UNDAC Environmental Emergency Assessment

Ammunitions Depot Explosions

Brazzaville, Congo

March 2012

JOINT UNEP/OCHA ENVIRONMENT UNIT

Mobilizing and coordinating the international response to environmental emergencies

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Published in Switzerland, 2012 by the Joint UNEP/OCHA Environment Unit

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Executive summary

On 4 March 2012, a series of explosions occurred in the Regiment Blindé munitions depot in the eastern portion of Brazzaville, Congo. The explosions caused disastrous damage to humans and surrounding buildings and infrastructure in the perimeter of 1.5km. Over 250 people were reported dead, over 3,000 injured and approximately 20,000 were displaced to emergency shelters. Due to the shock wave, an inestimable amount of unexploded ordnances (UXOs) were spread throughout the surrounding city. Several tons of explosive agents, rifle and artillery ammunition and possibly rocket fuel were reportedly detonated in the blast.

On 5 March 2012, an official request for environmental emergency response services was made by the United Nations Resident Coordinator (UN RC). The United Nations Office for the Coordination of Humanitarian Affairs (OCHA) through their Emergency Services Branch subsequently coordinated the deployment of an UN Disaster and Coordination (UNDAC) Team to undertake a rapid environmental emergency assessment and assist with the coordination of international assistance. The team was comprised of UNDAC trained environmental emergency experts from a variety of environmental backgrounds. The scope of the mission was to assess the secondary impacts on industrial facilities for damage and possible risks to people and environment, and to provide scientific information in relation to the extent and nature of contamination and exposure to chemical agents resulting from the blast with the aim to assist the decision-making and priority-setting of the authorities and other actors for follow-up activities at the affected site.

The main conclusions found no industrial facilities visited posed a secondary risk, which could create vulnerability to chemical spills or explosions, and additional contamination to the surrounding soils and water in the area. Furthermore, no indicators were found that significant amounts of heavy metals or explosive agents were distributed throughout the city. While trace amounts of chemicals were detectable in samples from the zone of impact, and were above the normal background levels, they do not exceed the threshold values as determined by Swiss law. However, due to the limited number of samples taken from the large-area zone of impact, “hot spots” could be present in the area and not captured in the sampled data. Therefore, further analysis in this area is warranted once the debris and remaining UXOs are removed from the area.

No contamination was present in the water samples taken however, due to the limited number of samples analyzed, a better knowledge of the drinking water supply would be necessary to properly assess the contamination risk to the surrounding population. For instance, if the drinking water supply is fed by groundwater from the zone of impact, a possible risk of exposure could be present.

Detailed recommendations have been provided in the report, which feature the immediate measures to be taken for reducing exposure risk from UXOs and possible further contamination through the leaching of toxic substances.

List of acronyms and glossary of terms

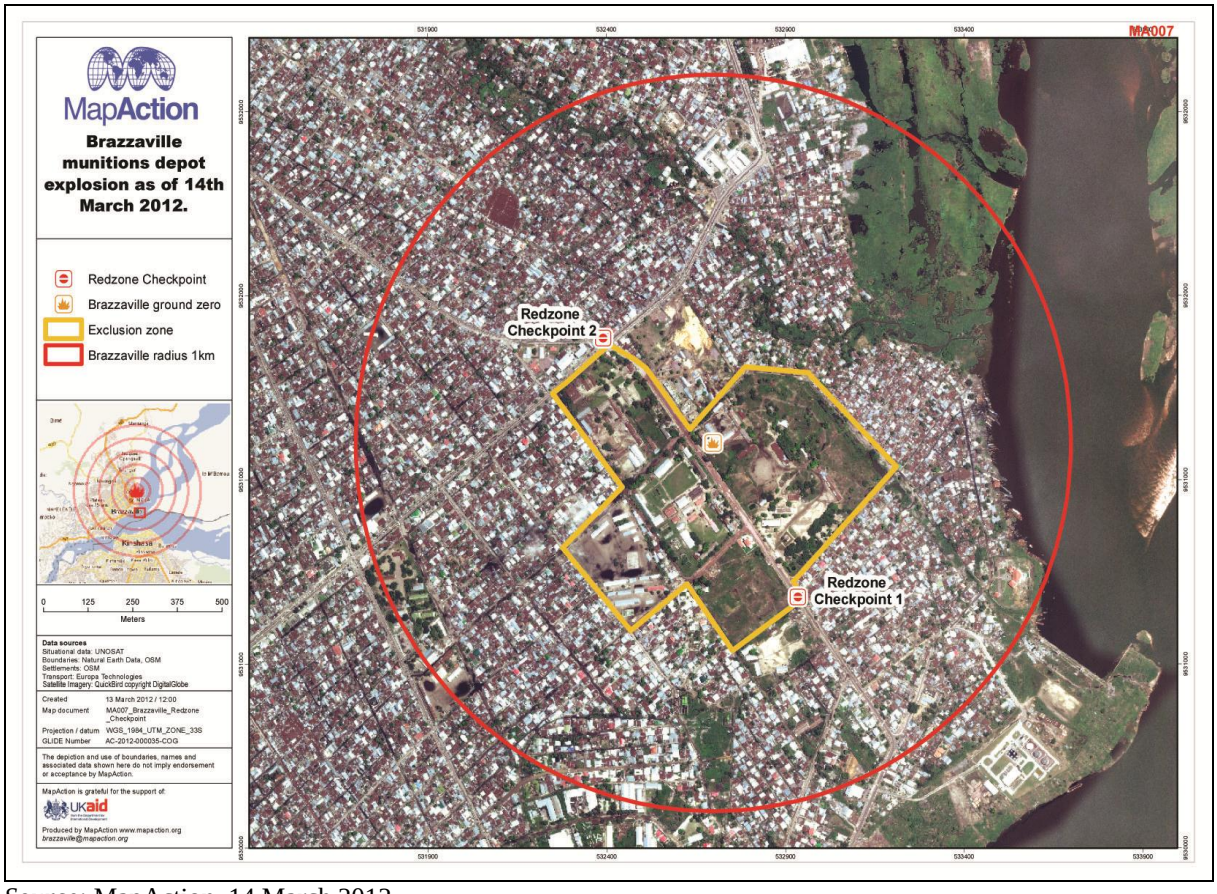
AFEL	Armoured front-end loader
B-FAST	Belgian First Aid and Support Team
DG ECHO	Directorate General for Humanitarian Aid and Civil Protection (EC)
DWM	Disaster Waste Management
EC	European Commission
EOD	Explosive Ordnance Disposal
EUCP	European Union Civil Protection
IDP	Internally Displaced Person
IFRC	International Federation of Red Cross and Red Crescent Societies
JEU	Joint UNEP/OCHA Environment Unit
MAG	Mines Advisory Group
OCHA	UN Office for the Coordination of Humanitarian Affairs
RoC	Republic of Congo
ROWCA	Regional Office for West and Central Africa (OCHA)
SDC	Swiss Agency for Development and Cooperation
UN	United Nations
UNDAC	United Nations Disaster Assessment and Coordination
UNDP	United Nations Development Programme
UNDSS	United Nations Department of Safety and Security
UNEP	United Nations Environment Programme
UNITAR	United Nations Institute for Training and Research
UNOSAT	United Nations Operational Satellite Applications Programme
UN RC	United Nations Resident Coordinator
UXO	Unexploded Ordnance
WHO	World Health Organization

1 Introduction

1.1 Context

On 4 March 2012, five major explosions occurred at the Regiment Blindé munitions depot nearby the city centre of Brazzaville, Republic of Congo. Approximately 250 people were killed, over 3,000 injured and an estimated 20,000 people have been displaced as a result of the blasts.

Using imagery provided by an analysis conducted by UNOSAT, an estimated 1.5 km radius from the epicenter was seriously affected by the blast. Within this area, preliminary results indicate that of the 1,558 buildings examined, 62% were identified as destroyed, 9% were severely damaged, and 29% minimal or damage[1].



Source: MapAction, 14 March 2012

Upon notification of the explosions, the Joint UNEP/OCHA Environment Unit (JEU) of the Office for the Coordination of Humanitarian Affairs (OCHA) offered immediate technical support to the OCHA Regional Office for West and Central Africa (ROWCA). On 5 March, 2012, an official request for environmental emergency assessment and response services was made by the UN Resident Coordination (UN RC).

Immediately following the explosions, additional international humanitarian assistance was provided[2], including deployment of ECHO humanitarian experts. Following a request from the Republic of Congo (RoC), a European Union Civil Protection (EUCP) team was also

[1] http://unosat-maps.web.cern.ch/unosat-maps/CG/AC20120203COG/UNOSAT_COG_AC2012_DamageAssessment_v1.pdf
[2] EC-MIC. 2012. ECHO Crisis Reports 1-4.

deployed to address emergency services and formulate recommendations on how to improve response capacity emergency services. Aid was also provided by the Directorate General for Humanitarian Aid (DG ECHO), the NGO Mine Advisory Group (MAG) and the International Federation of Red Cross and Red Crescent Societies (IFRC). A de-contamination project to provide an initial survey of the situation on-site was undertaken by the MAG through funding by the European Development Fund.

Belgium supplied medical aid through the deployment of the Belgian First Aid and Support Team (B-FAST), and France supplies medical aid as well.

Italy provided support through housing provisions, and deployed an Explosive Ordnance Disposal (EOD) team, followed by an armoured front-end loader (AFEL).

The Swiss Agency for Development and Cooperation (SDC) aided with the deployment of the metals analyst expert from Spiez Laboratory, a facility that provides scientific and technological expertise in relation to the testing and analysis of nuclear, biological and chemical weapons, who joined the UNDAC team in Brazzaville.

1.2 Scope of Mission

OCHA coordinated the deployment of an UN Disaster and Coordination (UNDAC) Team to assess and determine the extent of the adverse humanitarian and environmental effects caused directly by the exploded munitions, including remaining threat to the surrounding population. The information reported by the team is intended to assist the authorities in setting priorities for best management of follow-up activities. The scope of the mission did not include the assessment of liability in relation to the explosions, nor was it responsible for removal or remediation activities.

The mission focused on the assessment of secondary impacts to infrastructure in and surrounding the impact zone, an assessment of internally displaced persons (IDP) centers, identifying the presence and concentrations of explosive agents in the soil and surface water, including the assessment of potential secondary hazards, and providing recommendations for mitigation based on the results. The UNDAC team was also responsible for the coordination of the environmental emergencies component of the assessment.

The specific objectives of the mission included:

- On site sampling to determine nature and extent of pollution from:
    - Explosive agents
    - Degrading products of explosive agents
    - Stabilizers of explosive agents
    - Heavy metals
- Determine the secondary impacts to surrounding infrastructure and buildings;
- Identify remaining threat to surrounding population and environment;
- Identify potential secondary hazards; and
- Provide recommendations for remediation and support dissemination of results.

The mission took place from 8 March 2012 to 16 March 2012.

The mission team was composed of the following experts (from left to right):

- Mr. Denis Lopez, EC Mechanism, Information and Coordination Management (France/EUCP)
- Mr. Alain Pasche, UNDAC Team Leader (Switzerland)
- Mr. Olivier Bruyere, Deputy Team Leader (JEU/UNDSS)
- Mr. Sunday Babatunde, Civil Military Coordination Support (OCHA)
- Mr. Marc Stauffer, Laboratory Spiez Metals analyst, SDC (not shown)

The team undertook field visits to five industrial sites located within 500m of the detonation epicenter. Site visits to seven IDP Centers was also conducted to enable first-hand observation of on-site sanitation and waste issues. On-site measurements of water and soil samples were taken from 22 sampling locations for a later, more detailed analysis to be conducted at Laboratory Spiez in Switzerland. Due to the time delay between the ammunitions explosion and deployment to the affected area, no air sampling was carried out.

2 Assessments and Findings

2.1 Findings

Secondary Environmental Risks

Field visits to five industrial sites in a 500 meter radius from the detonation epicenter were undertaken. The objectives were to determine the presence and extent of secondary impacts to surrounding installations, to assess potential impact to the population and environment should damage be present, and to identify potential secondary threats. This was determined with the support of the Flash Environmental Assessment Tool (FEAT), which aids in the identification of existing or potential acute environmental impacts that pose risks for humans, human life-support functions, following sudden-onset disasters; it can also help to identify potential long-term issues such as those found with the release of persistent compounds. Damage to these facilities could present additional vulnerability to chemical spills or explosions, and additional contamination to the surrounding soils and water in the area.

The first field observation took place at a hydrocarbon storage facility (04˚6,00'74"S/15˚17,47'76"E) operated by the Société Commune de Logistique Petroliere (SCLOG). Due to limited access, observations were made outside of the installation perimeter. Fifteen hydrocarbon tanks, each of 4,000 m³ in size, were observed to be in good condition and well maintained. The industrial installation was fully operation and well secured, with no detectible damage.

SCLOG Storage Facility

Brewery Brasco

The second field observation occurred at Brewery Brasco (04˚15,33'14"S/15˚17,54'13"E), where limited damage to the roofs of the buildings was observed, though repairs were in progress. There was no visible damage to the vertical and horizontal tanks of fuel and compressed gas, and no visible damage to the network of pipes. The installation was well secured.

A third inspection took place at the local power station (04˚14,56'80"S/15˚18,10'09"E) where no damage to the three fuel tanks and ancillary equipment was visible. Additionally, it was reported that a technical inspection had been carried out immediately following the explosion and the area was declared safe and secure.

LPG Storage and Distribution

Air Liquide

The fourth site visit occurred at LPG Storage and Distribution (04˚15,14'88"S/15˚17,52'94"E) where noticeable damage to the roofs of buildings was detected. No visible damage to the small storage cylinders or horizontal tanks was visible, and the pipes and equipment were determined to be intact. The activities and installation were well secured.

The final location observed was the property of Air Liquide (04˚15,71'90"S/15˚17,48'72"E), a temporary storage and redistribution site for compressed gas cylinders. Limited damage to the roof of the building was observed, but no visible damage to the storage cylinders was present.

In all sites visited, damage was limited in scale and no secondary hazards appeared to be present. Therefore, it was determined that the damages were not so extensive as to pose a significant risk to the population or to the environment.

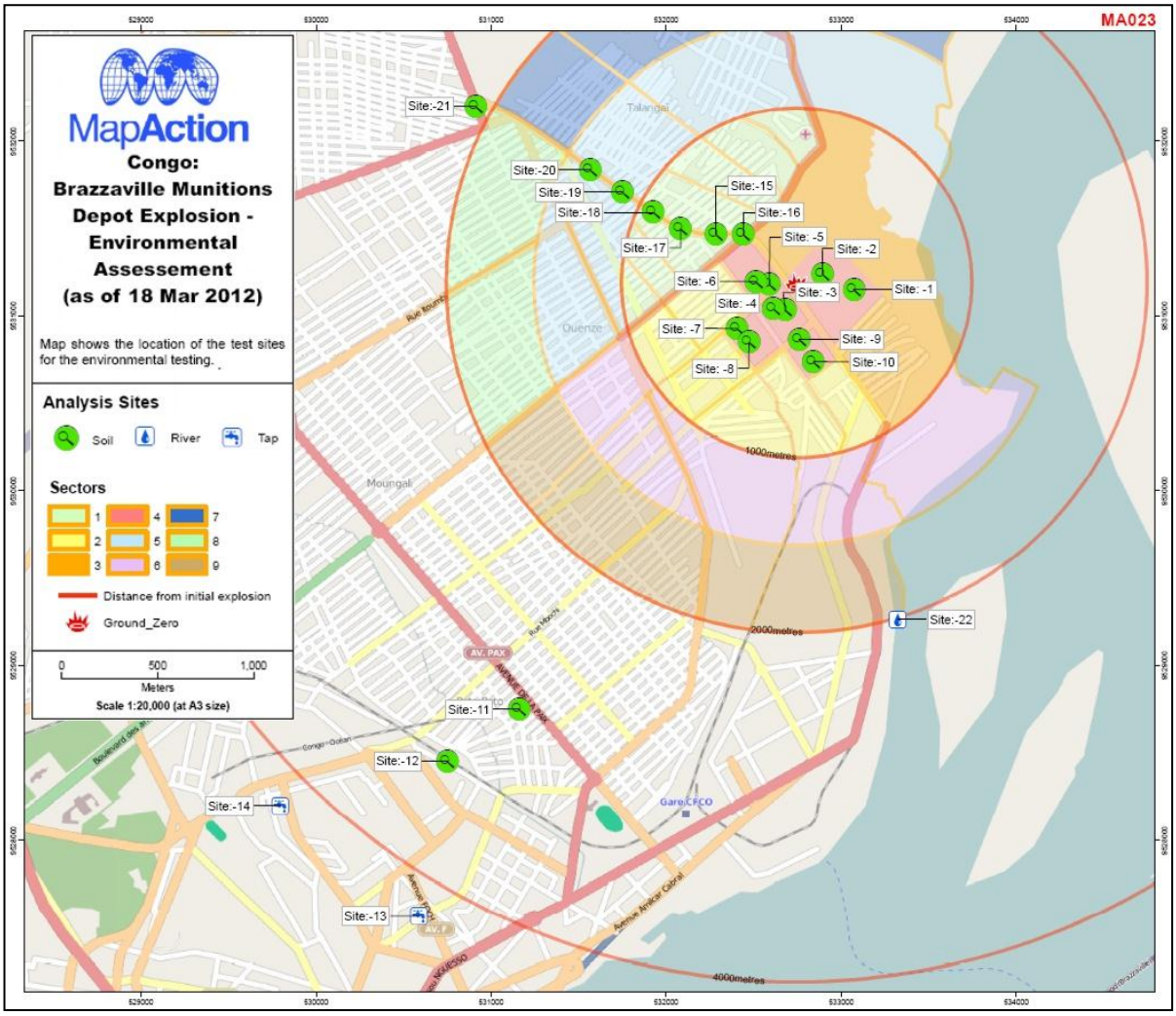
IDP Centers and Environmental Concerns

The UNDAC team also visited the centers of those persons internally displaced by the explosions. Seven major IDP centers (see Annex II for locations) were visited to gain a more comprehensive understanding of the sanitation and waste situation and to determine the possible scope of intervention required. The locations visited were the Kimbanguiste Plateau, the Arme du Salut, Kimbanguiste Talangai, Saint Gregoire, Marche Nkombo, Stade Annex and the Notre Dame de Rosaire.

At the time of the assessment, the Kimbanguiste Plateau center housed 512 people and lacked proper sanitation arrangements. The Arme du Salut center housed 757 people and there were currently no toilet or bathing facilities on-site for the IDPs. The Kimbanguiste Talangai center housed 1,095 people and had only two existing man-hole toilets. The Saint Gregoire center was not yet operational, but expected to house a maximum of 500 people; however it lacked water, toilet and bathing facilities. The Marche Nkombo center housed an estimated 1,500 people and had limited toilet and bathing facilities, the sanitation was poorly managed and there was a potential for future disease outbreak. The Stade Annex center housed 309 people and there was no water for the toilets; the sanitation practices were also poor and raised susceptibility to exposure to disease. The last center visited, Notre Dame de Rosaire housed 725 people, with the number expected to double.

Sampling and Analysis

The possible presence of explosive agents, degraded products of explosive agents, stabilizing materials of explosive agents, and heavy metals are considered potentially dangerous to human health and/or life support (drinking water and soil contamination). The toxicity of these metals and substances by direct ingestions of significant amounts of lead and mercury or some explosive agents (and residues) via drinking water would lead to severe intoxication or death. Long-term effects could result in slowly progressing physical, muscular, and neurological degenerative processes that can mimic Alzheimer's disease, Parkinson's disease, muscular dystrophy, and multiple sclerosis[3]. Analyzing the soil examines a possible pathway for further contaminations of the ground- river- or drinking water. Furthermore, the fertility of the soil for agricultural purposes is analysed. These contaminants were considered to be present via the distribution of chemical agents in the air during the explosion, thereby affecting the surrounding water and soils, and through the emission of toxic substances caused by UXOs that remain unsheltered and uncollected, potentially leaching chemicals into the water and soil.



[3] Science Daily. 2007. Metals linked to Alzheimer's and Other Neurodegenerative Diseases. http://www.sciencedaily.com/releases/2007/08/070813185007.htm

Therefore, water and soil samples were taken from 22 sites reflected in the above map (See Annex I for detailed location information). Ten soil samples were taken from the impact zone by a de-miner from the NGO Mines Advisory Group (MAG). Seven samples were taken along an axis 2km in length, beginning at the fence of the impact zone. Two additional samples were taken from reference points presumably not affected by the plume.

Soil samples were taken per sampling location from 0-5cm at the surface, from a total area of 50cm x 50cm, mixed with a shovel and transferred into plastic bags. The first phase of the soil analysis occurred on site via x-ray fluorescence. In the samples taken from the impact zone, the on-site analysis revealed that lead was present in concentration levels above the local background levels, but below the Swiss threshold values[4]. The soil sample indicated that the presence of lead did not exceed 180mg/kg. The Swiss threshold value is 1000mg/kg.

All soil samples were taken to Spiez Laboratory[5]to be analyzed for additional hazardous content. The soil samples were dried at 40˚C, sieved and milled to obtain homogenous samples. The data were obtained by using ICP-mass spectrometry after leaching according to the EPA[6] 3051 method. The EPA 7473 method was also used to determine possible mercury concentrations in the soil. The more detailed analysis confirmed the findings of the on-site analysis. Furthermore, mercury was detectable in samples from the zone of impact. Similar to the concentrations of lead and copper, the levels of mercury were higher than the local background levels, but also below the Swiss threshold values (Mercury: 0.5 mg/kg, Copper and Lead: 1000 mg/kg).

In the soil samples taken from the zone of impact, and in some soil samples from areas immediately outside this zone, traces of tri-nitrotoluol (TNT), amino-nitrotoluols, octogen (HMX) and hexogen (RDX) were detected. Though these explosive agents were present, they were below the German threshold values (1000 µg/kg)[7].

Marc Stauffer, Laboratory Spiez

[4] Federal Office for the Environment. Ordinance on Impact on Soil (OIS). 1998. http://www.bafu.admin.ch/bodenschutz/10161/10178/10180/index.html?lang=en
[5] For additional information on Spiez Laboratory, see http://www.labor-spiez.ch/enindex.htm
[6] EPA. 2012. Hazardous Waste Test Methods. http://www.epa.gov/osw/hazard/index.htm
[7] Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. 2010.Health and Chemical Safety. http://www.bmu.de/english/chemical_safety/aktuell/3813.php

Only three water samples could be obtained due to limited accessibility. One sample was taken from the Congo River, downstream from the zone of impact; two were taken at nearby UNDAC and UNDP buildings, as access to areas closer to zone of impact was not available at the time of the assessment.

The water samples for heavy metal analyses were stabilized with 1 mL of HNO_3 30% per 100mL sample and filtered through a 0.45 µm syringe filter, then measured. The data for the water samples were obtained through semi-quantitative ICP-mass spectrometry.

Water samples for explosive analyses were left untreated but decanted to glass vials for analyses at the Bachema AG (Zürich, Switzerland)[8].

The procedures were controlled by analyzing the Standard Reference Material NIST N° 1643 "Trace Elements in Natural Water" [9] and the several ISE PER Samples from recent proficiency tests (2011-2/4). Based on these control measurements, the results contain an uncertainty of (p=0.95) of ±20%.

In the water samples taken, the amount of metals present did not exceed the recommended concentration set by the WHO "Guidelines for Drinking Water Quality."[10] No explosive agents were detected in the water samples.

Though the presence of contaminants were not reflected in the water samples, the persistent presence of UXOs awaiting removal could present threats of possible contamination to surrounding water and soils via leaching, while uncovered and exposed to the elements.

[8] For explosives in water: Bachema method + DIN EN ISO 22478, Prevention guideline value: 1 µg/L; For explosives in soil: Bachema method, Prevention guideline value: 1000 µg/kg; http://www.bachema.ch/cms/upload/Dienstleistungsverzeichnis/Methoden_Wasser.pdf

[9] National Institute of Standards and Technology (NIST). Standard Reference Material (SRM) 1643. https://www-s.nist.gov/srmors/view_detail.cfm?srm=1643D

[10] WHO. 2008. Guidelines for Drinking Water Quality.

3 Conclusions & Recommendations

3.1 Conclusions

The industrial facilities visited reflected only minimal damage in need of repair; therefore no significant risk or secondary hazards to the population or to the environment were present. Given the poor sanitation and waste management at the IDP centers visited, and the number of IDPs expected to increase at these locations, environmental pollution to soil and waterways is a possibility. Furthermore, these sites lacking sanitation measures are also indicative of likelihood for outbreak of disease; however there are several efforts currently underway, in particular by the IFRC, to ameliorate these effects.

Based on the results of the assessments, no significant amounts of mercury, lead, or copper were distributed throughout the city. Heavy metals were detectable in samples from the zone of impact and above natural background levels, but below the threshold values according to Swiss law. While explosive agents were detectable in samples from the zone of impact and above natural background levels, they were below German threshold values. Due to the limited number of samples taken from the zone of impact, "hot spots" could be present in the affected area and a further analysis would be warranted.

3.2 Recommendations

The zone of impact remains challenging to access due to the widespread amount of debris still present. Extensive amounts of rubble need to be cleared and building structures will need to be demolished. This is further complicated by an inestimable number of UXOs still existing in the area. These unsheltered UXOs also pose an additional threat as they remain uncovered and exposed to the elements, which can lead to further leaching of toxic substances during rainy periods into soil and groundwater.

Priority recommendations include the development of a Disaster Waste Management plan, for which the JEU could assist in the development. This plan should account for the location, amount and extent of debris remaining in the area and assess nearby waste management facilities and storage sites capable of managing the waste as it is removed; the plan can also provide potential methods for reusing or recycling the debris during the reconstruction phase of operations. The removal of all remaining UXOs should be given priority to prevent further human harm and limit threat to environmental contamination.

Medium-term activities should commence once the remaining UXOs and debris are removed and decommissioned, and should include an expanded environmental assessment of the impact zone to provide a more thorough understanding of the toxins present in the area. Furthermore, this assessment should include a comprehensive study and mapping of the groundwater, stormwater and drainage systems in or near the zone of impact in order to determine further exposure risk to water pollution. The assessment would also provide more detailed information on the soil contamination in the zone of impact.

Longer term activities should take into account the vulnerability of populations to these types of emergencies, specifically in relation to their proximity to industrial or potentially hazardous areas, and the preparedness activities that could be utilized when events such as these occur.

A national level hazard inventory of storage facilities housing munitions or other hazardous materials should be undertaken as part of a national disaster management, or contingency planning, process. By building capacity for more coordinated response efforts through the assistance of decision makers and technical personnel in government, industry and the local community, and increasing community awareness, public safety and environmental quality can be preserved.

Given the large number of people displaced by this emergency, and the lack of proper latrines and disposal of waste, there is the increased likelihood for the IDP centers to create further exposure to risk to disease and environmental pollution. Additional waste is generated from relief supplies and from food items and packaging material, which further reduce the living conditions. The development of a disaster waste management plan could also prove useful in this regard, in aiding to identify disposal and transportation options and possible "cash for work" options available to those displaced.

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Annex I: Spiez Laboratory Soil and Water Test Results

Samples and Codes

SOP: L 101 011 02

Order	Site	Code	Coordinates		Date	Time	Matrix	Remarks location	further remarks
	No	UA	S	E					
UA-2012-12	-1	-B01	S04°14'30.10"	E015°17'52.90"	16.03.2012	09:22	Soil	Hot Zone, Sector 4	Samples taken by deminer (ONG MAG)
UA-2012-12	-2	-B02	S04°14'27.20"	E015°17'47.10"	16.03.2012	09:27	Soil		
UA-2012-12	-3	-B03	S04°14'33.80"	E015°17'40.20"	16.03.2012	09:45	Soil		
UA-2012-12	-4	-B04	S04°14'33.60"	E015°17'38.00"	16.03.2012	09:48	Soil		
UA-2012-12	-5	-B05	S04°14'29.10"	E015°17'37.20"	16.03.2012	09:52	Soil		
UA-2012-12	-6	-B06	S04°14'28.60"	E015°17'34.80"	16.03.2012	09:56	Soil		
UA-2012-12	-7	-B07	S04°14'37.40"	E015°17'31.30"	16.03.2012	10:02	Soil		
UA-2012-12	-8	-B08	S04°14'39.90"	E015°17'33.50"	16.03.2012	10:05	Soil		
UA-2012-12	-9	-B09	S04°14'39.40"	E015°17'42.80"	16.03.2012	10:12	Soil		
UA-2012-12	-10	-B10	S04°14'43.50"	E015°17'45.40"	16.03.2012	10:15	Soil		
UA-2012-12	-11	-B11	S04°15'48.30"	E015°16'50.90"	16.03.2012	16:30	Soil	Reference site 1	presumably not contaminated
UA-2012-12	-12	-B12	S04°15'58.00"	E015°16'37.60"	16.03.2012	16:40	Soil	Reference site 2	
UA-2012-12	-13	-W13	S04°16'26.83"	E015°16'32.36"	16.03.2012	14:15	Water	Tap water UNDP	
UA-2012-12	-14	-W14	S04°16'06.35"	E015°16'06.62"	16.03.2012	18:40	Water	Tap water Hotel Etoile	
UA-2012-12	-15	-B15	S04°14'19.78"	E015°17'27.34"	17.03.2012	10:20	Soil	Avenue de l'Intendance	Sampling along an axis away from hot zone, towards northwest
UA-2012-12	-16	-B16	S04°14'19.73"	E015°17'32.34"	17.03.2012	10:12	Soil		
UA-2012-12	-17	-B17	S04°14'18.75"	E015°17'20.77"	17.03.2012	10:28	Soil		
UA-2012-12	-18	-B18	S04°14'15.72"	E015°17'15.70"	17.03.2012	10:31	Soil		
UA-2012-12	-19	-B19	S04°14'11.96"	E015°17'10.00"	17.03.2012	10:34	Soil		
UA-2012-12	-20	-B20	S04°14'07.82"	E015°17'04.03"	17.03.2012	10:38	Soil		
UA-2012-12	-21	-B21	S04°13'55.97"	E015°16'42.86"	17.03.2012	10:49	Soil		
UA-2012-12	-22	-W22	S04°15'31.57"	E015°18'01.04"	17.03.2012	11:26	Water	Congo River downstream hot zone	

Results

Soil samples, elements A-L, mass concentration based on dry substance

		Antimony	Arsenic	Cadmium	Cobalt	Chromium	Copper	Lead
		w(Sb) /	*w*(As) /	*w*(Cd) /	*w*(Co) /	*w*(Cr) /	*w*(Cu) /	*w*(Pb) /
Sample	UA-2012-12	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Site -01	-B01	< 0.5	< 0.5	< 0.5	< 0.5	5.0	4.6	17
Site -02	-B02	< 0.5	< 0.5	< 0.5	0.6	5.4	4.7	160
Site -03	-B03	< 0.5	2.8	< 0.5	0.6	4.0	4.2	20
Site -04	-B04	< 0.5	< 0.5	< 0.5	0.6	7.9	5.3	9.7
Site -05	-B05	< 0.5	1.2	1.8	0.9	10	14	70
Site -06	-B06	1.9	4.3	2.4	2.8	37	59	500
Site -07	-B07	< 0.5	< 0.5	< 0.5	< 0.5	1.6	1.3	5.5
Site -08	-B08	< 0.5	< 0.5	< 0.5	1.3	3.1	8.9	6.7
Site -09	-B09	< 0.5	0.5	< 0.5	0.6	11	9.3	93
Site -10	-B10	< 0.5	0.8	< 0.5	0.9	7.5	12	53
Site -11	-B11	< 0.5	0.6	< 0.5	0.7	8.2	4.6	7.9
Site -12	-B12	< 0.5	< 0.5	< 0.5	0.5	4.6	4.6	18
Site -15	-B15	< 0.5	< 0.5	< 0.5	0.6	2.9	13	20
Site -16	-B16	< 0.5	0.9	< 0.5	0.9	6.2	9.8	23
Site -17	-B17	< 0.5	< 0.5	< 0.5	< 0.5	3.3	3.7	18
Site -18	-B18	< 0.5	< 0.5	< 0.5	< 0.5	3.6	5.6	13
Site -19	-B19	< 0.5	0.6	< 0.5	0.9	6.8	66	16
Site -20	-B20	< 0.5	< 0.5	< 0.5	< 0.5	2.4	3.9	13
Site -21	-B21	< 0.5	0.7	< 0.5	0.8	6.3	16	64

Soil samples, elements M-Z, mass concentration based on dry substance. Mercury mass concentrations in µg/kg!

		Mercury	**Molybdenum**	**Nickel**	**Thallium**	**Uranium**	**Zinc**
		w(Hg) /	*w*(Mo) /	*w*(Ni) /	*w*(Tl) /	*w*(U) /	*w*(Zn) /
Sample	UA-2012-12	µg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Site -01	-B01	36	< 0.5	2.8	< 0.5	< 0.5	18
Site -02	-B02	74	< 0.5	2.1	< 0.5	< 0.5	26
Site -03	-B03	130	< 0.5	1.8	< 0.5	< 0.5	64
Site -04	-B04	110	< 0.5	2.8	< 0.5	< 0.5	14
Site -05	-B05	220	< 0.5	5.3	< 0.5	< 0.5	94
Site -06	-B06	120	5.0	10	< 0.5	< 0.5	230
Site -07	-B07	13	< 0.5	0.7	< 0.5	< 0.5	9.5
Site -08	-B08	20	2.3	1.6	< 0.5	< 0.5	84
Site -09	-B09	79	< 0.5	3.6	< 0.5	< 0.5	36
Site -10	-B10	37	< 0.5	3.2	< 0.5	< 0.5	34
Site -11	-B11	51	< 0.5	2.1	< 0.5	< 0.5	28
Site -12	-B12	64	< 0.5	1.7	< 0.5	< 0.5	58
Site -15	-B15	59	< 0.5	1.6	< 0.5	< 0.5	83
Site -16	-B16	120	< 0.5	2.9	< 0.5	< 0.5	69
Site -17	-B17	74	< 0.5	1.1	< 0.5	< 0.5	57
Site -18	-B18	83	< 0.5	1.5	< 0.5	< 0.5	51
Site -19	-B19	110	< 0.5	2.1	< 0.5	< 0.5	95
Site -20	-B20	95	< 0.5	1.1	< 0.5	< 0.5	55
Site -21	-B21	78	< 0.5	2.5	< 0.5	< 0.5	63

Water samples, elements A-L

		Antimony	**Arsenic**	**Cadmium**	**Cobalt**	**Chromium**	**Copper**	**Lead**
		β(Sb) /	β(As) /	β(Cd) /	β(Co) /	β(Cr) /	β(Cu) /	β(Pb) /
Sample	UA-2012-	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Site -13	-W13	< 1	< 1	< 1	< 1	< 1	2.0	< 1
Site -14	-W14	< 1	< 1	< 1	< 1	< 1	97	8.1
Site -22	-W22	< 1	< 1	< 1	< 1	< 1	2.4	< 1

Water samples, elements M-Z

		Mercury	**Molybdenum**	**Nickel**	**Thallium**	**Uranium**	**Zinc**
		β(Hg) /	β(Mo) /	β(Ni) /	β(Tl) /	β(U) /	β(Zn) /
Sample	UA-2012-	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Site -13	-W13	< 1	< 1	< 1	< 1	< 1	330
Site -14	-W14	< 1	< 1	1.7	< 1	< 1	370
Site -22	-W22	< 1	< 1	< 1	< 1	< 1	3.2

Objekt: **Sprengstoff-Analytik**
Auftraggeber: Labor Spiez
Auftrags-Nr. Bachema: 20121973

Probenübersicht

Bachema-Nr.		Probenbezeichnung	Probenahme / Eingang Labor
10825	F	12-001	/ 28.03.12
10826	F	12-002	/ 28.03.12
10827	F	12-003	/ 28.03.12
10828	F	12-004	/ 28.03.12
10829	F	12-005	/ 28.03.12
10830	F	12-006	/ 28.03.12
10831	F	12-007	/ 28.03.12
10832	F	12-008	/ 28.03.12
10833	F	12-009	/ 28.03.12
10834	F	12-010	/ 28.03.12
10835	F	12-011	/ 28.03.12
10836	F	12-012	/ 28.03.12
10837	F	12-015	/ 28.03.12
10838	F	12-016	/ 28.03.12
10839	F	12-017	/ 28.03.12
10840	F	12-018	/ 28.03.12
10841	F	12-019	/ 28.03.12
10842	F	12-020	/ 28.03.12
10843	F	12-021	/ 28.03.12
10844	W	12-013	/ 28.03.12
10845	W	12-014	/ 28.03.12
10846	W	12-022	/ 28.03.12

Abkürzungen

W	Wasserprobe
F	Feststoffprobe
TS	Trockensubstanz
<	Bei den Messresultaten ist der Wert nach dem Zeichen < (kleiner als) die Bestimmungsgrenze der entsprechenden Methode.
*	Die mit * bezeichneten Analysen fallen nicht in den akkreditierten Bereich der Bachema AG oder sind Fremdmessungen.

Akkreditierung

Detailinformationen zu Messmethode, Messunsicherheiten und Prüfdaten sind auf Anfrage erhältlich (s. auch Dienstleistungsverzeichnis oder www.bachema.ch).

Probenbezeichnung		12-001	12-002	12-003	12-004		
Proben-Nr. Bachema		10825	10826	10827	10828		
Tag der Probenahme							
Probenparameter							
Angelieferte Probemenge	kg	<1.5	<1.5	<1.5	<1.5		
Trockensubstanz (105°C)	%	95.1	93.5	95.2	91.1		
Sprengstoffe							
1,3-Dinitrobenzol (TS)	µg/kg TS	<1	<1	<1	<1		
1,3,5-Trinitrobenzol (TS)	µg/kg TS	<1	<1	<1	<1		
2,4-Dinitrotoluol (TS)	µg/kg TS	3	3	<1	3		
2,6-Dinitrotoluol (TS)	µg/kg TS	1	<1	<1	2		
2,4,6-Trinitrotoluol (TNT) (TS)	µg/kg TS	<1	<1	2	18		
2-Amino-4,6-Dinitrotoluol (TS)	µg/kg TS	1	<1	74	38		
4-Amino-2,6-Dinitrotoluol (TS)	µg/kg TS	3	<1	76	88		
2,4-Diamino-6-Nitrotoluol (TS)	µg/kg TS	<1	<1	<1	<1		
2,6-Diamino-4-Nitrotoluol (TS)	µg/kg TS	<1	<1	<1	<1		
Tetryl (TS)	µg/kg TS	<10	<10	<10	<10		
Hexogen (RDX) (TS)	µg/kg TS	5	2	14	7		
Octogen (HMX) (TS)	µg/kg TS	<2	<2	3	71		
PETN (TS)	µg/kg TS	<1	<1	<1	<1		
Nitroglycerin (TS)	µg/kg TS	<10	<10	<10	13		
EGDN (TS)	µg/kg TS	<10	<10	<10	<10		
Diphenylamin (TS)	µg/kg TS	<1	<1	<1	<1		
N-Nitrosodiphenylamin (TS)	µg/kg TS	<10	<10	<10	<10		

Probenbezeichnung		12-005	12-006	12-007	12-008		
Proben-Nr. Bachema		10829	10830	10831	10832		
Tag der Probenahme							
Probenparameter							
Angelieferte Probemenge	kg	<1.5	<1.5	<1.5	<1.5		
Trockensubstanz (105°C)	%	92.9	92.0	95.9	99.0		
Sprengstoffe							
1,3-Dinitrobenzol (TS)	µg/kg TS	<1	<1	<1	<1		
1,3,5-Trinitrobenzol (TS)	µg/kg TS	<1	<1	<1	<1		
2,4-Dinitrotoluol (TS)	µg/kg TS	<1	<1	<1	<1		
2,6-Dinitrotoluol (TS)	µg/kg TS	<1	<1	<1	<1		
2,4,6-Trinitrotoluol (TNT) (TS)	µg/kg TS	<1	<1	<1	<1		
2-Amino-4,6-Dinitrotoluol (TS)	µg/kg TS	<1	<1	<1	<1		
4-Amino-2,6-Dinitrotoluol (TS)	µg/kg TS	<1	<1	<1	<1		
2,4-Diamino-6-Nitrotoluol (TS)	µg/kg TS	<1	<1	<1	<1		
2,6-Diamino-4-Nitrotoluol (TS)	µg/kg TS	<1	<1	<1	<1		
Tetryl (TS)	µg/kg TS	<10	<10	<10	<10		
Hexogen (RDX) (TS)	µg/kg TS	7	<1	<1	<1		
Octogen (HMX) (TS)	µg/kg TS	<2	<2	<2	<2		
PETN (TS)	µg/kg TS	<1	<1	<1	<1		
Nitroglycerin (TS)	µg/kg TS	<10	<10	<10	<10		
EGDN (TS)	µg/kg TS	<10	<10	<10	<10		
Diphenylamin (TS)	µg/kg TS	<1	<1	<1	<1		
N-Nitrosodiphenylamin (TS)	µg/kg TS	<10	<10	<10	<10		

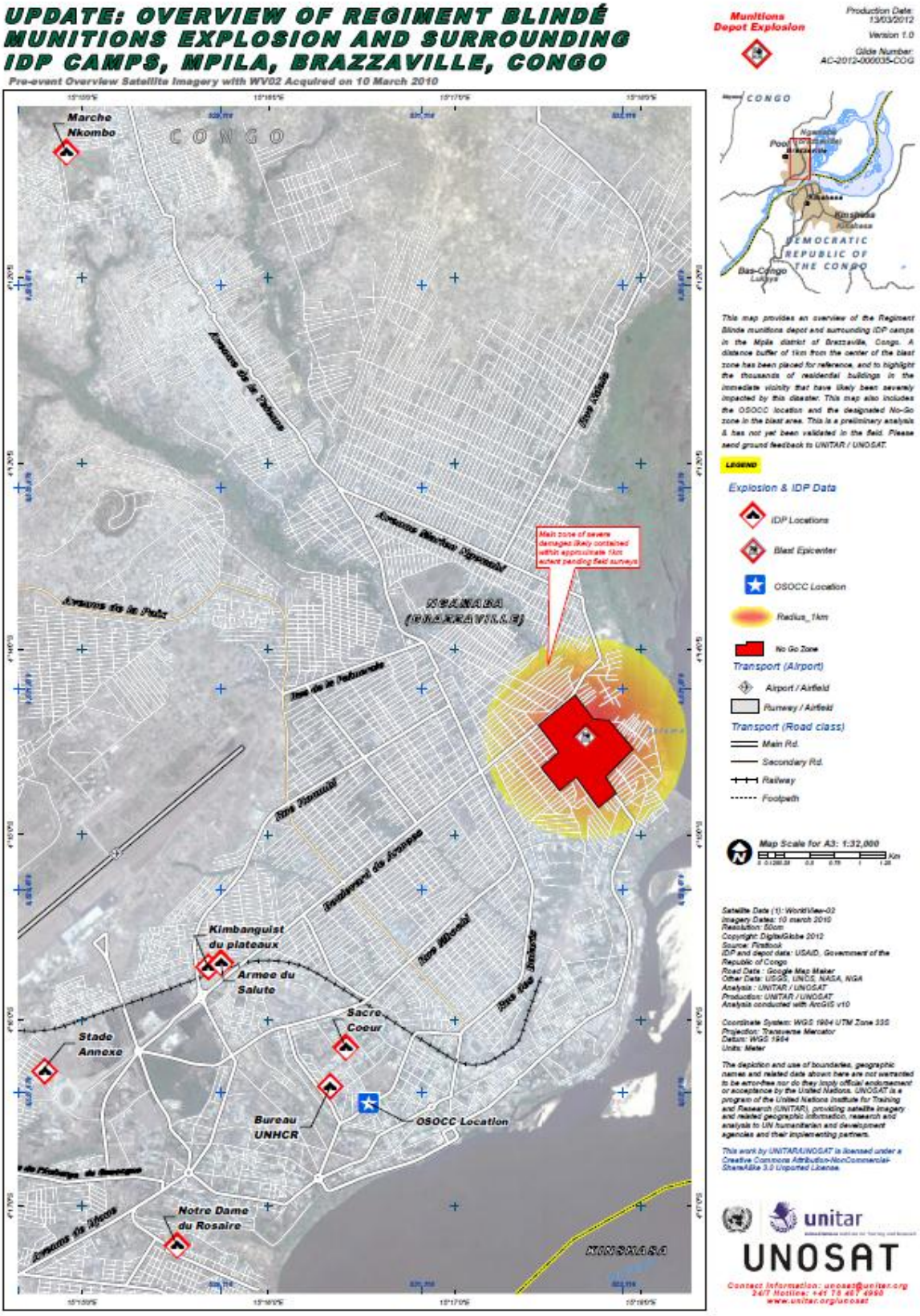
Probenbezeichnung		12-009	12-010	12-011	12-012		
Proben-Nr. Bachema		10833	10834	10835	10836		
Tag der Probenahme							
Probenparameter							
Angelieferte Probemenge	kg	<1.5	<1.5	<1.5	<1.5		
Trockensubstanz (105°C)	%	92.6	95.0	99.0	99.2		
Sprengstoffe							
1,3-Dinitrobenzol (TS)	µg/kg TS	<1	<1	<1	<1		
1,3,5-Trinitrobenzol (TS)	µg/kg TS	<1	<1	<1	<1		
2,4-Dinitrotoluol (TS)	µg/kg TS	<1	<1	<1	<1		
2,6-Dinitrotoluol (TS)	µg/kg TS	<1	<1	<1	<1		
2,4,6-Trinitrotoluol (TNT) (TS)	µg/kg TS	<1	<1	<1	<1		
2-Amino-4,6-Dinitrotoluol (TS)	µg/kg TS	<1	<1	<1	<1		
4-Amino-2,6-Dinitrotoluol (TS)	µg/kg TS	<1	<1	<1	<1		
2,4-Diamino-6-Nitrotoluol (TS)	µg/kg TS	<1	<1	<1	<1		
2,6-Diamino-4-Nitrotoluol (TS)	µg/kg TS	<1	<1	<1	<1		
Tetryl (TS)	µg/kg TS	<10	<10	<10	<10		
Hexogen (RDX) (TS)	µg/kg TS	<1	<1	<1	<1		
Octogen (HMX) (TS)	µg/kg TS	<2	<2	<2	<2		
PETN (TS)	µg/kg TS	<1	<1	<1	<1		
Nitroglycerin (TS)	µg/kg TS	<10	<10	<10	<10		
EGDN (TS)	µg/kg TS	<10	<10	<10	<10		
Diphenylamin (TS)	µg/kg TS	<1	<1	<1	<1		
N-Nitrosodiphenylamin (TS)	µg/kg TS	<10	<10	<10	<10		

Probenbezeichnung		12-015	12-016	12-017	12-018		
Proben-Nr. Bachema		10837	10838	10839	10840		
Tag der Probenahme							
Probenparameter							
Angelieferte Probemenge	kg	<1.5	<1.5	<1.5	<1.5		
Trockensubstanz (105°C)	%	99.1	99.2	99.1	99.0		
Sprengstoffe							
1,3-Dinitrobenzol (TS)	µg/kg TS	<1	<1	<1	<1		
1,3,5-Trinitrobenzol (TS)	µg/kg TS	<1	<1	<1	<1		
2,4-Dinitrotoluol (TS)	µg/kg TS	1	<1	<1	<1		
2,6-Dinitrotoluol (TS)	µg/kg TS	<1	<1	<1	<1		
2,4,6-Trinitrotoluol (TNT) (TS)	µg/kg TS	4	328	<1	<1		
2-Amino-4,6-Dinitrotoluol (TS)	µg/kg TS	<1	22	<1	<1		
4-Amino-2,6-Dinitrotoluol (TS)	µg/kg TS	2	32	<1	<1		
2,4-Diamino-6-Nitrotoluol (TS)	µg/kg TS	<1	<1	<1	<1		
2,6-Diamino-4-Nitrotoluol (TS)	µg/kg TS	<1	<1	<1	<1		
Tetryl (TS)	µg/kg TS	<10	<10	<10	<10		
Hexogen (RDX) (TS)	µg/kg TS	<1	3	<1	<1		
Octogen (HMX) (TS)	µg/kg TS	6	240	5	<2		
PETN (TS)	µg/kg TS	<1	<1	<1	<1		
Nitroglycerin (TS)	µg/kg TS	<10	<10	<10	<10		
EGDN (TS)	µg/kg TS	<10	<10	<10	<10		
Diphenylamin (TS)	µg/kg TS	<1	<1	<1	<1		
N-Nitrosodiphenylamin (TS)	µg/kg TS	<10	<10	<10	<10		

Probenbezeichnung		12-019	12-020	12-021			
Proben-Nr. Bachema		10841	10842	10843			
Tag der Probenahme							
Probenparameter							
Angelieferte Probemenge	kg	<1.5	<1.5	<1.5			
Trockensubstanz (105°C)	%	99.1	99.1	98.3			
Sprengstoffe							
1,3-Dinitrobenzol (TS)	µg/kg TS	<1	<1	<1			
1,3,5-Trinitrobenzol (TS)	µg/kg TS	<1	<1	<1			
2,4-Dinitrotoluol (TS)	µg/kg TS	<1	<1	<1			
2,6-Dinitrotoluol (TS)	µg/kg TS	<1	<1	<1			
2,4,6-Trinitrotoluol (TNT) (TS)	µg/kg TS	<1	<1	<1			
2-Amino-4,6-Dinitrotoluol (TS)	µg/kg TS	<1	<1	<1			
4-Amino-2,6-Dinitrotoluol (TS)	µg/kg TS	<1	<1	<1			
2,4-Diamino-6-Nitrotoluol (TS)	µg/kg TS	<1	<1	<1			
2,6-Diamino-4-Nitrotoluol (TS)	µg/kg TS	<1	<1	<1			
Tetryl (TS)	µg/kg TS	<10	<10	<10			
Hexogen (RDX) (TS)	µg/kg TS	<1	<1	<1			
Octogen (HMX) (TS)	µg/kg TS	<2	<2	<2			
PETN (TS)	µg/kg TS	<1	<1	<1			
Nitroglycerin (TS)	µg/kg TS	<10	<10	<10			
EGDN (TS)	µg/kg TS	<10	<10	<10			
Diphenylamin (TS)	µg/kg TS	<1	<1	<1			
N-Nitrosodiphenylamin (TS)	µg/kg TS	<10	<10	<10			

Probenbezeichnung		12-013	12-014	12-022			
Proben-Nr. Bachema		10844	10845	10846			
Tag der Probenahme							
Sprengstoffe							
4-Amino-2,6-Dinitrotoluol	µg/L	<0.1	<0.1	<0.1			
2-Amino-4,6-Dinitrotoluol	µg/L	<0.1	<0.1	<0.1			
2,6-Diamino-4-Nitrotoluol	µg/L	<0.1	<0.1	<0.1			
2,4-Diamino-6-Nitrotoluol	µg/L	<0.1	<0.1	<0.1			
1,3-Dinitrobenzol	µg/L	<0.1	<0.1	<0.1			
2,4-Dinitrotoluol	µg/L	<0.1	<0.1	<0.1			
2,6-Dinitrotoluol	µg/L	<0.1	<0.1	<0.1			
Diphenylamin	µg/L	<0.1	<0.1	<0.1			
EGDN	µg/L	<1	<1	<1			
Hexogen (RDX)	µg/L	<0.1	<0.1	<0.1			
Nitroglycerin	µg/L	<1	<1	<1			
N-Nitrosodiphenylamin	µg/L	<1	<1	<1			
Octogen (HMX)	µg/L	<0.1	<0.1	<0.1			
PETN	µg/L	<0.1	<0.1	<0.1			
Tetryl	µg/L	<1	<1	<1			
1,3,5-Trinitrobenzol	µg/L	<0.1	<0.1	<0.1			
2,4,6-Trinitrotoluol (TNT)	µg/L	<0.1	<0.1	<0.1			

Annex II: Overview of Regiment Blindé Munitions Explosion and Surrounding IDP Camps



Annex III: Map, Overview of JEU Activities (1994-2011)