Military Deployment
Periodic Occupational and Environmental Monitoring Summary (POEMS):
Barclay Training Center and Vicinity, Liberia
Calendar Years: (2014 to 2015)

AUTHORITY: This POEMS has been developed in accordance with Department of Defense (DoD) Instructions 6490.03, 6055.05, and Joint Chiefs of Staff memorandum MCM 0017-12 (References 1-3).

PURPOSE: This POEMS documents the Department of Defense (DOD) assessment of occupational Camp Buchanan, Bong Navy Ebola Lab (BNEL), Gbediah Ebola Treatment Unit (ETU), Camp Greenville, James Spriggs Airfield (JSA), National Police Training Academy (NPTA), Roberts International Airport (RIAP), Camp Sanniquellie, Camp Tappita, Camp Zwedru, and Camp Monrovia. It presents a qualitative summary of OEH risks identified at these locations and their potential medical implications. The report is based on information collected from 01 September 2014 through 31 December 2015 to include deployment OEH surveillance sampling and monitoring data (e.g., air, water, and soil), field investigation and health assessment reports, as well as country and area-specific information on endemic diseases.

This assessment assumes that environmental sampling at BTC and vicinity during this period was performed at representative exposure points selected to characterize health risks at the *population–level*. Due to the nature of environmental sampling, the data upon which this report is based may not be fully representative of all the fluctuations in environmental quality or capture unique occurrences. While one might expect health risks pertaining to historic or future conditions at this site to be similar to those described in this report, the health risk assessment is limited to 01 September 2014 through 31 December 2015.

The POEMS can be useful to inform healthcare providers and others of environmental conditions experienced by individuals deployed to BTC and vicinity during the period of this assessment. However, it does not represent an individual exposure profile. Individual exposures depend on many variables such as; how long, how often, where, and what someone is doing while working and/or spending time outside. Individual outdoor activities and associated routes of exposure are extremely variable and cannot be identified from or during environmental sampling. Individuals who sought medical treatment related to OEH exposures while deployed should have exposure/treatment noted in their medical records on a Standard Form (SF) 600 (Chronological Record of Medical Care).

SITE DESCRIPTION: Liberia is slightly larger than the state of Tennessee and is located on the west coast of Africa. Liberia has a total land area of about 96,300 square kilometers (km) (37,000 square miles) and consists of three geographic regions to include the coastal region (e.g., gently rolling hills broken up by tidal creeks, shallow lagoons, and swamps), the plateau region (e.g., rises from the coastal plain to elevations between 600 to 1,200 feet), and the rugged and densely forested mountainous region of eastern and northern Liberia (e.g., peak elevations between 4,530 to 5,740 feet above sea level). On the north, Liberia it is bounded by Guinea, on the east by Côte d'Ivoire, on the south and southwest by the Atlantic Ocean, and on the northwest by Sierra Leone, with a total land boundary length of 1,585 km (985 miles) and a coastline length of 579 kilometers (km) (360 miles).

Operation United Assistance (OUA) launched in September 2014. U.S. military personnel were tasked to provide command and control, logistics, training, and engineering support (e.g., ETUs and training healthcare providers) in Liberia. BTC, the primary base of operation for Joint

Forces Command–United Assistance (JFC-UA), was located in the city of Monrovia, but ETUs were constructed at various locations in Liberia.

Samples collected from the following locations were aggregated and risk was assessed collectively since the locations were in proximity to each other (i.e., less than 10 km or 6 miles away): BTC, NPTA, JSA, and Camp Monrovia.

Samples collected from the following locations were assessed for risk individually because the locations were not in proximity of other sampling locations: Camp Buchanan, BNEL, Gbediah ETU, Camp Greenville, RIAP, Camp Sanniquellie, Camp Tappita, and Camp Zwedru.

SUMMARY: Conditions that may pose a Moderate or greater health risk are summarized in Table 1. Table 2 provides population based risk estimates for identified OEH conditions at BTC and vicinity. As indicated in the detailed sections that follow Table 2, controls established to reduce health risk were factored into this assessment. In some cases, (e.g., ambient air), specific controls are noted, but not routinely available/feasible.

Table 1: Summary of Occupational and Environmental Conditions with MODERATE or Greater Health Risk

The following hazards may be associated with potential acute health effects in some personnel during deployment at BTC and vicinity:

Food/waterborne diseases (e.g., bacterial diarrhea, hepatitis A, typhoid/paratyphoid fever, diarrhea-cholera, diarrhea-protozoal, brucellosis, hepatitis E); other endemic diseases (e.g., malaria, dengue fever, yellow fever, chikungunya, Zika, rickettsioses-tickborne, West Nile fever, cutaneous leishmaniasis (acute), Crimean-Congo hemorrhagic fever, schistosomiasis, leptospirosis, tuberculosis (TB), meningococcal meningitis, rabies, Q fever, Lassa fever, soil transmitted helminthes (hookworm, strongyloidiasis, cutaneous larva migrans)); and heat stress. For food/waterborne diseases (e.g., bacterial diarrhea, hepatitis A, typhoid/paratyphoid fever, diarrhea-cholera, diarrhea-protozoal, brucellosis, hepatitis E), if ingesting local food and water, the health effects can temporarily incapacitate personnel (e.g., diarrhea) or result in prolonged illness (e.g., hepatitis A, typhoid/paratyphoid fever, brucellosis, hepatitis E). Risks from food/waterborne diseases may have been reduced with preventive medicine controls and mitigation, which includes hepatitis A and typhoid fever vaccinations and only drinking from approved water sources in accordance with standing U.S Africa Command (AFRICOM) policy. For other vector-borne endemic diseases (e.g., malaria, dengue fever, yellow fever, chikungunya, Zika, rickettsioses-tickborne, West Nile fever, cutaneous leishmaniasis (acute), Crimean-Congo hemorrhagic fever), these diseases may constitute a significant risk due to exposure to biting vectors. Risk is reduced to 'Low' by proper wear of the Permethrin-treated uniform, application of insect repellent to exposed skin, proper bed net use, and appropriate use of chemoprophylaxis, as well as utilizing environmental controls (e.g., minimizing areas of standing water and other vector-breeding areas). For water contact diseases (e.g., leptospirosis, schistosomiasis), activities involving extensive contact with surface water increase risk. For respiratory diseases (e.g., TB, meningococcal meningitis), personnel in close-quarter conditions could have been at risk for person-to-person spread. Animal contact diseases (e.g., rabies, Q fever), pose year-round risk. For soil transmitted helminthes (e.g., hookworm, strongyloidiasis, both internal infestation and cutaneous larva migrans), risk may have been reduced by limiting exposure to soil contaminated with human or animal feces (including not sleeping on bare ground, and not walking barefoot). For heat stress, risk can be greater for susceptible persons including those older than 45, of low fitness level, unacclimatized, or with underlying medical conditions, or those under operational constraints (e.g., equipment, personal protective equipment (PPE), vehicles). Risks from heat stress may have been reduced with preventive medicine controls, work-rest cycles, proper hydration and nutrition.

Air quality: For inhalable coarse particulate matter (PM) less than 10 micrometers in diameter (PM_{10}) and less than 2.5 micrometers in diameter ($PM_{2.5}$) from environmental dust (including any burn pits or incinerators that might have existed), the PM_{10} and $PM_{2.5}$ overall short-term health risk was not evaluated due to insufficient data. However, BTC and vicinity areas may have experienced dust-prone environmental conditions, also subject to vehicle traffic. Consequently, exposures to PM_{10} and $PM_{2.5}$ may vary, as conditions may vary, and may result in mild to more serious short-term health effects (e.g., eye, nose or throat and lung irritation) in some personnel while at this site, particularly exposures to high levels of dust such as during high winds or dust storms. For PM_{10} and $PM_{2.5}$, certain subgroups of the deployed forces (e.g., those with pre-existing asthma/cardio-pulmonary conditions) are at greatest risk of developing notable health effects. Burn pits and/or incinerators might have existed at BTC and vicinity (for example, burn pits used by the local population); however, there are

no reports or sampling data to indicate their presence or absence. Consequently, the PM_{10} and the $PM_{2.5}$ overall short-term health risks specifically for burn pits were not evaluated—see Section 10.7. Where burn pits and/or incinerators might have existed, exposures may vary, and exposures to high levels of PM_{10} and $PM_{2.5}$ from smoke may result in mild to more serious short-term health effects (e.g., eye, nose or throat and lung irritation) in some personnel and certain subgroups. Although most short-term health effects from exposure to PM and burn pit smoke should have resolved post-deployment, providers should be prepared to consider the relationship between deployment exposures and current complaints. Some individuals may have sought treatment for acute respiratory irritation while at BTC and vicinity. Personnel who reported with symptoms or required treatment while at site(s) with burn pit activity should have exposure and treatment noted in their medical record (e.g., electronic medical record and/or on a SF 600 (Chronological Record of Medical Care).

***Long-term health risks & medical implications*:**

The following hazards may be associated with potential chronic health effects in some personnel during deployment at BTC and vicinity:

For continuous noise exposure, the long-term risk was "Low to Moderate' and is greater for personnel working near major noise sources. Risk may have been reduced to personnel working near major noise sources (e.g., operations around sources of continuous noise such as flightlines, landing zones, and power production/generators) by wearing proper hearing protection. Certain individuals may need to be followed/evaluated for specific occupational exposures/injuries (e.g., annual audiograms as part of the medical surveillance for those enrolled in the Hearing Conservation Program.

Air quality: For inhalable fine PM less than 2.5 micrometers in diameter ($PM_{2.5}$) from environmental dust (including burn pits or incinerators that might have existed), the overall long-term health risk was 'not evaluated due to insufficient data.' Inhalable coarse PM less than 10 micrometers in diameter (PM_{10}) from environmental dust (including burn pits or incinerators that might have existed) was not evaluated for long-term health risk due to no available health guidelines. However, the BTC and vicinity areas may have experienced dust-prone environmental conditions, also subject to vehicle traffic, and other variable conditions. Burn pits and/or incinerators might have existed at BTC and vicinity (for example, burn pits used by the local population); however, there are no reports or sampling data to indicate their presence or absence. Consequently, the PM_{10} and the $PM_{2.5}$ overall long-term health risks specifically for burn pits were not evaluated—see Section 10.7. However, burn pit exposures may vary, as conditions may have varied. For inhalation exposure to high levels of dust containing PM_{10} and $PM_{2.5}$, such as during high winds or dust storms, and for exposures to burn pit smoke, it is considered possible that some otherwise healthy personnel, who were exposed for a long-term period to dust and PM, could develop certain health conditions (e.g., reduced lung function). Personnel with a history of asthma or cardiopulmonary disease could potentially be more likely to develop such chronic health conditions. While the dust and PM exposures and exposures to burn pits are acknowledged, at this time there were no specific recommended, post-deployment medical surveillance evaluations or treatments. Providers should still consider overall individual health status (e.g., any underlying conditions/susceptibilities) and any potential unique individual exposures (such as to burn pits/barrels, incinerators, as well as personal dosimeter data) when assessing individual concerns. Certain individuals may need to be followed/evaluated for specific occupational exposures/injuries (e.g., annual audiograms as part of the medical surveillance for personnel covered by Respiratory Protection Program and/or Hazardous Waste/Emergency Responders Medical Surveillance).

Table 2. Population-Based Health Risk Estimates – Barclay Training Camp and vicinity[1, 2]

Source of Identified Health Risk[3]	Unmitigated Health Risk Estimate[4]	Control Measures Implemented	Residual Health Risk Estimate[4]
AIR			
Particulate matter less than 10 micrometers in diameter (PM_{10})	Short-term: Not enough data to evaluate health risk. Daily levels vary, acute health effects (e.g., upper respiratory tract irritation) more pronounced during peak days. More serious effects are possible in susceptible persons (e.g., those with asthma/pre-existing respiratory diseases).	Limiting strenuous physical activities when air quality is especially poor; and actions such as closing tent flaps, windows, and doors.	Short-term: Not enough data to evaluate health risk. Daily levels vary, acute health effects (e.g., upper respiratory tract irritation) more pronounced during peak days. More serious effects are possible in susceptible persons (e.g., those with asthma/pre-existing respiratory diseases).
	Long-term: No health guidelines		Long-term: No health guidelines
Particulate matter less than 2.5 micrometers in diameter ($PM_{2.5}$)	Short-term: Not enough data to evaluate health risk. A majority of the time mild acute (short-term) health effects are anticipated; certain peak levels may produce mild eye, nose, or throat irritation in some personnel and pre-existing health conditions (e.g., asthma, or cardiopulmonary diseases) may be exacerbated.	Limiting strenuous physical activities when air quality is especially poor; and actions such as closing tent flaps, windows, and doors.	Short-term: Not enough data to evaluate health risk. A majority of the time mild acute (short-term) health effects are anticipated; certain peak levels may produce mild eye, nose, or throat irritation in some personnel and pre-existing health conditions (e.g., asthma, or cardiopulmonary diseases) may be exacerbated.
	Long-term: Not enough data to evaluate health risk. A small percentage of personnel may be at increased risk for developing chronic conditions. Particularly those more susceptible to acute effects (e.g., those with asthma/pre-existing respiratory diseases).		Long-term: Not enough data to evaluate health risk. A small percentage of personnel may be at increased risk for developing chronic conditions. Particularly those more susceptible to acute effects (e.g., those with asthma/pre-existing respiratory diseases).
SOIL			
Metals, Organic and Inorganic Compounds	Short-term: Not an identified source of health risk.		Short-term: Not an identified source of health risk.
	Long-term: No concentrations exceeded the 1-year Negligible MEGs for dermal contact.		Long-term: No concentrations exceeded the 1-year Negligible MEGs for dermal contact.
WATER			
Drinking Water	Short-term: Not enough data to evaluate health risk.	Use of U.S. Army Public Health Center (APHC) [former Army Institute of Public Health (AIPH) and former U.S. Army Veterinary Command] approved bottled water and treated water only from approved potable water sources	Short-term: Not enough data to evaluate health risk.
	Long-term: Not enough data to evaluate health risk.		Long-term: Not enough data to evaluate health risk.
Non-Drinking Water	Short-term: Not enough data to evaluate health risk.	Water treated in accordance with standards applicable to its intended use	Short-term: Not enough data to evaluate health risk.
	Long-term: Not enough data to evaluate health risk.		Long-term: Not enough data to evaluate health risk.
MILITARY UNIQUE			
Ionizing Radiation	Short-term: No data available		Short-term: No data available
	Long-term: No data available		Long-term: No data available

Source of Identified Health Risk[3]	Unmitigated Health Risk Estimate[4]	Control Measures Implemented	Residual Health Risk Estimate[4]
Non-ionizing Radiation	Short-term: No data available		Short-term: No data available
	Long-term: No data available		Long-term: No data available
ENDEMIC DISEASE			
Food borne/Waterborne (e.g., diarrhea-bacteriological)	Short-term: Variable; High (bacterial diarrhea, diarrhea-protozoal, hepatitis A, typhoid/paratyphoid fever) and Moderate (diarrhea-cholera, brucellosis, and hepatitis E)	Preventive measures include hepatitis A and typhoid fever vaccination, consumption of food, water, and ice only from approved sources, and proper handwashing.	Short-term: Low to none
	Long-term: None identified		Long-term: No data available
Arthropod Vector Borne	Short-term: Variable; High (malaria, dengue fever, and yellow fever), to Moderate (chikungunya, Zika, rickettsioses-tickborne, West Nile fever, leishmaniasis-cutaneous, Crimean-Congo hemorrhagic fever), and Low (leishmaniasis-visceral, trypanosomiasis – gambiense, sindbis, typhus-murine, Rift Valley fever, onyong-nyong).	Preventive measures include proper wear of permethrin treated uniform, application of insect repellent to exposed skin, bed net use, wearing sleeves and bloused boots, and minimizing areas of standing water.	Short-term: Low
	Long-term: Low for leishmaniasis-visceral infection.		Long-term: Low
Water-Contact (e.g., wading, swimming)	Short-term: High for schistosomiasis and Moderate for leptospirosis	Avoid skin contact with fresh surface water (rivers, lakes, irrigated fields)	Short-term: Low for leptospirosis.
	Long-term: No data available		Long-term: No data available
Respiratory	Short-term: Moderate for tuberculosis (TB) and meningococcal meningitis.	Providing adequate living and work space; avoid prolonged close contact with local populations which may be experiencing outbreaks, medical screening for latent TB infection, vaccination for meningoccal meningitis as is required for deployment to AFRICOM	Short-term: Low
	Long-term: No data available		Long-term: No data available
Animal Contact	Short-term: Variable; High for rabies, Moderate for Q-fever, and Low for anthrax.	Prohibiting contact with, adoption, or feeding of feral animals in accordance with Africa Command (AFRICOM) General Order #1. Risks are further reduced in the event of assessed contact by prompt post-exposure rabies prophylaxis in accordance with The Center for Disease Control's Advisory Committee on Immunization Practices guidance.	Short-term: No data available
	Long-term: Low (rabies)		Long-term: No data available
Aerosolized Dust or Soil-contact	Short-term: High for lassa fever and Moderate for soil transmitted	Risk was reduced to Low by limiting exposure to soil	Short-term: Low

Source of Identified Health Risk[3]	Unmitigated Health Risk Estimate[4]	Control Measures Implemented	Residual Health Risk Estimate[4]
	helminthes (hookworm, strongyloidiasis, cutaneous larva migrans)	contaminated with human or animal feces (including sleeping on bare ground, and walking barefoot).	
	Long-term: No data available		Long-term: No data available
PERSON TO PERSON DISEASES			
Person to Person	Short-term: Low for Ebola hemorrhagic fever and monkeypox	Risk reduced by avoiding contact with infected persons, and smallpox vaccination affords immunity to monkeypox.	Short-term: Low for Ebola hemorrhagic fever and monkeypox
	Long-term: No data available		Long-term: No data available
VENOMOUS ANIMALS			
Snakes, scorpions, and spiders	Short-term: Low. If encountered, effects of venom vary with species from mild localized swelling to potentially lethal effects.	Risk reduced by avoiding contact, proper wear of uniform (especially footwear), reducing suitable habitat, and proper and timely treatment.	Short-term: Low. If encountered, effects of venom vary with species from mild localized swelling to potentially lethal effects.
	Long-term: No data available		Long-term: No data available
HEAT/COLD STRESS			
Heat	Short-term: Low to High	Work-rest cycles, proper hydration and nutrition, and Wet Bulb Globe Temperature (WBGT) monitoring.	Short-term: Low. The risk of heat injury was reduced to low through preventive measures.
	Long-term: Low. However, the risk may be greater to certain susceptible persons–those older (i.e., greater than 45 years), in lesser physical shape, or with underlying medical/health conditions.		Long-term: Low. However, the risk may be greater to certain susceptible persons–those older (i.e., greater than 45 years), in lesser physical shape, or with underlying medical/health conditions.
Cold	Short-term: No risk of cold stress/injury.		Short-term: No risk of cold stress/injury.
	Long-term: No risk of long-term cold stress/injury.		Long-term: No risk of long-term cold stress/injury.
NOISE			
Continuous	Short-term: Low.	Hearing protection used by personnel in higher risk areas	Short-term: Low.
	Long-term: Low to Moderate. Noise injury with appropriate hearing protection use is low, and is elevated to Moderate if protective measures are not used.		Long-term: Low. Noise injury with appropriate hearing protection use is Low.
Impulse	Short-term: No data available		Short-term: No data available
	Long-term: No data available		Long-term: No data available
Unique Incidents/ Concerns			
Burn Pits/Burn Barrels PM_{10}	Short-term: Not enough data to evaluate health risk. See Section 10.7. A majority of the time mild acute (short-term) health effects are anticipated; certain peak levels may produce mild eye, nose, or throat irritation in some personnel and pre-existing health	Risks reduced by limiting strenuous physical activities when air quality was especially poor; and action such as closing tent flaps, windows, and doors. Other control measures	Short-term: Not enough data to evaluate health risk. See Section 10.7. A majority of the time mild acute (short-term) health effects are anticipated; certain peak levels may produce mild eye, nose, or throat irritation in some personnel and pre-

Source of Identified Health Risk[3]	Unmitigated Health Risk Estimate[4]	Control Measures Implemented	Residual Health Risk Estimate[4]
	conditions (e.g., asthma, or cardiopulmonary diseases) may be exacerbated.	included locating burn pits downwind of camps, increased distance from troop populations	existing health conditions (e.g., asthma, or cardiopulmonary diseases) may be exacerbated.
	Long-term: No health guidelines		Long-term: No health guidelines
Burn Pits/Burn Barrels $PM_{2.5}$	Short-term: Not enough data to evaluate health risk. See Section 10.7. A majority of the time mild acute (short-term) health effects are anticipated; certain peak levels may produce mild eye, nose, or throat irritation in some personnel and pre-existing health conditions (e.g., asthma, or cardiopulmonary diseases) may be exacerbated.		Short-term: Not enough data to evaluate health risk. See Section 10.7. A majority of the time mild acute (short-term) health effects are anticipated; certain peak levels may produce mild eye, nose, or throat irritation in some personnel and pre-existing health conditions (e.g., asthma, or cardiopulmonary diseases)
	Long-term: Not enough data to evaluate health risk. See Section 10.7. Exposure to burn pit smoke is variable. Exposure to high levels of PM_{10} and $PM_{2.5}$ in the smoke may be associated with some otherwise healthy personnel, who were exposed for a long-term period, possibly developing certain health conditions (e.g., reduced lung function, cardiopulmonary disease).		Long-term: Not enough data to evaluate health risk. See Section 10.7. Exposure to burn pit smoke is variable. Exposure to high levels of PM_{10} and $PM_{2.5}$ in the smoke may be associated with some otherwise healthy personnel, who were exposed for a long-term period, possibly developing certain health conditions (e.g., reduced lung function, cardiopulmonary disease).

[1]This Summary Table provides a qualitative estimate of population-based short- and long-term health risks associated with the occupational and environment health conditions at BTC and vicinity that includes: BNEL, Gbediah Ebola ETU, Camp Greenville, JSA, NPTA, RIAP, Camp Sanniquellie, Camp Tappita, Camp Zwedru, and Camp Monrovia. It does not represent an individual exposure profile. Actual individual exposures and health effects depend on many variables. For example, while a chemical may have been present in the environment, if a person did not inhale, ingest, or contact a specific dose of the chemical for adequate duration and frequency, then there may have been no health risk. Alternatively, a person at a specific location may have experienced a unique exposure, which could result in a significant individual exposure. Any such person seeking medical care should have their specific exposure documented in an SF 600.

[2] This assessment is based on specific environmental sampling data and reports obtained from 01 September 2014 through 31 December 2015. Sampling locations are assumed to be representative of exposure points for the camp population but may not reflect all the fluctuations in environmental quality or capture unique exposure incidents.

[3]This Summary Table is organized by major categories of identified sources of health risk. It only lists those sub-categories specifically identified and addressed at BTC and vicinity. The health risks are presented as Low, Moderate, High or Extremely High for both acute and chronic health effects. The health risk level is based on an assessment of both the potential severity of the health effects that could be caused and probability of the exposure that would produce such health effects. Details can be obtained from the APHC. Where applicable, "None Identified" is used when, though a potential exposure is identified, no health risks of either a specific acute or chronic health effects are determined. More detailed descriptions of OEH exposures that are evaluated but determined to pose no health risk are discussed in the following sections of this report.

[4]Health risks in this Summary Table are based on quantitative surveillance thresholds (e.g., endemic disease rates; host/vector/pathogen surveillance) or screening levels, e.g., Military Exposure Guidelines (MEGs) for chemicals. Some previous assessment reports may provide slightly inconsistent health risk estimates because quantitative criteria such as MEGs may have changed since the samples were originally evaluated and/or because this assessment makes use of all historic site data while previous reports may have only been based on a select few samples.

1 Discussion of Health Risks at Barclay Training Center and Vicinity, Liberia by Source

The following sections provide additional information about the OEH conditions summarized above. All risk assessments were performed using the methodology described in the U.S. Army Public Health Command (USAPHC) Technical Guide 230 (*Environmental Health Risk Assessment and Chemical Exposure Guidelines for Deployed Military Personnel*) (Reference 4). All OEH risk estimates represent residual risk after accounting for preventive controls in place. Occupational exposures and exposures to endemic diseases are greatly reduced by preventive measures. For environmental exposures related to airborne dust, there are limited preventive measures available, and available measures have little efficacy in reducing exposure to ambient conditions.

The ProUCL version 5.0 software package was used for statistical analyses when necessary (Reference 5). Means are followed by standard deviation (SD). Risk characterization was based on the 95% upper confidence level of the arithmetic mean (95% UCL) or the arithmetic mean depending on the quality and quantity of the data being evaluated. The sample mean is an uncertain estimate of the true mean of the population exposure point concentration (PEPC). The 95% UCL reduces the uncertainty inherent in the sample mean and states with a higher level of confidence that the mean PEPC is no greater than the 95% UCL.

2 Air

2.1 Site-Specific Sources Identified

Liberia is an underdeveloped country lacking clean, reliable power generating systems. As a result, the use of fuel burning generators is common throughout the region.

Vehicle emissions are a major contributor to the air pollution in the city of Monrovia, Liberia, which has a population of over 4.5 million people. Most of these vehicles are over 10 years old, and generally use substandard fuels, which further contribute to air pollution.

Inhalation exposure to high levels of dust and PM, such as during high winds or dust storms during the winter months, may result in mild to more serious short-term health effects (e.g., eye, nose or throat and lung irritation) in some personnel. Additionally, certain subgroups of the deployed forces (e.g., those with pre-existing asthma/cardio-pulmonary conditions) are at greatest risk of developing notable health effects.

2.2 PM

PM is a complex mixture of extremely small particles suspended in the air. The PM includes solid particles and liquid droplets emitted directly into the air by sources such as power plants, motor vehicles, aircraft, generators, construction activities, fires, and natural windblown dust. The PM can include sand, soil, metals, volatile organic compounds (VOCs), allergens, and other compounds such as nitrates or sulfates that are formed by condensation or transformation of combustion exhaust. The PM composition and particle size vary considerably depending on the source. Generally, PM of health concern is divided into two fractions: PM_{10}, which includes coarse particles with a diameter of 10 micrometers or less, and fine particles less than 2.5 micrometers ($PM_{2.5}$), which can reach the deepest regions of the lungs when inhaled. Exposure to excessive PM is linked to a variety of potential health effects.

2.3 PM_{10}

2.3.1 Exposure Guidelines:

Short-Term (24-hour) PM_{10} (micrograms per cubic meter, ($\mu g/m^3$)):

- Negligible MEG = 250
- Marginal MEG = 420
- Critical MEG = 600

Long-term PM_{10} MEG ($\mu g/m^3$):

- Not defined and not available.

2.3.2 Sample data/Notes:

BTC, NPTA, JSA, and Camp Monrovia: A total of two valid PM_{10} air samples were collected from 2014 to 2015. One sample (117 $\mu g/m^3$) was collected from JSA in December 2014 and one sample (101 $\mu g/m^3$) was collected from BTC in January 2015. The range of 24-hour PM_{10} concentrations was 101 $\mu g/m^3$ – 117 $\mu g/m^3$ with an average concentration of 109 $\mu g/m^3$. Although an insufficient number of PM_{10} air samples were available to sufficiently assess risk at these locations, it should be noted that the samples did not exceed the 24-hour Negligible MEG (250 $\mu g/m^3$).

Camp Buchanan, BNEL, Gbediah ETU, Camp Greenville, RIAP, Camp Sanniquellie, Camp Tappita, Camp Zwedru: No PM_{10} air samples were collected from these locations; therefore, risk could not be assessed.

2.3.3 Short-term health risks:

The data quantity (small sample size or lack of samples) was insufficient to characterize the potential short-term health risks from PM_{10} air exposure to U.S. personnel. However, it should be noted that no samples exceeded the 24-hour Negligible MEG.

2.3.4 Long-term health risk:

Not Evaluated-no available health guidelines. The U. S. Environmental Protection Agency (EPA) has retracted its long-term standard (National Ambient Air Quality Standards, NAAQS) for PM_{10} due to an inability to clearly link chronic health effects with chronic PM_{10} exposure levels.

2.4 $PM_{2.5}$

2.4.1 Exposure Guidelines:

Short-Term (24-hour) $PM_{2.5}$ ($\mu g/m^3$):

- Negligible MEG = 65
- Marginal MEG = 250
- Critical MEG = 500

Long-term (1-year) $PM_{2.5}$ MEGs ($\mu g/m^3$):

- Negligible MEG = 15
- Marginal MEG = 65.

2.4.2 Sample data/Notes:

BTC, NPTA, JSA, and Camp Monrovia: A total of five valid $PM_{2.5}$ air samples were collected from 2014 to 2015. In 2014, one sample (66 $\mu g/m^3$) was collected from JSA in December, and one sample (91 $\mu g/m^3$) was collected from NPTA in December. In 2015, two samples were

collected from BTC in January, and one sample was collected from BTC in February. The range of 24-hour $PM_{2.5}$ concentrations was 66 $\mu g/m^3$ – 108 $\mu g/m^3$ with an average concentration of 92 $\mu g/m^3$. Although an insufficient number of air samples were available to assess risk at these locations, it should be noted that the $PM_{2.5}$ concentrations exceeded the 1-year Negligible MEG.

Camp Buchanan, Gbediah ETU, Camp Greenville: No $PM_{2.5}$ air samples were collected; therefore, risk could not be assessed at these locations.

BNEL: A single $PM_{2.5}$ air sample (26 $\mu g/m^3$) was collected at this location in February 2015. Although an insufficient number of air samples were available to assess risk at this location, it should be noted that the $PM_{2.5}$ concentration exceeded the 1-year Negligible MEG (15 $\mu g/m^3$) but did not exceed the short-term 24-hour Negligible MEG (65 $\mu g/m^3$).

RIAP: Two $PM_{2.5}$ air samples were collected in January and February 2015. The range of 24-hour $PM_{2.5}$ concentrations was 17 $\mu g/m^3$ – 61 $\mu g/m^3$ with an average concentration of 39 $\mu g/m^3$. Although an insufficient number of air samples were available to assess risk at this location, it should be noted that the $PM_{2.5}$ concentrations exceeded the 1-year Negligible MEG (15 $\mu g/m^3$), but did not exceed the short-term, 24-hour Negligible MEG (65 $\mu g/m^3$).

Camp Sanniquellie: A single $PM_{2.5}$ air sample (118 $\mu g/m^3$) was collected in January 2015. Although an insufficient number of air samples were available to assess risk at this location, it should be noted that the $PM_{2.5}$ concentration exceeded the 1-year Negligible MEG (15 $\mu g/m^3$) and the short-term 24-hour Negligible MEG (65 $\mu g/m^3$).

Camp Tappita: Two $PM_{2.5}$ air samples were collected on 23 January 2015. The average of the two sample concentrations was 36 $\mu g/m^3$. Although an insufficient number of air samples were available to assess risk at this location, it should be noted that the $PM_{2.5}$ concentrations exceeded the 1-year Negligible MEG (15 $\mu g/m^3$) but did not exceed the short-term 24-hour Negligible MEG (65 $\mu g/m^3$).

Camp Zwedru: A single $PM_{2.5}$ air sample (28 $\mu g/m^3$) collected in January 2015. Although an insufficient number of air samples were available to assess risk at this location, it should be noted that the $PM_{2.5}$ concentration exceeded the 1-year Negligible MEG (15 $\mu g/m^3$), but did not exceed the short-term 24-hour Negligible MEG (65 $\mu g/m^3$).

2.4.3 Short-term health risks:

The data quantity (small sample size or lack of samples) was insufficient to characterize the potential short-term health risks from $PM_{2.5}$ air exposure to U.S. personnel.

2.4.4 Long-term health risks:

The data quantity (small sample size or lack of samples) was insufficient to characterize the potential long-term health risks from $PM_{2.5}$ air exposure to U.S. personnel.

2.5 Airborne Metals

2.5.1 Airborne Metals from PM_{10}:

2.5.1.1 Sample data/Notes:

BTC, NPTA, JSA, and Camp Monrovia: Two PM_{10} airborne metals samples were collected in December 2014 from JSA and in January 2015 from BTC. An insufficient number of air samples were available to assess risk at this location, and no metals concentrations were detected in the samples collected.

BNEL, Camp Buchanan, Gbediah ETU, Camp Greenville, RIAP, Camp Sanniquellie, Camp Tappita, Camp Zwedru: No PM_{10} airborne metals samples were collected; therefore, risk could not be assessed at these locations.

2.5.1.2 Short-term health risks:

The data quantity (small sample size or lack of samples) was insufficient to characterize the potential short-term health risks from PM_{10} airborne metals exposure to U.S. personnel.

2.5.1.3 Long-term health risks:

The data quantity (small sample size or lack of samples) was insufficient to characterize the potential long-term health risks from PM_{10} airborne metals exposure to U.S. personnel.

2.5.2 Airborne Metals from $PM_{2.5}$

2.5.2.1 Sample data/Notes:

BTC, NPTA, JSA, and Camp Monrovia: Five $PM_{2.5}$ airborne metals samples were collected from 2014 to 2015. In 2014, one sample (66 $\mu g/m^3$) was collected from JSA in December, and one sample (91 $\mu g/m^3$) was collected from NPTA in December. In 2015, two samples were collected from BTC in January, and one sample was collected from BTC in February. An insufficient number of air samples were available to assess risk at this location, and no metals concentrations were detected.

Camp Buchanan, Gbedia ETU, Camp Greenville: No $PM_{2.5}$ airborne metals samples were collected; therefore, risk could not be assessed at these locations.

BNEL: A single $PM_{2.5}$ airborne metals sample was collected at this location in February 2015. An insufficient number of air samples were available to assess risk at this location, and no metals concentrations were detected.

RIAP: Two $PM_{2.5}$ airborne metals samples were collected in January and February 2015. An insufficient number of air samples were available to assess risk at this location, and no metals concentrations were detected.

Camp Sanniquellie: A single $PM_{2.5}$ airborne metals sample was collected in January 2015. An insufficient number of air samples were available to assess risk at this location, and no metals concentrations were detected.

Camp Tappita: Two $PM_{2.5}$ airborne metals samples were collected in January 2015. An insufficient number of air samples were available to assess risk at this location, and no metals concentrations were detected.

Camp Zwedru: A single $PM_{2.5}$ airborne metals sample was collected in January 2015. An insufficient number of air samples were available to assess risk at this location, and no metals concentrations were detected.

2.5.2.2 Short-term health risks:

The data quantity (small sample size or lack of samples) was insufficient to characterize the potential short-term health risks from $PM_{2.5}$ airborne metals exposure to U.S. personnel.

2.5.2.3 Long-term health risks:

The data quantity (small sample size or lack of samples) was insufficient to characterize the potential long-term health risks from $PM_{2.5}$ airborne metals exposure to U.S. personnel.

2.6 VOCs

2.6.1 Exposure Guidelines

Short-term Acrolein MEGs ($\mu g/m^3$):
- 8-hour Negligible = 70.0
- 4-day Negligible = 46.0

Long-term Acrolein MEG ($\mu g/m^3$):
- 1-year Negligible = 0.14

2.6.2 Sample data/Notes:

The health risk assessment is based on average and peak concentrations of VOC air samples collected at BTC and vicinity from 2014-2015.

BTC, NPTA, JSA, and Camp Monrovia: Three VOC air samples were collected in 2015. A single sample was collected from BTC in February, one sample was collected from JSA in February, and one sample was collected from NPTA in February. Although an insufficient number of air samples were available to assess risk at these locations, it should be noted that acrolein was measured at a concentration (1.6 $\mu g/m^3$) above its 1-year negligible MEG (0.14 $\mu g/m^3$) in the sample collected from NPTA.

Camp Buchanan, Camp BNEL, Gbedia ETU, Camp Greenville, Camp Sanniquellie, Camp Tappita, Camp Zwedru: No VOC air samples were collected; therefore, risk could not be assessed at these locations.

RIAP: Two VOC samples were collected in February 2015. An insufficient number of air samples were available to assess risk at this location, and the VOC concentrations for the detected concentrations did not exceed their respective 1-year negligible MEGs.

2.6.3 Short-term health risks:

The data quantity (small sample size or lack of samples) was insufficient to characterize the potential short-term health risks from VOC exposure to U.S. personnel.

2.6.4 Long-term health risk:

The data quantity (small sample size or lack of samples) was insufficient to characterize the potential long-term health risks from VOC exposure to U.S. personnel.

3 Soil

3.1 Site-Specific Sources Identified

None Identified.

3.2 Sample data/Notes

Surface soil samples were collected from various locations in Liberia to assess OEH health risk to deployed personnel. The primary soil contamination exposure pathways are dermal contact and dust inhalation. Typical parameters analyzed for included semi-volatile organic compounds (SVOCs), heavy metals, polychlorinated biphenyls, pesticides, and herbicides. If the contaminant was known or suspected, other parameters may have been analyzed for (i.e., total petroleum hydrocarbons and polycyclic aromatic hydrocarbons near fuel spills). For the risk assessment, personnel are assumed to remain at this location for 6 months to 1 year.

BTC, NPTA, JSA, and Camp Monrovia: Nine surface soil samples were evaluated for this health risk assessment. Three soil samples were collected from BTC in November 2014, and six soil samples were collected from JSA in December 2014. The soil parameter concentrations did not exceed their respective 1-year Negligible MEGs.

Camp Buchanan: Three surface soil samples were evaluated for this health risk assessment. The soil parameter concentrations did not exceed their respective 1-year Negligible MEGs.

Camp BNEL: Three surface soil samples were evaluated for this health risk assessment. The soil parameter concentrations did not exceed their respective 1-year Negligible MEGs.

Gbedia ETU: Three surface soil samples were evaluated for this health risk assessment. The soil parameter concentrations did not exceed their respective 1-year Negligible MEGs.

Camp Greenville: Three surface soil samples were evaluated for this health risk assessment. The soil parameter concentrations did not exceed their respective 1-year Negligible MEGs.

RIAP: Six surface soil samples were evaluated for this health risk assessment. The soil parameter concentrations did not exceed their respective 1-year Negligible MEGs.

Camp Sanniquellie: Three surface soil samples were evaluated for this health risk assessment. The soil parameter concentrations did not exceed their respective 1-year Negligible MEGs.

Camp Tappita: Three surface soil samples were evaluated for this health risk assessment. The soil parameter concentrations did not exceed their respective 1-year Negligible MEGs.

Camp Zwedru: Three surface soil samples were evaluated for this health risk assessment. The soil parameter concentrations did not exceed their respective 1-year Negligible MEGs.

3.3 Short-term health risk

Not an identified source of health risk. Currently, sampling data for soil are not evaluated for short-term (acute) health risks**.**

3.4 Long-term health risk

None identified based on available sample data. Soil parameter concentrations did not exceed their respective 1-year Negligible MEGs. The dust inhalation exposure pathway is addressed in Section 2 above.

4 Water

In order to assess the health risk to U.S. personnel from exposure to water in theater, APHC identified the most probable exposure pathways. These are based on the administrative information provided on the field data sheets submitted with the samples taken over the time period being evaluated. It is assumed that 100% of all U.S. personnel at BTC and vicinity were directly exposed to reverse osmosis water purification unit (ROWPU) treated, disinfected fresh bulk water, municipal water, bottled water, and untreated well water since this classification of water is primarily used for personal hygiene, showering, cooking, and for use at vehicle wash racks. There is a possibility that personnel may use water that is not regularly disinfected for showering, personal hygiene, or cleaning. Field data sheets indicate that bottled water is the only approved source of drinking water; however, in instances where bottled water was unavailable, ROWPU-treated water was used.

4.1 Drinking Water

4.1.1 Site-Specific Sources Identified:

None Identified.

4.1.2 Sample data/Notes:

To assess the potential for adverse health effects to troops, the following assumptions were made about dose and duration: A conservative (protective) assumption was that personnel routinely ingested 5 liters per day (L/day) of bottled water for up to 365 days (1 year).

BTC, NPTA, JSA, and Camp Monrovia: No drinking water samples were collected from these locations; therefore, health risk could not be assessed.

Camp Buchanan: A single valid drinking water sample was collected in December 2014. An insufficient number of water samples were available to sufficiently assess risk at this location. It should be noted that initial analytical results exceeded the short-term drinking water MEG for Haloacetic acids (HAA5)/Monochloroacetic acid. However, this result is believed to be an analytical error. Reanalysis of the sample did not detect Monochloroacetic acid.

BNEL, Gbedia ETU, Camp Greenville, RIAP, Camp Sanniquellie, Camp Tappita, Camp Zwedru: No drinking water samples were collected from these locations; therefore, health risk could not be assessed.

4.1.3 Short-term health risk:

The data quantity (small sample size or lack of samples) was insufficient to characterize the potential short-term health risks from drinking water exposure to U.S. personnel.

4.1.4 Long-term health risk:

The data quantity (small sample size or lack of samples) was insufficient to characterize the potential long-term health risks from drinking water exposure to U.S. personnel.

4.2 Non-Drinking Water

4.2.1 Site-Specific Sources Identified:

Although the primary route of exposure for most microorganisms is ingestion of contaminated water, dermal exposure to some microorganisms, chemicals, and biologicals may also cause adverse health effects. Complete exposure pathways would include drinking, brushing teeth, personal hygiene, cooking, providing medical and dental care using a contaminated water supply or during dermal contact at vehicle or aircraft wash racks.

4.2.2 Sample data/Notes:

To assess the potential for adverse health effects to troops the following assumptions were made about dose and duration: All U.S. personnel at this location were expected to remain at this site for approximately 1 year. A conservative (protective) assumption is that personnel routinely consumed less than 5 L/day of non-drinking water for up to 365 days (1-year). It is further assumed that control measures and/or personal protective equipment (PPE) were not used.

BTC, NPTA, JSA, and Camp Monrovia: Two non-drinking water samples were collected in December 2014 from Camp Monrovia. Although an insufficient number of water samples were available to sufficiently assess risk at these locations, the parameter concentrations did not exceed 2.5 times their respective 1-year Negligible MEGs for the 5-L/day consumption rate.

Camp Buchanan: Four non-drinking water samples (three in December 2014 and one in February 2015) were collected from this location. Although an insufficient number of water samples were available to sufficiently assess risk at this location, the parameter concentrations did not exceed 2.5 times their respective the 1-year Negligible MEGs for the 5-L/day consumption rate.

BNEL: A single non-drinking water sample was collected in April 2015. Although an insufficient number of water samples were available to sufficiently assess risk at this location, the parameter concentrations did not exceed 2.5 times their respective 1-year Negligible MEGs for the 5-L/day consumption rate.

Gbedia ETU: Two non-drinking water samples were collected in January 2015. Although an insufficient number of water samples were available to sufficiently assess risk at this location, the parameter concentrations did not exceed 2.5 times their respective 1-year Negligible MEGs for the 5-L/day consumption rate.

Camp Greenville: A single non-drinking water sample was collected in January 2015. Although an insufficient number of water samples were available to sufficiently assess risk at this location, the parameter concentrations did not exceed 2.5 times their respective 1-year Negligible MEGs for the 5-L/day consumption rate.

RIAP: A single non-drinking water sample was collected in January 2015. Although an insufficient number of water samples were available to sufficiently assess risk at this location, the parameter concentrations did not exceed 2.5 times their respective 1-year Negligible MEGs for the 5-L/day consumption rate.

Camp Sanniquellie: A single non-drinking water sample was collected in January 2015. Although an insufficient number of water samples were available to sufficiently assess risk at this location, the parameter concentrations did not exceed 2.5 times their respective 1-year Negligible MEGs for the 5-L/day consumption rate.

Camp Tappita: A single non-drinking water sample was collected in January 2015. Although an insufficient number of water samples were available to sufficiently assess risk at this location, the parameter concentrations did not exceed 2.5 times their respective 1-year Negligible MEGs for the 5-L/day consumption rate.

Camp Zwedru: A single non-drinking water sample was collected in January 2015. Although an insufficient number of water samples were available to sufficiently assess risk at this location, the parameter concentrations did not exceed 2.5 times their respective 1-year Negligible MEGs for the 5-L/day consumption rate.

4.2.3 Short-term health risks:

The data quantity (small sample size) was insufficient to characterize the potential short-term health risks from non-drinking water exposure to U.S. personnel. However, it should be noted that the water concentrations did not exceed their respective short-term MEGs for the 5-L/day consumption rate.

4.2.4 Long-term health risks:

The data quantity (small sample size) was insufficient to characterize the potential long-term health risks from non-drinking water exposure to U.S. personnel. However, it should be noted that the water concentrations did not exceed their respective long-term MEGs for the 5-L/day consumption rate.

5 Military Unique

5.1 Chemical Biological, Radiological Nuclear Weapons

No specific hazard sources were documented in the Defense Occupational and Environmental Health Readiness System (DOEHRS) or the Military Exposure Surveillance Library (MESL) from 01 September 2014 through 31 December 2015 timeframe (References 1 and 6).

5.2 Depleted Uranium

No specific hazard sources were documented in the DOEHRS or MESL from 01 September 2014 through 31 December 2015 timeframe (References 1 and 6).

5.3 Ionizing Radiation

Medical and dental x-ray equipment used at the Aid Station at BTC served as potential sources of radiation. No other specific hazard sources were documented in the DOEHRS or MESL from 01 September 2014 through 31 December 2015 timeframe (References 1 and 6).

5.3.1 Short-term health risks:

None identified based on the available data.

5.3.2 Long-term health risks:

Low. Medical and dental x-ray equipment is properly shielded and radiology personnel are enrolled in the radiation dosimetry program through the Naval Dosimetry Center located in Bethesda, Maryland. If quarterly dosimetry results indicate that, an exposure occurred preventive measures would be applied.

5.4 Non-Ionizing Radiation

No specific hazard sources were documented in the DOEHRS or MESL from 01 September 2014 through 31 December 2015 timeframe (References 1 and 6).

6 Endemic Diseases

This document lists the endemic diseases reported in the region, its specific health risks and severity and general health information about the diseases. AFRICOM Force Health Protection Requirements and Medical Guidance for Entry into the U.S. Africa Command Theater (Reference 7), lists deployment requirements, to include immunizations and chemoprophylaxis, in effect during the timeframe of this POEMS.

6.1 Foodborne and Waterborne Diseases

Public health protection of food and water supplies may exist in some areas, but is absent in most of the country. Sanitation is poor, including major urban areas. Local food and water sources (including ice) are heavily contaminated with pathogenic bacteria, parasites, and viruses to which most U.S. Service members have little or no natural immunity. Effective disease surveillance does not exist within the country. Only a small fraction of diseases are identified or reported. Diarrheal diseases can be expected to temporarily incapacitate a very high percentage of personnel within days if local food, water, or ice is consumed. Hepatitis A and typhoid fever can cause prolonged illness in a smaller percentage of unvaccinated personnel. In addition, although not specifically assessed in this document, viral gastroenteritis (e.g., norovirus) and food poisoning (e.g., bacillus cereus, clostridium perfringens, staphylococcus) may cause significant outbreaks. Key disease risks are summarized below:

Mitigation strategies were in place and included consuming food and water from approved sources, vaccinations (when available), frequent hand washing, and general sanitation practices.

6.1.1 Diarrheal diseases (bacteriological):

High, mitigated to Low: Diarrheal diseases are expected to temporarily incapacitate a very high percentage of personnel (potentially over 50% per month) within days if local food, water, or ice is consumed. Field conditions (including lack of hand washing and primitive sanitation) may facilitate person-to-person spread and epidemics. Typically, diarrheal diseases are a mild disease treated in an outpatient setting with recovery and return to duty in less than 72 hours with appropriate therapy. A small proportion of infections may require greater than 72 hours limited duty, or hospitalization.

6.1.2 Hepatitis A, typhoid/paratyphoid fever, and diarrhea-protozoal:

High, mitigated to Low: Unmitigated health risk to U.S. personnel is High year round for hepatitis A typhoid/paratyphoid fever, and diarrhea-protozoal. Mitigation strategies in place include immunization, consumption of approved food, water, and ice; hand washing; and applied food/water safety mechanisms. U.S. Personnel did not drink untreated water, and vaccination for hepatitis A is required for deployment into the AFRICOM area of responsibility (AOR). Hepatitis A, typhoid/paratyphoid fever, and diarrhea-protozoal disease may cause prolonged illness in a small percentage of personnel (less than 1% per month).

6.1.3 Diarrhea-cholera:

Moderate, mitigated to Low: Unmitigated health risk to U.S. personnel is Moderate year round for diarrhea-cholera. Mitigation strategies in place include consumption of approved food, water, and ice; hand washing; and applied food/water safety mechanisms. U.S. personnel did not drink untreated water. Most symptomatic cases are mild, with recovery and return to duty in less than 72 hours with appropriate outpatient treatment. Severe cases may require 1-7 days of supportive or inpatient care, followed by return to duty. Cholera may cause prolonged illness in a small percentage of personnel (less than 1% per month).

6.1.4 Brucellosis:

Moderate, mitigated to Low: Unmitigated health risk to U.S. personnel is Moderate year round for brucellosis. It is a common disease in cattle, sheep, goats, swine, and some wildlife species and is contracted via consumption of contaminated dairy products (or foods made with such products) or by occupational exposures to infected animals. Mitigation strategies in place include consumption of approved food (i.e., pasteurization of dairy products), and applied food/water safety mechanisms. Rare cases (less than 0.1% per month attack rate) could occur among personnel consuming local dairy products or having direct occupational-type contact with livestock. With appropriate treatment, brucellosis is a febrile illness of variable severity, may require inpatient care, and convalescence is usually over 7 days even with appropriate treatment.

6.1.5 Hepatitis E:

Moderate, mitigated to Low: Unmitigated health risk to U.S. personnel is Moderate year round for hepatitis E. Hepatitis E occurs in four major genotypes. Genotypes 1 and 2 are found

primarily in Africa and cause large numbers of sporadic cases, as well as large outbreaks. The most common source of exposure is fecal contamination of drinking water. Mitigation strategies in place include consumption of approved food and applied food/water safety mechanisms. U.S. Personnel did not drink untreated water. Potential disease rates (1% per month) among personnel consuming local food, water, or ice may exceed 1% per month for personnel heavily exposed during outbreaks in the local population. Typical cases involve 1 to 3 weeks of debilitating symptoms and return to duty may require a month or more.

6.1.6 Short-term Health Risks:

Variable, unmitigated; Low, mitigated: The overall unmitigated short-term risk associated with food-borne and waterborne diseases are considered High (bacterial diarrhea, diarrhea-protozoal, hepatitis A, typhoid/paratyphoid fever) to Moderate (diarrhea-cholera, brucellosis, and hepatitis E) if local food or water is consumed. Preventive medicine measures reduced the risk to Low. Confidence in the health risk estimate is high.

6.1.7 Long-term Health Risks:

None identified based on available data.

6.2 Arthropod Vector-Borne Diseases

The climate and ecological habitat support large populations of arthropod vectors, including mosquitoes, ticks, and sandflies. Significant disease transmission is sustained year-round and countrywide, including urban areas. Rift Valley fever may be a major risk during peaks of transmission.

Mitigation strategies were in place and included proper wear of treated uniforms, application of repellent to exposed skin, and use of bed nets and chemoprophylaxis (when applicable). Additional methods included the use of pesticides, reduction of pest/breeding habitats, and environmental controls.

6.2.1 Malaria:

High, mitigated to Low: The potential unmitigated risk to U.S. personnel is High year round but is reduced to Low with mitigation measures. Malaria incidents are often associated with the presence of agriculture activity, including irrigation systems and standing water, which provide breeding habitats for vectors. A small number of cases may occur among personnel exposed to mosquito (*Anopheles spp*.) bites. Potential disease rates (11-50% per month) among personnel may occur. Malaria incidents may cause debilitating febrile illness typically requiring 1 to 7 days of inpatient care, followed by return to duty. Severe cases may require intensive care or prolonged convalescence.

6.2.2 Dengue Fever:

High, mitigated to Low: The potential unmitigated health risk is High year-round but is reduced to Low with mitigation measures. Disease rates of 1-50% per month could occur among personnel exposed to mosquito bites. Dengue fever is transmitted by *Aedes spp.* mosquitos, day-biting mosquitos that often breed in artificial containers, such as flower pots or discarded tires. Dengue fever is a debilitating febrile illness typically requiring 1 to 7 days of inpatient care, followed by return to duty. Some cases may require a longer recovery period.

6.2.3 Yellow Fever:

High mitigated to Low: The potential unmitigated health risk to U.S. personnel is High year round but is reduced to Low with mitigation measures. Yellow fever is transmitted by *Aedes spp*. and other mosquitos may transmit infection between primates and humans. During peak transmission, disease rates of 1-10% per month could occur among personnel exposed to mosquito bites. Yellow fever is a potentially severe disease that may require intensive care. Mortality rates may be 20-80% in hemorrhagic cases.

6.2.4 Chikungunya:

Moderate mitigated to Low: The potential unmitigated health risk to U.S. personnel is Moderate year-round but is reduced to Low with mitigation measures. Chikungunya is transmitted primarily by *Aedes aegypti* (a morning- and evening-biting mosquito), and possibly *Aedes albopictus* (a day-biting mosquito). During peak transmission, operationally significant disease rates of 1-50% per month could occur among personnel exposed to mosquito bites, primarily during the day. Chikungunya causes a debilitating febrile illness typically requiring 1-7 days of inpatient care, followed by return to duty. In some cases, join pain severe enough to limit activities may persist for weeks to months.

6.2.5 Zika:

Moderate mitigated to Low: The potential unmitigated health risk to U.S. personnel is Moderate year-round but is reduced to Low with mitigation measures. Zika is spread by daytime mosquitos, such as *Aedes aegypti* and *Aedes albopictus*. During peak transmission, operationally significant disease rates (potentially 1-50% per month) could occur among personnel exposed to mosquito bites, primarily during the day. Zika causes a debilitating febrile illness typically requiring 1-7 days of inpatient care, followed by return to duty. Symptoms of Zika infection (e.g., fever, rash, joint and muscle pain, red eyes, and vomiting) may last for several days to a week. In some cases, severe neurological complications (Guillain-Barre) may occur.

6.2.6 Rickettsioses, tickborne (spotted fever group):

Moderate, mitigated to Low: The potential unmitigated health risk to U.S. personnel is Moderate year-round but is reduced to Low with mitigation measures. A small number of cases (less than 1% per month) are possible among personnel exposed to tick bites. Rickettsioses are transmitted by multiple species of hard ticks, including *Rhipicepahalus spp*. and *Ixodes spp*. A debilitating febrile illness requiring 1 to 7 days of supportive care followed by return to duty is typical with appropriate treatment. More prolonged and severe infections may occur with rare fatalities.

6.2.7 West Nile fever:

Moderate, mitigated to Low: The potential unmitigated health risk to U.S. personnel is Moderate year-round but is reduced to Low with mitigation measures. Potential disease rates of less than 1% per month can occur among personnel under the worst case conditions. The disease is maintained in bird reservoirs and causes periodic outbreaks in humans and animals. Multiple species of *Culex* mosquitos can transmit the infection to humans. The majority of infections in young, healthy adults are asymptomatic although fever, headache, tiredness, body aches (occasionally with a skin rash on trunk of body), and swollen lymph glands can occur. In

many parts of the world, even symptomatic cases typically are undiagnosed and unreported. A febrile illness requiring 1-7 days of inpatient care followed by return to duty is typical.

6.2.8 Leishmaniasis - cutaneous and visceral:

Moderate, mitigated to Low: The potential unmitigated health risk to U.S. personnel is Low (visceral) to Moderate (cutaneous) year-round and reduced to Low with mitigation measures. Mitigation strategies in place include Individual Protective Measures (IPM) practices, permethrin-treated uniforms, pesticides, reduction of pest/breeding habitats, and engineering controls. Leishmaniasis is transmitted by sandflies typically at night. Rare cases (less than 0.1% per month) could occur among personnel exposed to sandfly bites in areas with infected people, rodents, dogs, or other reservoir animals. In groups of personnel exposed to heavily infected sandflies in focal areas, disease rates can be very high (over 50%). The leishmaniasis parasites may survive for years in infected individuals and this infection may go unrecognized by physicians in the United States when infections become symptomatic years later. Cutaneous infection is unlikely to be debilitating, though lesions may be disfiguring. Visceral disease can cause severe febrile illness, which typically requires hospitalization with convalescence over 7 days.

6.2.9 Crimean-Congo hemorrhagic fever:

Moderate, mitigated to Low: The potential unmitigated health risk to U.S. personnel is Moderate but is reduced to Low with mitigation measures. Crimean-Congo hemorrhagic fever occurs in rare cases (less than 0.1% per month attack rate among personnel exposed to tick bites, particularly *Hyalomma*, *Boophilus*, or *Rhipicephalus spp*. Direct contact with blood or body fluids from infected animals or people may also transmit infection. The severe illness typically requires intensive care with fatality rates from 5% to 50%.

6.2.10 Trypanosomiasis – Gambiense (African):

Low: The potential unmitigated health risk to U.S. personnel is Low year-round and is transmitted by

riverine species of tsetse flies. Rare cases (less than 0.1% per month) could occur among personnel exposed to tsetse fly bites. The parasite may survive in infected individuals for several months before developing symptoms. This is a potentially severe disease that may require hospitalization and convalescence over 7 days.

6.2.11 Sindbis (and Sindbis-like viruses):

Low: The potential unmitigated health risk to U.S. personnel is Low year-round. Rare cases (less than 0.1% per month) are possible among personnel exposed to *Culex spp*. mosquito bites. Risk is elevated during periods of increased vector mosquito activity. Sindbis is a debilitating febrile illness often accompanied by rash, typically requiring 1 to 7 days of supportive care; significant arthralgias can persist for several weeks or more in some cases.

6.2.12 Typhus murine (fleaborne):

Low: The potential unmitigated health risk to U.S. personnel is Low year-round. Rare cases (less than 0.1% per month) are possible among personnel exposed to rodents (particularly rats, *Rattus rattus* and *R. norvegicus*) and flea bites. Murine typhus usually occurs as sporadic

cases or occasionally in clusters of cases, associated with flea bites. Risk is highest where rats and humans occupy the same buildings. The disease can cause debilitating febrile illness typically requiring 1 to 7 days of inpatient care, followed by return to duty. Fatalities are rare.

6.2.13 Rift Valley Fever:

Low: The potential unmitigated health risk to U.S. personnel is Low year-round. Conditions may support unpredictable and explosive increases in transmission. Rift Valley Fever is transmitted by *Aedes* spp. found in close proximity to livestock, typically in rural settings. Rift Valley Fever is a debilitating febrile illness typically requiring 1-7 days of supportive care, followed by return to duty. Retinopathy sometimes leading to blindness may occur in up to 10% of patients. Severe complications including hepatitis with hemorrhage, and encephalitis may occur, leading to fatalities.

6.2.14 Onyong-nyong:

Low: The potential unmitigated health risk to U.S. personnel is Low year-round. Onyong-nyong is transmitted mosquitos, particularly at night, and significant disease rates (potentially 1-50% per month) could occur. Onyong-nyong is a debilitating febrile illness typically requiring 1-7 days of supportive care, followed by return to duty. In some cases, joint pain may persist for weeks to months.

6.2.15 Short-term health risks:

Low: The unmitigated health risk is High for malaria, Dengue fever, and yellow fever, Moderate for chikungunya, Zika, rickettsioses-tickborne, West Nile fever, leishmaniasis-cutaneous, and Crimean-Congo hemorrhagic fever, and Low for, leishmaniasis-visceral, trypanosomiasis – gambiense, sindbis, typhus-murine, Rift Valley fever, and onyong-nyong. Health risk is reduced to Low by proper wear of the uniform, application of repellent to exposed skin, and appropriate chemoprophylaxis. Confidence in health risk estimate is high.

6.2.16 Long-term health risks:

Low: The unmitigated risk is Moderate for leishmaniasis-visceral (chronic). Risk is reduced to Low by proper wear of the uniform and application of repellent to exposed skin. Confidence in the risk estimate is high.

6.3 Water Contact Diseases

Operations or activities that involve extensive water contact may result in personnel being temporarily debilitated with leptospirosis in some locations. Leptospirosis health risk typically increases during flooding. In addition, although not specifically assessed in this document, bodies of surface water are likely to be contaminated with human and animal waste. Activities such as wading or swimming may result in exposures to enteric diseases such as diarrhea and hepatitis via incidental ingestion of water. Prolonged water contact also may lead to the development of a variety of potentially debilitating skin conditions such as bacterial or fungal dermatitis. Mitigation strategies were in place and included avoiding water contact and recreational water activities, proper wear of uniform (especially footwear), and protective coverings for cuts/abraded skin.

6.3.1 Schistosomiasis:

High, mitigated to Low: The potential unmitigated health risk to U.S. personnel is High year-round but is reduced to Low with mitigation measures. A disease rate of 1-10% per month is possible among personnel wading or swimming in fecally contaminated bodies of water. In groups with prolonged exposure to heavily contaminated foci, disease rates can exceed 10%. Humans are the principal reservoir for schistosomes and shed schistosome eggs in urine or feces. When water temperatures are at or above 68 degrees Fahrenheit (°F), the eggs hatch, releasing larvae. If a suitable freshwater snail species is present, the larvae penetrate the snail and, after a period of development, emerge as free-swimming cercariae. Cercariae infect human hosts by penetrating skin, usually while the person is wading or swimming. Mild infections of Schistosomiasis are generally asymptomatic. In very heavy acute infections, a febrile illness (acute schistosomiasis) may occur, especially with *S. japonicum* and *S. mansoni*, requiring hospitalization and convalescence over 7 days.

6.3.2 Leptospirosis:

Moderate, mitigated to Low: The potential unmitigated health risk to U.S. personnel is Moderate year-round but is reduced to Low with mitigation measures. Human infections occur through exposure to water or soil contaminated by infected animals and is associated with wading, and swimming in contaminated, untreated open water. The occurrence of flooding after heavy rainfall facilitates the spread of the organism because as water saturates the environment *Leptospira* present in the soil passes directly into surface waters. *Leptospira* can enter the body through cut or abraded skin, mucous membranes, and conjunctivae. Infection may also occur from ingestion of contaminated water. The acute, generalized illness associated with infection may mimic other tropical diseases (for example, dengue fever, malaria, and typhus), and common symptoms include fever, chills, myalgia, nausea, diarrhea, cough, and conjunctival suffusion. Manifestations of severe disease can include jaundice, renal failure, hemorrhage, pneumonitis, and hemodynamic collapse. Recreational activities involving extensive water contact may result in personnel being temporarily debilitated with leptospirosis. Incidence could result in debilitating febrile illness typically requiring 1 to 7 days of inpatient care, followed by return to duty; some cases may require prolonged convalescence.

6.3.3 Short-term health risks:

Variable, unmitigated; Low, mitigated: Unmitigated health risk of Schistosomiasis is High and leptospirosis is Moderate year-round. Mitigation measures reduce the risk to Low. Confidence in the health risk estimate is high.

6.3.4 Long-term health risks:

None identified based on available data.

6.4 Respiratory Diseases

Although not specifically assessed in this document, deployed U.S. Forces may be exposed to a wide variety of common respiratory infections in the local population. These include influenza, pertussis, viral upper respiratory infections, viral and bacterial pneumonia, and others. The U.S. military populations living in close-quarter conditions are at risk for substantial person-to-person spread of respiratory pathogens. Influenza is of particular concern because of its ability to debilitate large numbers of unvaccinated personnel for several days. Mitigation strategies were

in place and included routine medical screenings, vaccination, enforcing minimum space allocation in housing units, implementing head-to-toe sleeping in crowded housing units, implementation of proper PPE when necessary for healthcare providers and detention facility personnel.

6.4.1 Tuberculosis:

Moderate, mitigated to Low: The potential unmitigated health risk to U.S. personnel is Moderate year round but is reduced to Low with mitigation measures. Transmission typically requires close and prolonged contact with an active case of pulmonary or laryngeal tuberculosis (TB), although it also can occur with more incidental contact. Individuals with prolonged indoor exposure to the local population are at increased risk for latent TB infection.

6.4.2 Meningococcal meningitis:

Moderate, mitigated to Low: The potential unmitigated health risk to U.S. personnel is Moderate year-round but is reduced to Low with mitigation measures. Per AFRICOM 4200.03 (updated 20 September 2011), meningococcal vaccine is required for deployment or travel in the AFRICOM AOR. The peak transmission period is December through April and the disease is transmitted from person to person through droplets of respiratory or throat secretions. Close- and prolonged-contact facilitates the spread of this disease. Rare cases (less than 0.1% per month) could occur among unvaccinated personnel. Meningococcal meningitis is potentially a very severe disease typically requiring intensive care; fatalities may occur in 5-15% of cases.

6.4.3 Short-term health risks:

Moderate, unmitigated; Low, mitigated: Unmitigated health risk of TB and meningococcal meningitis is Moderate year-round. Mitigation measures reduce the risk to Low. Confidence in the health-risk estimate is high.

6.4.4 Long-term health risks:

None identified based on available data. TB is evaluated as part of the post-deployment health assessment. A TB skin test is required post-deployment if potentially exposed and is based upon individual service policies.

6.5 Animal-Contact Diseases

6.5.1 Rabies:

High, mitigated to Low: The potential unmitigated health risk to U.S. personnel is High (among the highest in the world) year-round but is reduced to Low with mitigation measures. Rabies is transmitted by exposure to the virus-laden saliva of an infected animal, typically through bites, but could occur from scratches contaminated with the saliva. Although the vast majority (>99%) of persons who develop rabies disease will do so within a year after a risk exposure, there have been rare reports of individuals presenting with rabies disease up to six years or more after their last known risk exposure. Mitigation strategies included command emphasis of AFRICOM General Order #1, reduction of animal habitats, active pest management programs, timely treatment of feral animal scratches/bites, and immunizations if required.

6.5.2 Q-Fever:

Moderate, mitigated to Low: The potential unmitigated health risk to U.S. personnel is Moderate year round but is mitigated to Low with mitigation measures. Rare cases (less than 0.1% per month) are possible among personnel exposed to aerosols from infected animals, with clusters of cases possible in some situations. Significant outbreaks (affecting 1-50%) can occur in personnel with heavy exposure to barnyards or other areas where animals are kept. Unpasteurized milk may also transmit infection. The primary route of exposure is respiratory, with an infectious dose as low as a single organism. Incidence could result in debilitating febrile illness, sometimes presenting as pneumonia, typically requiring 1 to 7 days of inpatient care followed by return to duty. Mitigation strategies in place include avoiding contact with livestock, or areas heavily contaminated by livestock such as barnyards, and only drinking unpasteurized milk.

6.5.3 Anthrax:

Low: The potential unmitigated health risk to U.S. personnel from naturally occurring anthrax is Low year-round. Rare cases (less than 0.1% per month) could occur among personnel with occupational-type exposure to livestock (e.g., cattle, sheep, goats, horses, pigs, water buffalo) or wild herbivores (e.g., antelopes, elephants, giraffes, zebras), or hides or wool products from these species, as well as handling or consumption of undercooked meat. Cutaneous anthrax (typically requiring 1 to 7 days of supportive care with return to duty) and gastrointestinal anthrax (typically requiring hospitalization, and fatality if untreated) are the most common forms of naturally occurring anthrax. The risk of naturally acquired inhalation (pulmonary) anthrax is remote. Inhalation anthrax is very severe, often requiring intensive care with potential fatalities occurring even in treated cases. Mitigation strategies in place include avoiding contact with livestock or consumption of undercooked meat.

6.5.4 Short-term health risks:

Low: The short-term unmitigated risk is High for rabies, Moderate for Q-fever, and Low for anthrax. Mitigation measures reduced the overall risk to Low. Confidence in risk estimate is high.

6.5.5 Long-term health risks:

Low: A Low long-term risk exists for rabies because, in rare cases, the incubation period for rabies can be several years.

6.6 Aerosolized Dust or Soil-contact Diseases

6.6.1 Soil-transmitted helminths (hookworm, strongyloidiasis, internal infestation, cutaneous larva migrans):

Moderate, mitigated to Low: The potential unmitigated health risk to U.S. personnel is Moderate year-round but is mitigated to Low with mitigation measures. A significant attack rate (potentially 1-10% per month) could occur among personnel with direct skin exposure to soil contaminated with human or animal feces (including sleeping on bare ground, walking barefoot). Initial skin symptoms typically are mild and are not debilitating. However, systemic symptoms of fever, cough, abdominal pain, nausea, and diarrhea may develop weeks to months after initial infection with hookworm or *Strongyloides*. More severe infections with high worm burden may

be debilitating in some cases. Abdominal pain, nausea, and intermittent diarrhea may occur in some patients due to invasion of the intestinal lining. Chronic intestinal infection may persist for months to years, with low-level or intermittent intestinal symptoms, anemia, and weight loss. Mitigation strategies in place include avoiding bare skin contact with moist soil, which may be contaminated with human or animal feces.

6.6.2 Lassa fever:

High, mitigated to Low: The potential health risk to U.S. personnel is High year-round (peak transmission period is November through April) but is mitigated to Low with mitigation measures. Multimammate mice (*Mastomys natalensis*) are the reservoir for Lassa fever, and shed the virus in urine and feces. Lassa fever is transmitted primarily by inhalation of aerosols containing infected rodent urine or feces; although, it can also be transmitted by consuming food or water contaminated with rodent urine or feces. A small number of cases (less than 1% per month attack rate) could occur among personnel exposed to dust or aerosols in rodent-infected areas, particularly in or around local dwellings. Though most infections are asymptomatic or cause moderate self-limited febrile illness, severe cases requiring intensive care may occur, overall fatality rate may be 2-3%.

6.6.3 Short-term health risks:

Low: Moderate for soil transmitted helminthes and High for lassa fever. Overall risk was reduced to Low with mitigation measures. Confidence in the health risk estimate is high.

6.6.4 Long-term health risks:

None identified based on available data.

6.7 Person to Person Diseases

6.7.1 Ebola hemorrhagic fever:

Low: Potential health risk is Low year round. Extremely rare cases (less than 0.01% per month attack rate) could occur. It should be noted that the risk during the 2014-2015 Ebola outbreak was Low for U.S. personnel since they were only in Liberia for support purposes (i.e., building ETUs and training health care personnel) but likely Moderate to High for the general public. Ebola virus is maintained in asymptomatic animal reservoirs, possibly fruit bats. Primates become infected via exposure to the bat or other reservoir, often with a fatal outcome. Transmission from infected primates to humans occurs very rarely, and likely requires extensive contact with blood or the consumption of infected primate meat. Once a human case occurs, the infection can be transmitted person to person, leading to limited outbreaks. Outbreaks remain limited because the virus can be transmitted only through direct contact with blood or body fluids of an infected person. Ebola hemorrhagic fever is a very severe illness, typically requiring isolation and supportive care. The fatality rate may be as high as 50-90%.

6.7.2 Monkeypox:

Low: Potential health risk is Low year round. Extremely rare cases (less than 0.01% per month attack rate) could occur. Monkeypox virus is sustained in ground squirrel reservoirs in rainforest habitat. Although transmission is highly inefficient and sporadic, monkeys and humans can be infected as incidental hosts through close contact with animal reservoirs, particularly butchering and consumption of infected carcasses. Infection results from the deposition of aerosolized virus on respiratory or oropharyngeal membranes. Monkeypox clinically resembles smallpox.

6.7.3 Short-term health risks:

Low: Low for Ebola hemorrhagic fever and monkeypox. The smallpox vaccination affords immunity to monkeypox. Confidence in the health risk estimate is high.

6.7.4 Long-term health risks:

None identified based on available data.

7 Venomous Animals

All information was taken directly from the Armed Forces Pest Management Board (Reference 8) and the Clinical Toxinology Resources Web site from the University of Adelaide, Australia (Reference 9). The species listed below have home ranges that overlap the location of BTC and vicinity, Liberia, and may present a health risk if personnel encounter them. See Section 9 for more information about pesticides and pest control measures.

7.1 Spiders

- *Latrodectus renivulvatus* (black button or black widow spider): Initially a minor "sting," then progressively severe local pain plus sweating and erythema/blanching may occur. Widow spider bites are mostly minor and even significant envenoming is unlikely to be lethal.

7.2 Scorpions

- *Pandinus imperator* (emperor scorpion): Mild envenoming only and not likely to prove lethal.

7.3 Snakes

All snake species listed may be found in Sub-Saharan Africa, specifically Liberia.

- *Amblyodipsas unicolor* (western or dull purple glossed snake), *Aparallactus lineatus* (lined centipede-eater), *Aparallactus modestus* (grey forest snake), *Aparallactus niger*: Unlikely to cause significant envenoming, possible minor local pain or swelling, systemic effects not likely.
- *Atheris chloroechis* (West African green tree viper, western bush viper): Severe envenoming possible and potentially lethal which may cause local pain, swelling, bruising, and blistering. May cause systemic effects, renal damage, and moderate to

severe coagulopathy. Antivenom is unavailable, so treatment is symptomatic, supportive, and if severe coagulopathy exists, consider factor replacement.

- *Atractaspis aterrima* (West African mole viper, Western forest burrowing adder and *Atractaspis irregularis* (variable burrowing adder): Severe envenoming possible and potentially lethal. May cause local and systemic effects. *Atractaspis corpulenta* (fat burrowing adder): Moderate envenoming possible but unlikely to prove lethal. May cause local and systemic effects.
- *Bitis nasicornis* (Liheri, Ekeli, Mpoma): Moderate envenoming possible and potentially lethal. May cause local and systemic effects and moderate to severe necrosis. *Bitis rhinoceros* (West African gaboon viper): Severe envenoming possible and high lethality potential. Marked local effects, moderate to severe necrosis, may cause systemic effects, and other common effects include coagulopathy plus haemorrhagins causing bleeding, cardiotoxicity, and shock is likely in severe cases.
- *Causus lichtensteini* (forest night adder), *Causus maculatus* (western rhombic night adder), and *Causus rhombeatus* (common night adder, rhombic night adder): Unlikely to cause significant envenoming, possible minor local effects, systemic effects unlikely (*Causus lichtensteini*) to fever (*Causus maculatus and Causus rhombeatus*).
- *Dendroaspis viridis* (Hallowell's green mamba): Severe envenoming possible and potentially lethal. Local and systemic effects and neurotoxic paralysis is common.
- *Dispholidus typus* (common Aftrican tree snake): Severe envenoming possible and potentially lethal. Local and systemic effects, and moderate to severe coagulopathy plus haemorrhagins causing bleeding.
- *Naja melanoleuca* (black cobra): Severe envenoming possible and potentially lethal. Marked local effects, moderate to severe necrosis, systemic effects, and may cause neurotoxic paralysis.
- *Thelotornis kirtlandi* (forest twig snake): Severe envenoming possible and potentially lethal. Local and systemic effects common.

7.4 Short-term health risk

Low: If encountered, effects of venom vary with species from mild localized swelling to potentially lethal effects. See effects of venom above. Mitigation strategies included avoiding contact, proper wear of uniform (especially footwear), and timely medical treatment. Confidence in the health risk estimate is low (Reference 4, Table 3-6).

7.5 Long-term health risk

None identified.

8 Heat/Cold Stress

8.1 Heat

The climate is tropical and humid, with little change in temperature throughout the year. Temperatures in Liberia are generally higher on the coast than inland. The warmer months are typically from January to May. Coastal temperatures are uniformly high, while the interior seasonal temperatures may exceed 111°F and fall below 48°F. The mean temperature is 81°F with temperatures rarely exceeding 97°F or falling below 68°F. Liberia's tropical climate has two rainy seasons in the south (May through July and October through November) and one rainy season (May through October) in the rest of the country. Rainfall is heaviest along the

northwest coast. Work intensity and clothing/equipment worn pose greater health risk of heat stress/injury than environmental factors alone (Reference 10). Managing risk of hot weather operations included monitoring work/rest periods, proper hydration, and taking individual risk factors (e.g., acclimation, weight, and physical conditioning) into consideration. Risk of heat stress/injury was reduced with preventive measures.

8.1.1 Short-term health risk:

Low to High, mitigated to Low: Risk of heat injury in unacclimatized or susceptible populations (e.g., older, previous history of heat injury, poor physical condition, underlying medical/health conditions), and those under operational constraints (e.g., equipment, PPE, vehicles) is High. The risk of heat injury was reduced to Low through preventive measures such as work/rest cycles, proper hydration and nutrition, and monitoring WBGT. The WBGT reading drives preventive measures such as adjustment to work/rest cycles and limitation of outdoor activities to reduce the risk of heat injury. WBGT index measurements were taken hourly, from 0600 to 2000, to report the heat advisory conditions to camp residents at BTC. Confidence in the health risk estimate is low (Reference 4, Table 3-6).

8.1.2 Long-term health risk:

Low: The long-term risk is Low. However, the risk may be greater for certain susceptible persons—those older (i.e., greater than 45 years), in lesser physical shape, or with underlying medical/health conditions. Long-term health implications from heat injuries are rare but may occur, especially from more serious injuries such as heat stroke. It is possible that high heat in conjunction with various chemical exposures may increase long-term health risks, though specific scientific evidence is not conclusive. Confidence in these risk estimates is medium (Reference 4, Table 3-6).

8.2 Cold

8.2.1 Short-term health risks:

Although Liberia typically does not have a cold season since there is little change in temperature throughout the year, the cooler months are from July to September. Coastal temperatures are uniformly high, while the interior seasonal temperatures may exceed 111°F and fall below 48°F. The mean temperature is 81°F with temperatures rarely exceeding 97°F or falling below 68°F. The risk assessment for Non-Freezing Cold Injuries, such as chilblain, trench foot, and hypothermia, is Low, based on historical temperature and precipitation data. Frostbite is unlikely to occur because temperatures rarely drop below freezing. As with heat stress/injuries, cold stress/injuries are largely dependent on operational and individual factors instead of environmental factors alone (Reference 10).

None: A health risk to cold injury does not exist. Confidence in the health risk estimate is high.

8.2.2 Long-term health risk:

None: A health risk to cold injury does not exist. Confidence in the health risk estimate is high (Reference 4, Table 3-6).

9 Noise

9.1 Continuous

The Services have established occupational exposure limits (OEL) for continuous or intermittent noise at 85 decibels on the A-weighted scale (dbA), 84 dbA for the Navy, as an 8-hour time-weighted average. The A-weighted scale of noise measurement is used because it mimics the human ear's response to sound. All services require that individuals routinely exposed to noise levels greater than the OEL be enrolled in the hearing conservation program. Generally, "routinely exposed" is defined as 2 or more days per month.

Aircraft operations have the potential to cause significant noise hazard to flightline and helicopter landing zone support personnel. Support personnel working in the flightline area of the aircraft operations may be exposed to noise levels ranging from 100 to 110 dbA, during intermediate and full power runs by fixed wing aircraft. Because of the potential noise hazard inherent in flightline operations and the helicopter landing zone, personnel are required to wear dual hearing protection when working on the flightline. Hand tools capable of producing hazardous noise are labeled and hearing protection for individuals potentially exposed are readily available.

Personnel residing in close proximity to generators will routinely be exposed to high noise levels. The threshold requiring hearing protection is 85 dbA.

BTC: A sound level survey conducted showed highest dbA was 101.2 at the generator housing unit, located about 20ft from the Gate Guard station. The sound levels tested at the Gate Guard station was 90.4 dbA. Military personnel are stationed at the gate 24/7 conducting gate security and did not always wear ear plugs.

Camp Buchanan: Noise sources present at this location included generators, motor pool operations, and heavy equipment traffic. Military personnel are not routinely exposed to noise levels in excess of 85 dbA in work/living areas on a daily basis; however, hearing protection is available for those that are routinely exposed to excessive noise.

NPTA: Most military personnel have issued hearing protection of some form, may not be medically fitted. Sound level surveys conducted showed the highest dbA was 90 immediately in front of the generators located outside the military personnel quarters that continuously run. Military personnel may or do not always wear their hearing protection when needed.

JSA: Most military personnel have issued hearing protection of some form, but may not be medically fitted. Sound level survey conducted showed highest dbA was 87.9. Military personnel are not susceptible to prolonged continuous exposure to any high dbA above 85 without hearing protection.

RIA: The only time that the decibels go above 85 dbA is when a fixed wing aircraft arrives/departs.

9.1.1 Short-term health risks:

Low: The short-term risk of noise injury with appropriate hearing protection use is Low. Few exposed personnel (if any) are expected to have noticeable health effects during mission.

9.1.2 Long-term health risks:

Low to moderate: The long-term risk of noise injury with appropriate hearing protection use is Low with few exposed personnel (if any) expected to develop delayed onset, irreversible effects. If protective measures are not used, the risk is elevated to moderate and many exposed personnel are plausibly expected to develop delayed onset, irreversible effects.

9.2 Impulse

No information about potential sources of impulse noise (140 dbA or greater) were documented in the DOEHRS or MESL from 01 September 2014 through 31 December 2015.

10 Unique Incidents/Concerns

10.1 Potential environmental contamination sources

DOD personnel are exposed to various chemical, physical, ergonomic, and biological hazards in the course of performing their mission. These types of hazards depend on the mission of the unit and the operations and tasks, which the personnel are required to perform to complete their mission. The health risk associated with these hazards depends on a number of elements including what materials are used, how long the exposure lasts, what is done with the material, the environment where the task or operation is performed, and what controls are used. The hazards can include exposures to heavy metal particulates (e.g., lead, cadmium, manganese, chromium, and iron oxide), solvents, fuels, oils, and gases (e.g., carbon monoxide, carbon dioxide, oxides of nitrogen, and oxides of sulfur). Most of these exposures occur when performing maintenance task such as painting, grinding, welding, engine repair, or movement through contaminated areas. Exposures to these occupational hazards can occur through inhalation (air), skin contact, or ingestion; however, exposures through air are generally associated with the highest health risk.

10.2 Waste Sites/Waste Disposal

No specific hazard sources were documented in the DOEHRS or MESL from 01 September 2014 through 31 December 2015.

JSA: All dumpsters, which were located 200 meters (m) of troop living/work areas, were emptied once every day and hauled away by truck.

NPTA: All dumpsters, which were located 200 m of troop living/work areas, were emptied once every day and hauled away (off base) by truck. The ground surrounding the area was kept free and clean of trash and debris by military personnel, but locals were sneaking into the dumpsters at night and leaving a mess. Compound security came up with a system that kept locals off the compound, resulting in a cleaner dumpster area and stricter security controls. Note that the local nationals were burning trash during the sampling period.

BNEL: Solid waste is transported from the lab to the burn pit outside the lab, which is about 30 m away.

RIA: All solid waste is hauled off-site by local nationals hired by Fluor contractors.

Camp Buchanan: Solid waste is handled by a Liberian subcontractor that supplies large waste containers and disposes it outside the compound at an authorized city waste disposal site.

Camp Greenville: The trash dumpster is located near the entrance, and solid waste is burned in a 55-gallon burn barrel.

Camp Sannequellie: Solid waste is placed in receptacles and continuously emptied into a 55-gallon drum, approximately 50 feet to the back of the building, where it is burned.

10.3 Fuel/petroleum products/industrial chemical spills

No specific hazard sources were documented in the DOEHRS or MESL from 01 September 2014 through 31 December 2015.

10.4 Pesticides/Pest Control:

No specific hazard sources were documented in the DOEHRS or MESL from 01 September 2014 through 31 December 2015. Fluor contract is responsible for maintaining pest control at many of the locations. Pest control services on BTC are provided through contract and augmented by the 61st PM detachment. Contract personnel are required to meet Department of Defense certification requirements or have a state pest control operator's license. Pest management services include the control of arthropod and vertebrate pests in and around buildings. Sanitation, glue traps, and exclusion are the primary means of non-chemical control in and around structures. Low toxicity insecticidal baits are used effectively for cockroaches and ants. Low toxicity rodenticide was also used for mice and rat control around sleeping tents and the Joint Operations Center. Most pesticides used on site consist of contact chemicals or those that degrade rapidly in the environment. Oversight of pest management activities was provided by CPT Scott Mueller, Senior Entomologist in-country.

10.5 Asbestos

No specific hazard sources were documented in the DOEHRS or MESL from 01 September 2014 through 31 December 2015.

10.6 Lead Based Paint

No specific hazard sources were documented in the DOEHRS or MESL from 01 September 2014 through 31 December 2015.

10.7 Burn Pit

The Institute of Medicine (IM) produced a study on the long-term health consequences of exposure to burn pits in Iraq and Afghanistan (Reference 11). While not specific to BTC and vicinity, this study may be applicable since burn pits were present at some of the locations presented in this POEMS. The consolidated epidemiological and environmental sampling and studies on burn pits that have been conducted as of the date of this publication have been unable to determine whether an association does or does not exist between exposures to emissions from the burn pits and long-term health effects (Reference 11). The IM committee's review of long-term health consequences of exposure to burn pits in Iraq and Afghanistan suggests that service in the two countries (i.e., a broader consideration of air pollution than

exposure only to burn pit emissions) may be associated with long-term health effects, particularly in susceptible (e.g., those who have asthma) or highly exposed subpopulations, such as those who worked at or near the burn pit. Such health effects would be due mainly to high ambient concentrations of PM from both natural and anthropogenic sources, including military sources. If that broader exposure to air pollution turns out to be relevant, potentially related health effects of concern are respiratory and cardiovascular effects and cancer. Susceptibility to the PM health effects could be exacerbated by other exposures, such as stress, smoking, local climatic conditions, and co-exposures to other chemicals that affect the same biologic or chemical processes. Individually, the chemicals measured at burn pit sites in the study were generally below concentrations of health concern for general populations in the United States. However, the possibility of exposure to mixtures of the chemicals raises the potential for health outcomes associated with cumulative exposure to combinations of the constituents of burn pit emissions and emissions from other sources. This study focused on burn pits in Iraq and Afghanistan, and it should be noted that burn pits, if present, likely vary from country to country and basecamp to basecamp with regard to size and materials burned. Pollution from other sources may differ as well; thus, exposures to military personnel located at various basecamp locations are likely variable.

10.7.1 PM_{10}

10.7.2 Exposure Guidelines:

Short-Term (24-hour) PM_{10} ($\mu g/m^3$):

- Negligible MEG = 250
- Marginal MEG = 420
- Critical MEG = 600

Long-term PM_{10} MEG ($\mu g/m^3$):

- Not defined and not available.

10.7.2.1 Sample data/Notes:

BTC, NPTA, JSA, and Camp Monrovia: No PM_{10} air samples associated with burn pits or burn barrels were collected; therefore, risk could not be assessed at this location.

Camp Buchanan: A single PM_{10} air sample associated with burn pits (e.g., locals burning unknown materials in a pit outside the base) was collected at this location in January 2015. Although an insufficient number of air samples were available to assess risk at this location, it should be noted that the PM_{10} concentration exceeded the 1-year Negligible MEG.

BNEL, Gbediah ETU, Camp Greenville, RIAP, Camp Sanniquellie, Camp Tappita, Camp Zwedru: No PM_{10} air samples associated with burn pits or burn barrels were collected; therefore, risk could not be assessed at these locations.

10.7.2.2 Short-term health risks:

The data quantity (small sample size or lack of samples) was insufficient to characterize the potential short-term health risks from PM_{10} air exposure from burn pits or burn barrels to U.S. personnel.

10.7.2.3 Long-term health risk:

Not Evaluated-no available health guidelines. The EPA has retracted its long-term NAAQS for PM_{10} due to an inability to clearly link chronic health effects with chronic PM_{10} exposure levels.

10.7.3 $PM_{2.5}$

10.7.4 Exposure Guidelines:

Short-Term (24-hour) $PM_{2.5}$ ($\mu g/m^3$):

- Negligible MEG = 65
- Marginal MEG = 250
- Critical MEG = 500

Long-term $PM_{2.5}$ MEG ($\mu g/m^3$):

- Negligible MEG = 15
- Marginal MEG = 65

10.7.4.1 Sample data/Notes:

BTC, NPTA, JSA, and Camp Monrovia: A total of seven valid $PM_{2.5}$ air samples associated with burn pits (e.g., locals burning unknown materials outside the compound) were collected from 2014 to 2015. One sample was collected from BTC in January 2015, one sample was collected from NPTA in December 2014, and six samples were collected from NPTA in January - February 2015. The range of 24-hour $PM_{2.5}$ concentrations was 60 $\mu g/m^3$ – 275 $\mu g/m^3$ with an average concentration of 140 $\mu g/m^3$. Samples were collected in December and January in 2014 (n=6) and in January in 2015 (n=1). Although data was insufficient to characterize risk since it was not representative of annual exposure, it should be noted that the $PM_{2.5}$ concentrations exceeded the 1-year Negligible MEG.

Camp Buchanan: A single $PM_{2.5}$ air sample associated with burn pits (e.g., locals burning unknown materials outside of the base) was collected at this location in December 2014. Although an insufficient number of air samples were available to assess risk at this location, it should be noted that the $PM_{2.5}$ concentration exceeded the 1-year Negligible MEG.

BNEL, Gbediah ETU, RIAP, Camp Tappita: No $PM_{2.5}$ air samples associated with burn pits or burn barrels were collected; therefore, risk could not be assessed at this location.

Camp Greenville: A single $PM_{2.5}$ air sample associated with a burn barrel was collected at this location in January 2015. Although an insufficient number of air samples were available to assess risk at this location, it should be noted that the $PM_{2.5}$ concentration exceeded the 1-year Negligible MEG.

Camp Sanniquellie: A single $PM_{2.5}$ air sample associated with a burn barrel was collected at this location in January 2015. Although an insufficient number of air samples were available to assess risk at this location, it should be noted that the $PM_{2.5}$ concentration exceeded the 1-year Negligible MEG.

Camp Zwedru: A single $PM_{2.5}$ air sample associated with burn pits (e.g., locals burning unknown materials in a pit 450 meters away) was collected at this location in January 2015. Although an insufficient number of air samples were available to assess risk at this location, it should be noted that the $PM_{2.5}$ concentration exceeded the 1-year Negligible MEG.

10.7.4.2 Short-term health risks:

The data quantity (small sample size or lack of samples) or data quality (did not represent annual exposure) was insufficient to characterize the potential short-term health risks from $PM_{2.5}$ air exposure from burn pits or burn barrels to U.S. personnel.

10.7.4.3 Long-term health risks:

The data quantity (small sample size or lack of samples) or data quality (did not represent annual exposure) was insufficient to characterize the potential long-term health risks from $PM_{2.5}$ air exposure from burn pits or burn barrels to U.S. personnel.

11 References

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11. Institute of Medicine. 2011. Long-term health consequences of exposure to burn pits in Iraq and Afghanistan. Washington, DC: *The National Academies Press*.

12 Where Do I Get More Information?

If a provider feels that the Service member's or Veteran's current medical condition may be attributed to specific OEH exposures at this deployment location, he/she can contact the Service-specific organization below. Organizations external to DoD should contact Deputy Assistant Secretary of Defense for Health Readiness Policy and Oversight (HRP&O).
U.S. Army Public Health Center Phone: (800) 222-9698. http://phc.amedd.army.mil/
Navy and Marine Corps Public Health Center (NMCPHC) Phone: (757) 953-0700. http://www.med.navy.mil/sites/nmcphc/Pages/Home.aspx
U.S. Air Force School of Aerospace Medicine (USAFSAM) Phone: (888) 232-3764. http://www.wpafb.af.mil/afrl/711hpw/usafsam.asp
DoD Health Readiness Policy and Oversight (HRP&O) Phone: (800) 497-6261. http://fhpr.dhhq.health.mil/home.aspx