Sinadouwirou	Theophile A. Sinadouwirou +229 23630080 / +229 23650195 / +229 94403435 / +229 97112756 parcwbenin@yahoo.fr tsinad@yahoo.com
18	Friday, January 22nd, 2016	Gogounou Health Center Head Nurse Georgette Bodee-N'goye	Georgette Bodee-N'goye +229 94318863 / +229 96372792
19		Directeur de l'environnement de l'Atacora et de la Donga - Chabi Sero Tamou	Chabi Sero Tamou +229 96063640 / +229 94592224 tchabisro@gmail.com

12. Annex E: References

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

Abt Associates. March 2015. *Benin Start-up & Transition work Plan February 20, 2015 – September 30 2015.* USAID

FAO (1996). *Disposal of bulk quantities of obsolete pesticides in developing countries* http://www.fao.org/fileadmin/user_upload/obsolete_pesticides/docs/w1604e.pdf

Najera JA, Zaim M (2002). *Malaria vector control – Decision-making criteria and procedures for judicious use of insecticides.* WHO, Geneva, WHO/CDS/ WHOPES/2002.5

Abt Associates, (2010). Supplemental Environmental Assessment: Benin, using Pyrethroids, Organophosphates, and Carbamates, USAID.

Ministry of Health and Social Welfare, Benin National Malaria Strategic Plan 2011-2015 (2018)

USAID (2015a). PMI Benin Malaria Operational Plan FY 2015.

USAID (2015b). President's Malaria Initiative Strategy 2015–2020.

USAID (2015c). President's Malaria Initiative Best Management Practices (BMP) for Indoor Residual Spraying (IRS) in Vector Control Interventions.

Were, Allan. (August 2013). AIRS IRS Storekeepers Pocket Guide. Bethesda, MD: Africa Indoor Residual Spraying Project, President's Malaria Initiative.

Were, Allan. (January 2014). Spray Operator Pocket Guide. Bethesda, MD: Africa Indoor Residual Spraying Project, President's Malaria Initiative.

WHO (2012). Global plan for insecticide resistance management in malaria vectors. World Health Organization, Geneva.

WHO. (2013) Test procedures for insecticide resistance monitoring in malaria vectors. World Health Organization, Geneva.

WHO (2014). Report of the seventeenth WHOPES working group meeting: WHO/HQ, Geneva, 15-19 September 2014: review of Alpha-cypermethrin 250 WG-SB, Icon maxx, Netprotect LN, Chlorfenapyr 240 SC. World Health Organization, Geneva.

WHO-UNEP Sound Management of Pesticides and Diagnosis and Treatment of Pesticide Poisoning: A Resource Tool. World Health Organization, Geneva.

13. Annex F: Summary of Acute Exposure Symptoms & Treatment of IRS Pesticides

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

Carbamates	Human side effects	Treatment
Bendiocarb	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.	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.
Propoxur	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.	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.

Summary of Acute Exposure Symptoms and Treatment of WHO-recommended organophosphates

Organo phosphate	Human side effects	Treatment
Malathion	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.	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, tranquillizers, and central stimulants are all contraindicated.
Fenitrothion	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.	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.

Organo phosphate	Human side effects	Treatment
Pirimiphos-methyl	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.	OP poisoning is a medical emergency and requires immediate treatment. All supervisors and individual spray operators (in the case of dispersed operations) should be trained in first-aid and emergency treatment of OP intoxication. 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. 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. Atropine sulfate. Administer atropine sulfate intravenously or intramuscularly if intravenous injection is not possible. Glycopyrolate has been studied as an alternative to atropine and found to have similar outcomes using continuous infusion.

Summary of Acute Exposure Symptoms and Treatment of WHO-recommended pyrethroids

Pyrethroids	Human side effects	Treatment
Bifenthrin	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.	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.
Deltamethrin	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.	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.
Lambda-Cyhalothrin	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.	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.

Pyrethroids	Human side effects	Treatment
Alpha-Cypermethrin	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	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.
Cyfluthrin	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.	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.
Etofenprox	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.	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.

Summary of Acute Exposure Symptoms and Treatment for Chlorfenapyr

Human side effects	Treatment
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, hyper-perspiration, nausea and vomiting. He was initially diagnosed as being dehydrated. Another patient initially presented with hyper-perspiration, headache and cough. Symptomatic management was initiated, but after seven days she suffered neurological and respiratory deterioration, causing her death.	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.

USAID
FROM THE AMERICAN PEOPLE

Allison Belemvire <abelemvire@usaid.gov>

Re: 2nd Draft Supplemental Environmental Assessment, Benin

Rachel Dagovitz <rdagovitz@usaid.gov> Fri, Apr 8, 2016 at 7:11 PM
To: Allison Belemvire <abelemvire@usaid.gov>
Cc: Peter Chandonait <Peter_Chandonait@abtassoc.com>, Rachel Dagovitz <rdagovitz@usaid.gov>

Thank you. Internet seems to be working (for now) so I was able to complete the review by going back to track changes document. I agree that the language for bio-monitoring should be addressed through the PEA update. I saw that my comments were addressed, so I clear the Benin SEA. I'll be in the office April 20-21 and then out until May2nd. I can clear by email or sign if the document is ready by 4/21.

On a separate note, I wanted to let you know that Peter and his team organized an excellent traning. Additionally, a great opportunity for me to meet most of the ECOs.

Rachel

On 4/8/16, Allison Belemvire <

> final comments and edits, if necessary.
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> Best,
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> Peter
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>
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