Technical Report

on

Capacity-building for the Assessment of Depleted Uranium in Iraq

United Nations Environment Programme
Geneva, August 2007

UNEP

First published in Switzerland in 2007 by the United Nations Environment Programme.

United Nations Environment Programme
PO Box 30552, Nairobi, Kenya
Tel: +254 (0)20 762 1234
Fax: +254 (0)20 762 3927
E-mail: uneppub@unep.org
Web: http://www.unep.org

DISCLAIMER

The contents of this volume do not necessarily reflect the views of UNEP, or contributory organizations. The designations employed and the presentations do not imply the expressions of any opinion whatsoever on the part of UNEP or contributory organizations concerning the legal status of any country, territory, city or area or its authority, or concerning the delimitation of its frontiers or boundaries.

Report Coordination: Alain Wittig
Maps: Yves Barthélemy & Ola Nordbeck
Design and Layout: Rachel Dolores

Table of Contents

1 Background

In April 2003, the United Nations Environment Programme (UNEP) published a *Desk Study on the Environment in Iraq*, which outlined the environmental vulnerabilities resulting from years of conflict in the country, the low priority given to environment by the previous regime, and the unintended environmental effects of international economic sanctions in the 1990s. One of the issues identified in the study was the impact of the use of depleted uranium (DU) during the conflict. The report accordingly recommended that a comprehensive field assessment be conducted in Iraq to investigate the use of DU and its residual impacts.

Following a formal request for such an assessment from the Iraqi Minister for Environment H.E. Mishkat Moumin in August 2004, UNEP – in association with the World Health Organization (WHO) – submitted a proposal to the UNDG Iraq Trust Fund during the autumn. The proposal was not approved, but UNEP carried on with a scaled-down plan of work, thanks to funding from the United Kingdom's Department for International Development (DFID).

UNEP's original plan called for the deployment of international experts to Iraq to conduct the investigation. However in June 2005, due to the continuously deteriorating security situation, UNEP decided instead to train and equip national experts from the Radiation Protection Centre (RPC) of the Iraqi Ministry of Environment (MoEn) to undertake the expert DU assessment locally.

This report focuses on the various capacity-building activities carried out by UNEP to ensure good quality procedures during the local expert DU assessment and subsequent fieldwork. A second report presenting the findings and conclusions of the fieldwork will be published in 2007.

1.1 Depleted uranium in Iraq

The 1991 Gulf war is reportedly the first conflict in which depleted uranium ammunition was used on a large military scale. Overall, 50 metric tonnes of DU were fired during tank battles and 250 tonnes in air to ground attacks.

A UNEP expert demonstrates sampling techniques for depleted uranium.

The total amount of DU ammunition used during the conflict in 2003 is still unknown, but speculative figures from various studies range between 170 and 1,700 metric tonnes. The United Kingdom Ministry of Defence (UK MOD) has indicated that less than one tonne of DU ammunition during the 1991 Gulf war, and approximately 1.9 tonnes in the 2003 Iraq war. Ammunition was fired exclusively from tanks, as airplanes were not used by the UK in either conflict.

While it has not disclosed where such ammunition was used in the 1991 conflict, the UK MOD provided UNEP in June 2003 with the coordinates of DU firing points for UK Challenger II tanks in the 2003 Iraq conflict. The United States government has to date not released information to UNEP on DU target coordinates for the 1991 and 2003 wars.

1.2 Objectives

The five main objectives of UNEP's depleted uranium capacity-building project in Iraq were to:

1. Train officials from Iraq to undertake a field-based assessment of depleted uranium using internationally accepted methodologies and modern equipment;

2. Provide the trained officials with precise information on sites to assess and type of samples to collect;
3. Remotely supervise the assessment and retrieve samples;
4. Analyse the field observations, monitoring results and samples to draw conclusions on the effectiveness of the capacity-building activities; and
5. Review the results and provide recommendations to the Ministry of Environment on follow-up actions.

1.3 Scope of work

The scope of UNEP's capacity-building project on depleted uranium in Iraq included the following activities:

- seminars and training workshops on environmental site assessments, sample analysis, and DU-specific field procedures;
- the selection and procurement of sensitive field-monitoring equipment for DU investigations;
- defining the scope of the DU assessment project, and providing relevant information tools in the form of site assessment packages to facilitate good quality deliverables for local experts;
- providing logistical support for data and sample transfers between Iraq and UNEP; and
- interacting with the local experts throughout the DU assessment project.

The capacity-building project also included extensive fieldwork by local experts who had completed the basic UNEP training. The scope of the DU assessment performed by local experts in southern Iraq included:

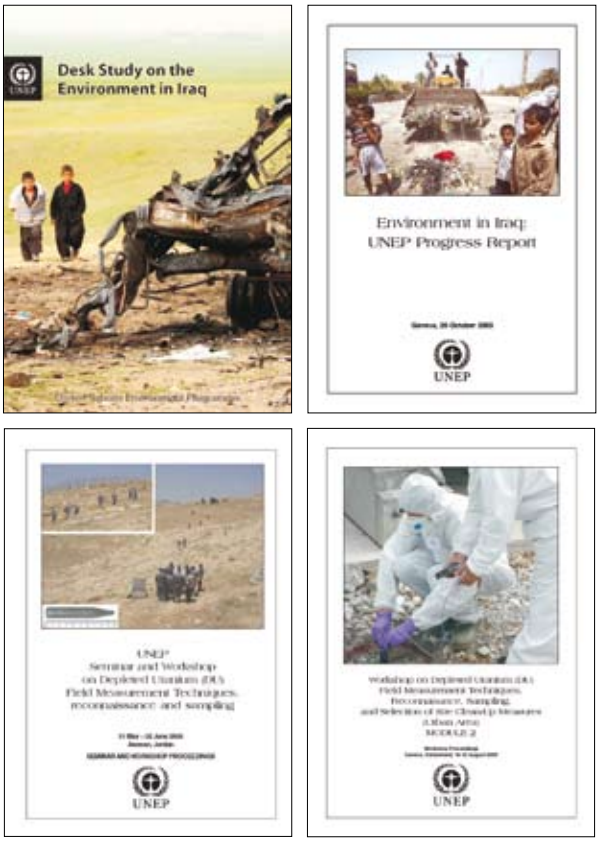
- the identification of areas where DU ammunition was used and contamination might be detected; and
- the implementation of a sampling programme for DU in soil, water, vegetation and on surfaces002E

1.4 International cooperation

On 6 April 2005, UNEP convened a meeting with the World Health Organization (WHO) and the International Atomic Energy Agency (IAEA) in Geneva to discuss, coordinate and plan work on DU in Iraq. The three organizations already shared a history of collaboration in the field of DU, starting in the Balkans in the year 2000.

At the meeting, UNEP, WHO and the IAEA agreed to collaborate with the Iraqi Ministry of Environment's Radiation Protection Centre (RPC). WHO and IAEA also agreed to actively participate in upcoming seminars and workshops organized by UNEP on the topic of DU. Both agencies subsequently took part in a UNEP seminar in Amman in May 2005, where they presented their latest findings in the field of radiation protection, DU and related health effects. This gave them the opportunity to meet and share their latest knowledge with other stakeholders.

In a workshop held in Geneva in August 2005, IAEA then presented a status report on its work in Iraq.



Publications by the UNEP Iraq Programme

UNEP and the Swiss SPIEZ LABORATORY have collaborated closely on a number of projects, including the UNEP Iraq DU capacity-building programme

In March 2006, a meeting between IAEA, UNEP and the RPC (WHO experts were not able to attend) was held in Geneva to review the procedures and preliminary results of the first phase of the local expert DU assessment, and to offer feedback to the Iraqi experts. UNEP and the RPC also defined follow-up field activities and the second phase of the assessment.

In addition, UNEP was invited to participate in the UK MOD's second and third Depleted Uranium Workshops, held in October 2004 and March 2006 respectively. The purpose of these events was to bring together representatives of the UK MOD, the research community and veterans groups with an interest in DU issues, and to communicate and review achievements within the UK DU research programme. While the workshops were unclassified, attendance was by invitation only. UNEP received the opportunity to present a summary of its activities on DU, as well as to report on progress made in its DU projects. US Army representatives were also invited.

1.5 Swiss SPIEZ LABORATORY

SPIEZ LABORATORY is a governmental institute of the Swiss Department of Defence, Civil Protection and Sports, under the authority of the Federal Office of Civil Protection. It focuses principally on nuclear, biological and chemical defence-related matters, and has become a reference laboratory for international organizations in this field, such as the Organization for the Prohibition of Chemical Weapons (OPCW).

The institute is also active in comprehensive environmental analysis, and experts from SPIEZ LABORATORY have been involved in all UNEP DU assessments as well as various UNEP capacity-building projects since November 2000, and performed highest quality analysis on samples collected during assessments and other missions. SPIEZ LABORATORY's departments are all accredited in accordance with ISO/IEC 17025.

1.6 The Swedish Radiation Protection Authority (SSI)

UNEP has collaborated periodically with the SSI – a government authority dedicated to protecting people and the environment from the harmful effects of radiation – ever since the very first DU assessment it carried out in Kosovo. An expert from the SSI was accordingly involved in the UNEP capacity-building programme on DU in Iraq.

2 Capacity-building Activities

UNEP provided training to Iraqi experts from the RPC through three workshops designed to cover all the aspects of DU assessment in the affected areas. The first workshop was held at the SPIEZ LABORATORY in Switzerland in May 2004. It focused broadly on environmental inspections and laboratory analyses, rather than specifically on depleted uranium. The second workshop – on DU site investigation techniques – took place in June 2005 in Amman, Jordan. This event was preceded by a one-day seminar on DU for representatives from Jordanian and Iraqi ministries, embassies and local UN agencies. A third workshop held in Geneva, Switzerland in August 2005 concentrated on site investigation techniques in urban areas. Together, these workshops had the objective to prepare local experts and their field staff to undertake DU site assessment work using the appropriate methodologies. A brief account of each workshop and associated events is provided below.

2.1 Workshop I on environmental inspections and environmental laboratory analyses, 2-16 May 2004, Geneva and Spiez, Switzerland

UNEP and SPIEZ LABORATORY experts trained participants in the basics of environmental inspections, as well as soil, air, and water pollution, hazardous chemicals and waste management. The fundamentals of environmental inspections covered the preparation phase, the launch of the assessment, on-site inspection/assessment, forms, sampling strategy procedures, chemical analysis strategy, evaluation of the results, reporting and the follow-up phase. Theoretical training was complemented by specific field training on environmental inspections and sampling procedures for different media, including air, water, soil and biota. Field measurement techniques were also covered.

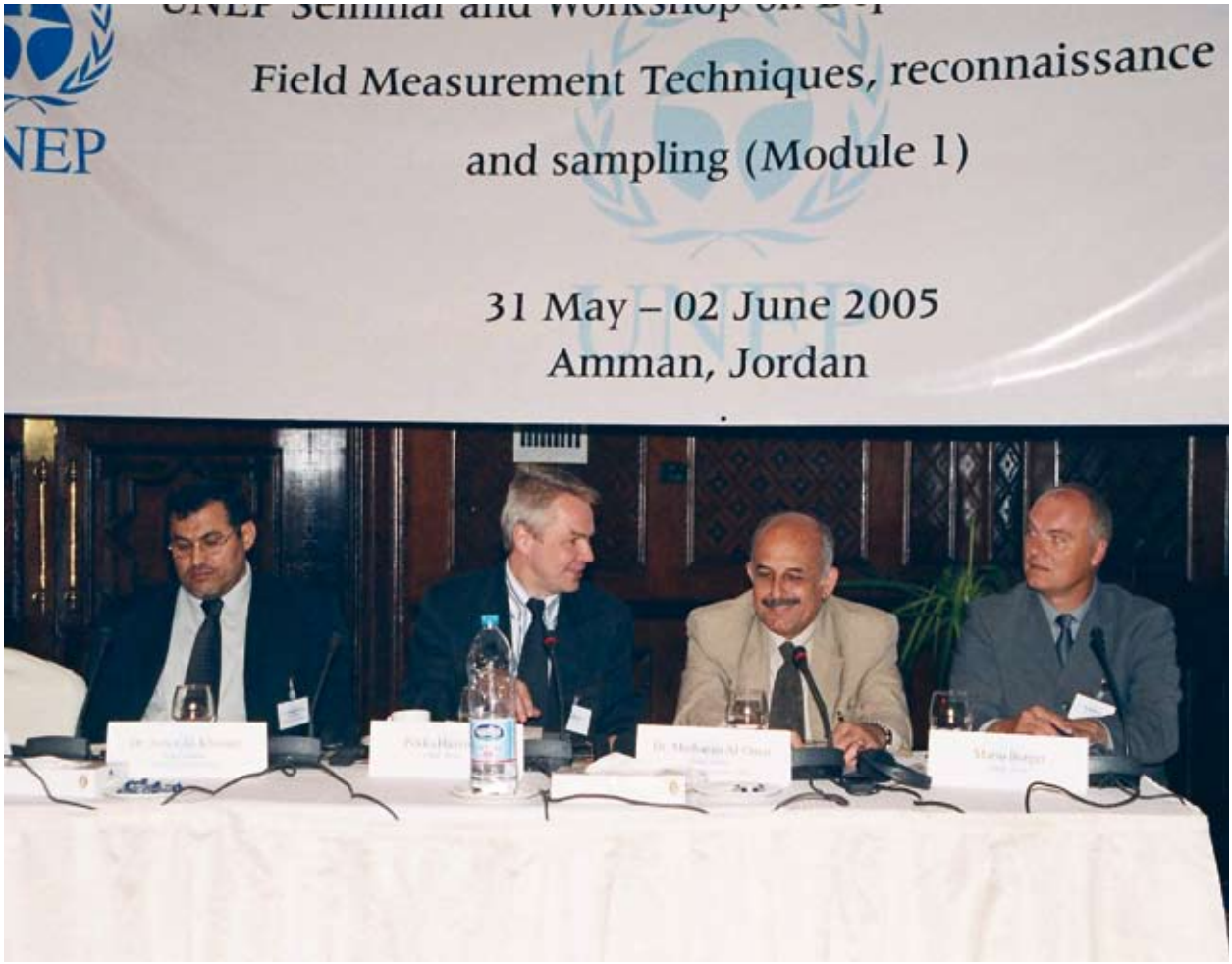
Dr. Klaus Töpfer, the former UNEP Executive Director, opens the Iraq DU capacity-building programme in Geneva in May 2004.

2.2 UNEP one-day seminar on depleted uranium, 31 May 2005, Amman, Jordan

The seminar was attended by the fifteen workshop participants from Iraq (see following section), the Iraqi Deputy Ministers of Environment and Health, thirty invitees from Jordanian ministries, embassies and the UN, and two observers from the UK and the US. Participants were given an overview of UNEP activities in general, as well as of specific work on Iraq and DU issues. UNEP reviewed DU assessments undertaken in the Balkans in 2001, 2002, and 2003, and IAEA presented the findings of the 2002 joint IAEA/UNEP DU mission to Kuwait. In addition, the seminar included presentations by the WHO on health-related issues in Iraq, including on DU, and IAEA discussed planned procedures for setting up a regulatory body in the field of radioactivity in Iraq. Finally, DU experts from the UK and US presented the main findings from their respective studies.

2.3 Workshop II on DU field measurement techniques, reconnaissance and sampling (Module 1), 1-2 June 2005, Amman, Jordan

The objective of this second workshop, which followed the seminar at the Jordan Atomic Energy Commission (JAEC) in Amman, was to provide training, equipment and technical assistance to selected Iraqi professionals from the Ministry of Environment's Radiation Protection Centre (MoEn RPC) and the Ministry of Health (MoH). Eleven Iraqi experts from the Ministry of Environment and four from the Ministry of Health received basic technical training. Participants were trained in the use of instruments that were handed over to the MoEn Head of Delegation, as well as equipment foreseen to be provided to the MoEn in the near future. These instruments constituted the first batch of equipment delivered by UNEP under the project.



The second workshop on depleted uranium was held in Amman, Jordan, in May-June 2005

2.4 Workshop III on DU field measurement techniques, reconnaissance, sampling and selection of site clean-up measures for urban areas (Module 2), 16-18 August 2005, Geneva, Switzerland

This final workshop was attended by fifteen participants from the MoEn RPC and MoH, thirteen of which had taken part in the first module in Amman. An observer from the US military was also present for the duration. Presentations and practical training were provided by UNEP and international DU expert consultants from the SSI and SPIEZ LABORATORY.

The theoretical session included presentations by the different branches of UNEP, offering the audience a general overview of UNEP's activities worldwide. In addition, the IAEA presented a status report on Iraq pertaining to its mandate. Finally, an introduction to health and safety procedures was provided for the fieldwork to follow.

The practical session of the workshop had a comprehensive agenda covering nearly all the measurement techniques that are useful also in urban areas. It also comprised detailed training on sampling methods, clean-up and small-scale decontamination measures. The practical work focused on realistically simulating the prevailing conditions on a site targeted by DU. Measurement and clean-up techniques were demonstrated by the UNEP expert team and experimented in detail by each participant. Sampling strategies and techniques were also developed.

Above: Inspector Geiger-Müller instrument

2.5 Fieldwork equipment

To enable the RPC to conduct adequate and safe DU field assessments and other radiological investigations covered by its mandate, UNEP supplied field equipment. Selection criteria included durability, portability, and suitability to the operating environment of Iraq. Personal protective equipment (PPE) was given to each workshop participant to use and take back to Iraq. Monitoring instruments were either handed over to Iraqi experts during the workshops, or shipped directly to the RPC. The field training sessions were an opportunity to handle and test the instruments, and to demonstrate the importance of PPE and its correct use. The list of equipment provided includes:

- various types of personal protective equipment;
- soil augers;
- four *Garmin GPS 12* Global Positioning Systems;
- four *Canon PowerShot A85* digital cameras;
- four *Automess AD6* dose rate meters, including four alpha-beta-gamma probes;
- four Geiger-Müller *Inspector* instruments; and
- two *SAPHIMO-SRAT S.P.P.2 NF* scintillometers.

Left: Automess AD6 dose rate meter, including alpha-beta-gamma probe

Right: SAPHIMO-SRAT S.P.P.2 NF scintillometer

3 Preparation for the Fieldwork

In addition to training Iraqi officials and providing them with suitable equipment, UNEP had to identify ways of guiding the local experts to sites that might contain DU residues. The geographical scope of the work was limited to the southern governorates of Iraq for the following reasons:

1. There had been reports of DU use and related health impacts in Southern Iraq for many years;
2. Immediately after the conflict, the UK MOD provided UNEP with coordinates for the use of DU by its army in southern Iraq;
2. The Iraqi Ministry of Environment had already conducted fieldwork for preliminary data gathering in southern Iraq; and
3. The security situation in southern Iraq was better than in other areas reportedly impacted by DU.

To identify potential sites containing DU residues within southern Iraq, UNEP used the sources detailed below.

3.1 UK MOD coordinates

On 24 June 2003, the UK MOD provided UNEP with a list of fifty-one DU target coordinates for the 2003 Iraq conflict, as well as a map identifying Challenger II tank target points. In addition, the UK disclosed that it had fired a total amount of approximately 1.9 tonnes of DU ammunition during the conflict.

In combination with other data, this list of DU target coordinates for the region of Al Basrah enabled UNEP to define the coverage of both phases of the local expert DU site assessment and provide the Iraqi experts with enough information to plan their field missions.

Data on the quantity of DU used by UK forces during the 1990/91 conflict – less than one tonne – was also included in the 24 June 2003 correspondence, though no coordinates of firing points or target sites were given for that conflict.

A scrap yard full of debris potentially contaminated by depleted uranium

Years after the conflict, tanks hit by DU ammunition can be found corroding by the side of the road

3.2 Iraq RPC data

UNEP and the RPC exchanged information very regularly throughout the capacity-building process. Efficient communications systems were set up using email and a file exchange platform – the File Transfer Protocol (FTP) web interface. The RPC shared all of its updated data and new findings with the UNEP DU team, as well as photos, presentations and information flyers on its activities. All of this information was frequently updated in UNEP's DU database.

In the process, UNEP obtained very useful information on the findings of earlier DU campaigns performed by the RPC, including maps illustrating the areas affected by DU in Iraq and more specifically in Al Basrah and Baghdad, as well as the exact coordinates of the areas studied and tanks hit by DU.

3.3 UNEP data collection

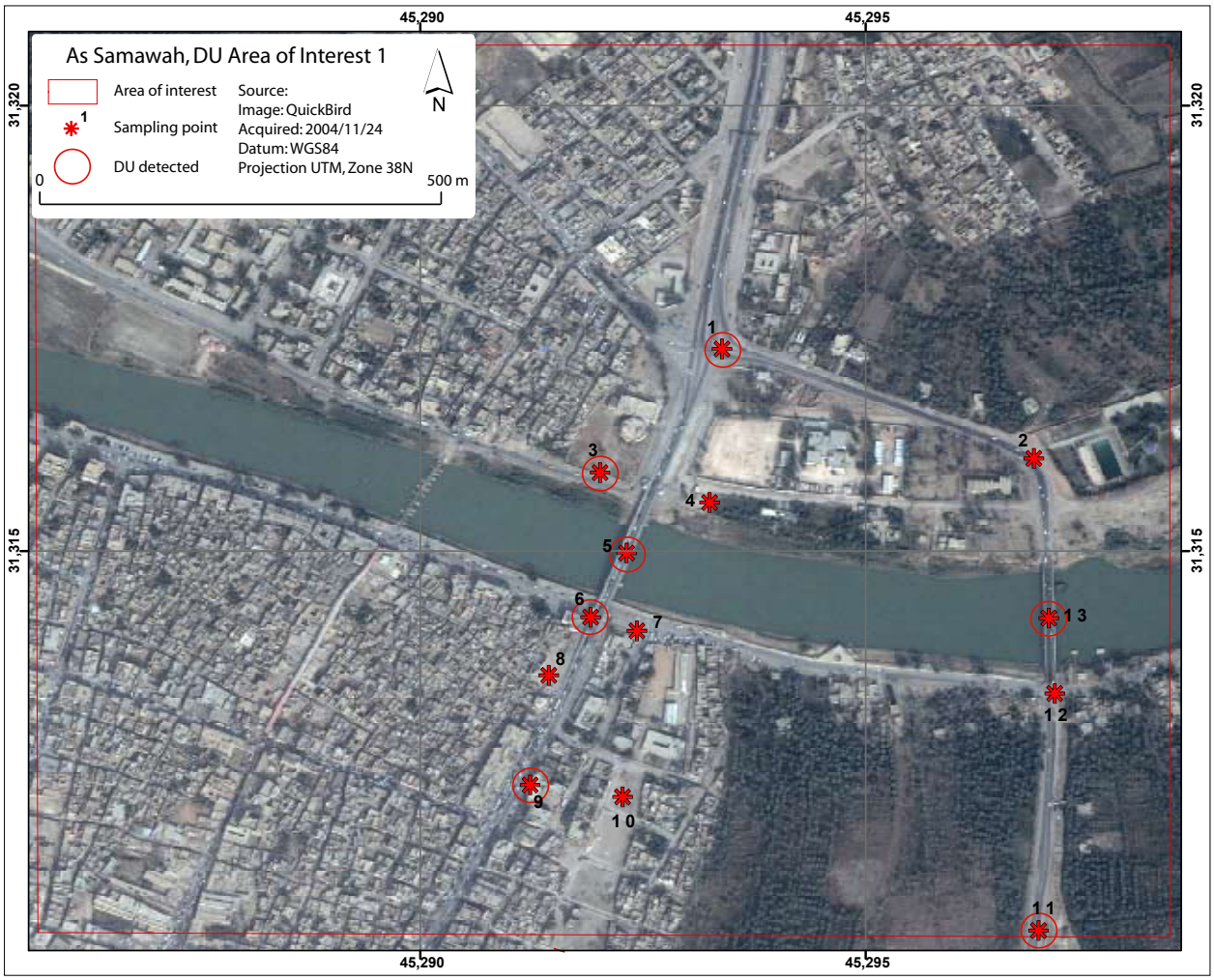
UNEP also used extensive internet searches, media coverage, specialized reports, proceedings from international seminars and conferences, and Coalition forces documents as additional sources of information. This data was then combined with that provided by the RPC and UK MOD to identify potential sites containing DU residues. These were located partly within the UK coordinates, and partly outside them.

3.4 Preparation of site maps

Once the preliminary site identification had been made, UNEP procured high resolution satellite images of these locations, taken before and as soon as possible after the conflict event. These images were compared and studied in detail for operational signs of where DU could have been employed (e.g. tanks, artillery guns, tank tracks etc). Based on this analysis, a series of maps showing suggested sampling areas was produced. Sites identified as potentially contaminated by DU included:

- places where Iraqi military equipment was placed, hidden or destroyed;
- places where signs of intense fighting were apparent;
- places (such as bridges and locations of strategic military importance) where significant damages were detected and military equipment could have been present;
- the UK DU coordinate sites provided by the UK MOD; and
- sites provided by the MoEn RPC and of interest to both RPC and UNEP.

As Samawah, DU Area of Interest



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

3.5 Local Expert DU Site Assessment Packages I and II

Through the process described above, UNEP was able to define precise areas of interest thought to be contaminated by DU, and to produce ***Local Expert DU Site Assessment Packages***, which comprised site maps, DU sampling plans and full information on the areas included in the assessment phase.

Local Expert DU Site Assessment Package I covered the area of As Samawah and Az Zubayr. For details see Appendices A and B.

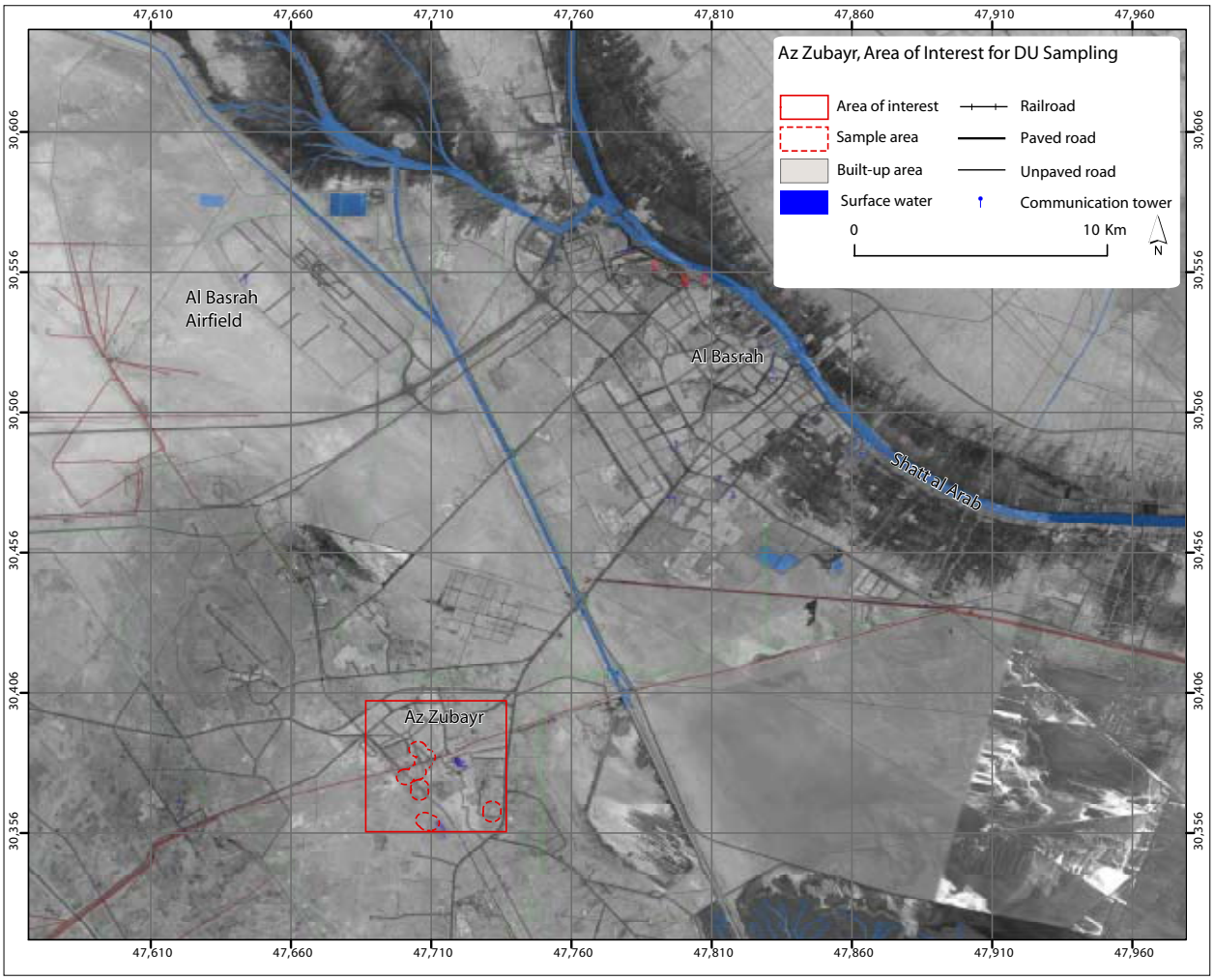
Local Expert DU Site Assessment Package II focused on the area of Al Basrah and An Nasiriyah. For details see Appendices C and D.

The aim of these comprehensive documents was to guide the RPC to perform ground truthing and collect samples following appropriate methodologies and good practices to allow subsequent analysis by national and international laboratories. To enable quality analysis and interpretation to occur, UNEP recommended that the Iraq field teams adopt the suggested sampling and reporting methods, including the proper use of forms, procedures etc. The team was also asked to make photographic records of all the fieldwork.

3.6 Sites identified for field visits

As Samawah, which has a population of approximately 180,000, is located some 250 km south of Baghdad, along the main road linking the capital to the port of Umm Qasr. At its northern end, the town is split by the Euphrates river, with several bridges linking both sides. One of the main bridges – used for the town's main road – came under heavy fighting between Iraqi and Coalition forces during the conflict in 2003.

Az Zubayr, DU Area of Interest



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

A cement factory south-east of the town is believed to have served as a strategic location for Iraqi tanks protecting the bridge, located some 1.5 km away (the approximate firing range of a T-72 tank). A number of Iraqi tanks were also reportedly placed along both sides of the main road, which curves eastward for three to four kilometres after the bridge. Although the exact number of tanks stationed at each site is unknown, estimates based on reports and standard conflict strategies indicate that some 50 Iraqi tanks were used during the battle of As Samawah.

Six A10 Warthog aircraft attacks by Coalition Forces are believed to have targeted these sites between 29 March and 2 April 2003. One A10 airplane typically drops up to 2,000 DU penetrators on the target and its surroundings during an attack. The flight direction of the planes is unknown.

Four areas of interest were studied in As Samawah: the area surrounding the main bridge, the upper section of the main road, the lower section of the main road, and the cement factory. Additional investigations were carried out in areas where DU contamination was suspected based on field observations, including vacant land on the outskirts of the town, the train station in the Al Khafora region, a scrap yard near the cement factory and areas in which piles of waste and debris were found. Intact and bombarded tanks were observed at several of these locations, and samples of soil and surfaces were collected from the tanks and their immediate surroundings. See Appendix A for details.

Az Zubayr, with an approximate population of 185,000, has long been an important centre of trade with Saudi Arabia and Kuwait. It is located in south-eastern Iraq, some 20 km south of the major city of Al Basrah. A former munitions storage facility is located there.

Destroyed military equipment contaminated by depleted uranium is transported by rail

Az Zubayr was the site of intense conflict in April 2003, as Coalition troops moved toward Al Basrah. DU munitions were reportedly used during A-10 aircraft attacks throughout the city. Several bombarded tanks and tank parts were identified in the course of the field investigation, and soil and surface smear samples were taken from the tanks and surrounding areas. For the purposes of this assessment, the city was considered as a single area of interest. See Appendix B for details.

Al Basrah, located on the western bank of the Shatt Al Arab waterway, is the second largest city in Iraq, with an estimated population of 2.6 million people. The city is situated approximately 55 km from the Persian Gulf and 550 km south-east of Baghdad. Al Basrah is the main port in Iraq and the terminal point for oil pipelines.

Intense fighting took place in and around Al Basrah in 2003, as Coalition forces advanced into the city. Multiple tank battles and aircraft attacks using DU munitions were reported in the area. DU investigations focused on sites south of the city centre and the city's southern suburbs. A total of four areas of interest were examined. See Appendix C for details.

An Nasiriyah, finally, is situated on the Euphrates river, approximately 360 km south-east of Baghdad. The city, which has an estimated population of 560,000, is an important crossing point of the Euphrates and a major railroad junction. The predominant industries are date production, the fabrication of aluminum and ship-building.

In March and April 2003, An Nasiriyah was the site of intense conflict as Coalition forces attempted to take control of the city. Confrontations included tank battles and aircraft attacks using DU munitions, although the exact number of DU rounds fired in this area remains unknown. DU investigations were conducted in the city centre and surrounding areas; samples were also taken from bombarded tanks and the soil nearby. In total, fourteen areas of interest were examined. See Appendix D for details.

4 Fieldwork

The RPC team visited the sites identified in ***Local Expert DU Mission Packages I and II*** to conduct field measurements and sampling. Given the prevailing security situation, all fieldwork had to be planned and executed with due diligence to ensure the safety of the staff at all times.

The field teams used visual indicators as the primary signs of potential DU contamination. In potentially contaminated areas, experts used their discretion when selecting locations for soil and water sampling. Information was also provided by the local population.

4.1 Radiological field measurements

Radiological field measurements were taken to measure ambient dose rates in the areas of interest, to identify potential DU contamination on surfaces, and to locate DU residues, such as jackets, penetrators and/or fragments lying on or just below the ground surface. Ambient dose rates were usually measured by the *Automess AD6* instrument, although results were also reported from measurements taken by the *Inspector* instrument. Other DU-related field investigations were carried out using *SRAT* (gamma radiation; search for jackets, fragments, penetrators; gamma-emitting radioactive sources) and *Inspector* (beta radiation; increased surface contamination) radiation survey meters. *IdentiFINDER* portable gamma spectrometers (supplied to the Basrah governorate laboratory by private donors) were also employed by field teams to distinguish between gamma radiation emitted from natural and artificial sources. *GARMIN GPS-12* was used to determine global positioning system coordinates for the study areas and sampling coordinates.

4.2 Soil sampling

The objective of soil sampling was principally to check for the presence of DU as measured in the 0-5 cm surface soil layer of the area of interest, or – in the case of measurements beyond the analytical detection limits – to define the extent of localized ground contamination and its concentrations.

Local experts trained by UNEP investigate a tank hit by DU-ammunition

The following procedures were followed for the collection of soil samples:

- Soil samples from a depth of 0-5 cm were recovered using a manual corer;
- Each soil sample consisted of a minimum of ten soil cores, randomly collected from an area of approximately 2 x 2 m;
- The soil cores were combined in a double plastic bag and the bags were labeled with the sample code. A sampling form was completed for each sample;
- The typical mass of each composite soil sample was approximately 2 kg;
- Approximately 1.5 kg per sample of the total mass collected from areas covered in ***Local Expert DU Site Assessment Package I*** was sent to the SPIEZ LABORATORY for analysis;
- Based on a decision taken in the March 2006 meeting between RPC and UNEP in Geneva, samples collected in areas covered by ***Local Expert DU Site Assessment Package II*** were dried and mixed, and 2 mm were sieved at RPC. Approximately 250 g per sample were then shipped to the SPIEZ LABORATORY for detailed analysis.

Experts collect samples of soil to measure for DU contamination

4.3 Water sampling

Where possible, water samples were collected from private wells and taps to check for the presence of DU in drinking water. One litre of water was sampled at selected locations using a polyethylene bottle. Samples were preserved immediately after sampling. Bottles were labeled, stored and transported to the RPC laboratory before being shipped to SPIEZ LABORATORY.

4.4 Smear sampling

Surface dust deposits on smooth undisturbed surfaces between 20 x 20 cm^2 and 50 x 50 cm^2 in size were collected using dry smear sampling kits. Exact measurements of the sampled area were taken and recorded in the corresponding form. The smear sample was folded, placed in a plastic bag and coded. Field blank samples were also collected for quality assurance/quality control purposes. These samples were transported in the field, exposed to the atmospheric conditions and subjected to the standard sample handling procedures, but were not used to collect surface samples. All smear samples were stored and transported to the RPC and SPIEZ LABORATORY.

4.5 Vegetation sampling

Grass, vegetable, and date samples were recovered in the course of the fieldwork, but only in areas covered by ***Local Expert DU Site Assessment Package I***. The total volume collected was about 1.5 litres. They were stored and transported to the RPC laboratory, before being sent to SPIEZ LABORATORY untreated. Samples were generally of bad quality, rotten and contaminated with soil.

4.6 Total samples collected

As Samawah: A total of 202 samples was collected in the four areas of interest and additional investigation points, with the following breakdown: 71 soil samples, 10 water samples, 106 smear samples, and 15 vegetation samples.

Az Zubair: 62 samples were collected in total in Az Zubair, with the following breakdown: 22 soil samples, one water sample, 29 smear samples, and 10 vegetation samples.

Al Basrah: A total of 103 samples were collected in the four areas of interest, with the following breakdown: 65 soil samples, 4 water samples and 34 smear samples.

An Nasiriyah: 153 samples were collected in total in the thirteen areas of interest and additional investigation points, with the following breakdown: 106 soil samples, 44 smear samples, and 3 water samples.

4.7 Limitations

The DU assessment objectives and tasks were subject to the following limitations:

Not all locations were visited

DU ammunition was used in many areas during military confrontations in Iraq. Limited locations were visited not allowing a generalization of the "DU situation in Iraq" or in southern Iraq. The amount of DU at each targeted location depends on the amount fired at that specific location, the type and history of the target, the specific meteorological conditions, the nature of the terrain etc.

However, the results of the assessment did not vary significantly.

Access to some locations was limited

In ensuring the safety of the team, the main concern was the risk of ongoing military conflict and the potential presence of unexploded ordnance (UXO). In some cases these risks limited the extent of the investigation.

DU sources change over time

In the three-year period between the 2003 military conflict and the local DU assessment mission, the conditions for detecting DU residues most probably changed significantly. Penetrators and DU fragments lying on the ground surface may have been covered by soil, grass and other organic matter, or taken away by the local population or military personnel. DU dust originally dispersed over a specific area may have been moved by wind or rain. If the dust was displaced by wind, contamination would have been dispersed over large areas and therefore diluted to such a degree that the mission would have been unable to detect it. Dispersion of DU by rain would have resulted in displacement into the ground. If the ground surface was composed of concrete or asphalt (i.e. hard surfaces), DU dust would most likely have been swept a certain distance away and been absorbed by adjacent soil or carried into a ditch, stream or river. Contaminated vehicles may also have been removed.

4.8 Quality control and laboratory analysis

Collected samples were shipped to the RPC laboratory for screening and preliminary gamma spectrometric analysis. Those from sites covered by ***Local Expert DU Assessment Package II*** were sent for preliminary sample preparation.

Aliquots of samples collected in the field were then sent to SPIEZ LABORATORY for detailed analysis, where they were prepared and measured through the implementation of accredited procedures (ISO/IEC 17025) in Spiez's STS 028 testing laboratory. Samples of the various media (soil, water, vegetation and smear samples) were prepared for analysis following standard procedures specific to each sample type. Soil samples were dried and homogenized prior to analysis with a double focusing sector field inductively coupled plasma mass spectrometer (ICP-MS). Water samples were filtered and acidified with HNO_3. Vegetation samples were dried and separated from the soil and leaves. The smear sample filter papers were leached in HNO_3 and exposed to an ultrasonic bath prior to leachate filtration.

All samples were analysed with an ICP-MS instrument. The U-238 concentration in each sample was measured quantitatively with external calibration. The uranium isotopes U-234, U-235, and U-236 were also measured. The uranium contribution of the chemical reagents was determined through the analysis of blank samples – nitric acid was used as a blank for soil, vegetation and smear samples, and distilled water as a blank for water samples. The uranium contribution was found to be low enough to be neglected for all blank samples.

The percentage of DU (DU [%]) was calculated from the $^{235}U/^{238}U$ isotope ratio as follows:

$$DU[\%] = 100 \cdot \frac{R_{U-nat} - R_m}{R_{U-nat} - R_{DU}} = 100 \cdot \frac{0.00725 - R_m}{0.00525}$$

R_{U-nat} Isotope ratio $^{235}U/^{238}U$ of natural U (= 0.00725)

R_{DU} Isotope ratio $^{235}U/^{238}U$ of depleted U (= 0.002)

R_m Measured isotope ratio $^{235}U/^{238}U$ of the sample

It should be noted, however, that there is inherent uncertainty in the measurement of uranium isotopes, corresponding to a combination of laboratory procedural errors. The detection limit of the percentage of DU of the total uranium was calculated from three times the uncertainty of the isotope ratio U-235/U-238.

Small amounts of DU, ranging from 0.03 to 10 ng DU per filter, were detected in several of the blank samples from the smear sampling campaign. There were also indications that some water samples and most of the vegetation samples (e.g. those containing soil) were not representative of the on-site situation and had been contaminated by the team during fieldwork.

These results highlight the difficulty of obtaining truly representative samples and avoiding cross-contamination through the handling of equipment and other samples in the field. Analytical instruments in use nowadays are highly sensitive and therefore have very low detection limits. High sensitivity/low detection limits require very strict fieldwork procedures to avoid cross-contaminating samples.

The procedural weaknesses that led to cross-contamination were found to result from the lack of some basic field equipment during the mission:

- The same pair of one-way gloves was worn over a long period;
- A number of samples were taken with the same pair of gloves;
- Different samples were taken with the same pair of gloves, not taking into account contamination levels and sampling procedures used for the earlier sample(s);
- Poor quality plastic bags were used to pack the samples, and surface cuts and leaking occurred occasionally;
- Samples taken were not stored by type or separated by expected contamination level during the fieldwork and transport to the RPC laboratory; and
- Samples were sent to SPIEZ LABORATORY in bulk, and not packed according to the issues mentioned above.

However, there was no indication that laboratory procedures at the RPC had led to cross-contamination.

The results of the sampling programme – particularly for samples in which low levels of DU were detected – are therefore subject to additional uncertainties related to the field blank results and procedural problems.

5 Conclusions and Recommendations

Capacity-building and institutional strengthening are challenging in the best of circumstances. When they are undertaken in a country with serious logistical and security challenges, extensive planning and effort are required over a sustained duration to successfully impart knowledge and resources to local experts.

Although it was not clear at the onset that the approach would be successful in Iraq, the capacity-building exercise delivered the expected results. The following conclusions may be drawn from this exercise:

1. The work demonstrated that developing national capacity to undertake complex DU analyses is possible when international agencies pool their resources and provide sustained support;
2. The national team showed a high degree of technical expertise as well as personal commitment in undertaking the project in spite of the very difficult security environment in Iraq;
3. Creative use of modern information system tools such as high resolution satellite images and high accuracy global positioning systems made it possible for the international experts to steer the national experts precisely to target areas;
4. Even though the final results are still being interpreted, the study resulted in a number of very useful findings, such as the presence of DU-impacted tanks in open areas and uncontrolled recycling of DU impacted scrap, which could be used as the basis of decision-making for immediate action;
5. At a technical level, the work demonstrated that military equipment impacted by DU ammunition had in many cases not been collected or moved to secure areas;
6. The assessment also found that local people were being exposed to DU and other heavy metals in uncontrolled scrap yards and scrap metal processing areas, with potential consequences for their health. Indeed, it should be noted that the toxic effects of DU may be more serious for human health than its radiological effects; and
5. The results clearly indicated that methodological improvements were needed in some areas for such a capacity-building process.

The following recommendations can be made in light of these findings:

1. The Iraqi Ministry of Environment should continue to receive support from the international community to maintain staff expertise and morale;
2. All tanks, armoured personnel carriers, and other military equipment hit by DU ammunition should be identified and isolated to prevent access by the general population;
3. All metal scrap yards that have received scrap related to the conflict(s) should be assessed for the potential presence of DU;
4. Health and safety precautions in scrap yards and scrap processing plants should be improved to minimize long-term health impacts to people working there. With respect to human health, the radiotoxicity or radiological effects of DU should be considered secondary to its chemical toxicity;
5. Education and awareness-raising efforts on DU-related issues should be scaled up throughout the country to avoid that the population be accidentally exposed to DU residues and DU-impacted scraps; and
4. The issue of the storage and disposal of DU-contaminated scrap metal should be taken into account as part of national efforts to decommission and store radioactive sources.

Appendix A: Site-specific information - As Samawah

As Samawah - General Map

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

A1. Area of Interest 1 – Area Surrounding the Main Bridge

City/Town	As Samawah
Area of Interest	AOI-1
Description	Area surrounding the main bridge
UTM Coordinates (Centroid)	527990 E
	3464442 N
Area Size	850 m x 700 m
Investigation Dates	5 – 6 February 2006 7 – 8 May 2006
Infrastructure	Two bridges across the Euphrates River, located approximately 530 m apart, linking both sides of the main north-south road, bordered by several buildings.
Conflict Dates	March-April 2003
Conflict Description	Heavy fighting occurred on both the north and south sides of the bridge, including multiple A-10 attacks.
Samples taken	SAMA 101 – SAMA 113

A1.1 General information

The two sections of the main bridge in As Samawah, located approximately 530 m apart, cross the Euphrates River. Between 29 March and 2 April 2003 the area was the location of intense conflict, involving the reported use of DU munitions by A-10 aircraft. Heavy fighting took place on both the north and south sides of the bridge.

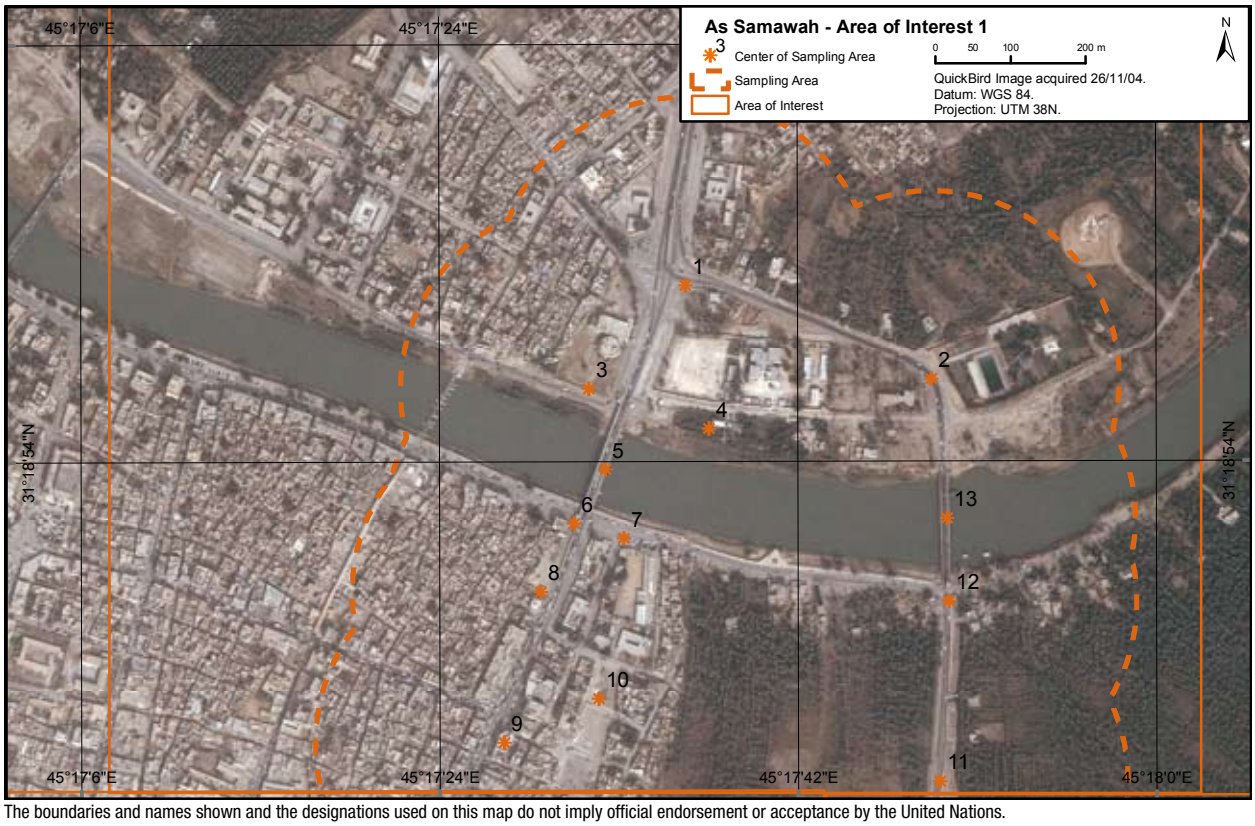
Field observations indicate that AOI-1 is within an urban area, and the predominant land uses are commercial and residential. The ground surface cover consists of paved roads and bridges, bare sandy soil and grassy vegetated areas. The Euphrates River is the main body of surface water in this area, and flows from west to east.

AOI-1 was subdivided in 13 sampling areas, based on the available conflict information and inferred areas of interest. Each sampling area was sampled for one or more of soil, water, vegetation and surface presence of DU.

A1.2 Field data

A total of 56 samples (14 soil samples, 5 water samples, 30 smear samples, and 7 vegetation samples) was collected in this Area of Interest (*Samples include re-visits (2nd mission)*).

As Samawah, AOI-1



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

The ambient dose rates (measurements about 1 metre above ground) were measured between 0.08 and 0.16 μSv/h.

No residues of DU were detected.

A2. Area of Interest 2 – The Main Road (Upper Section)

A2.1 General information

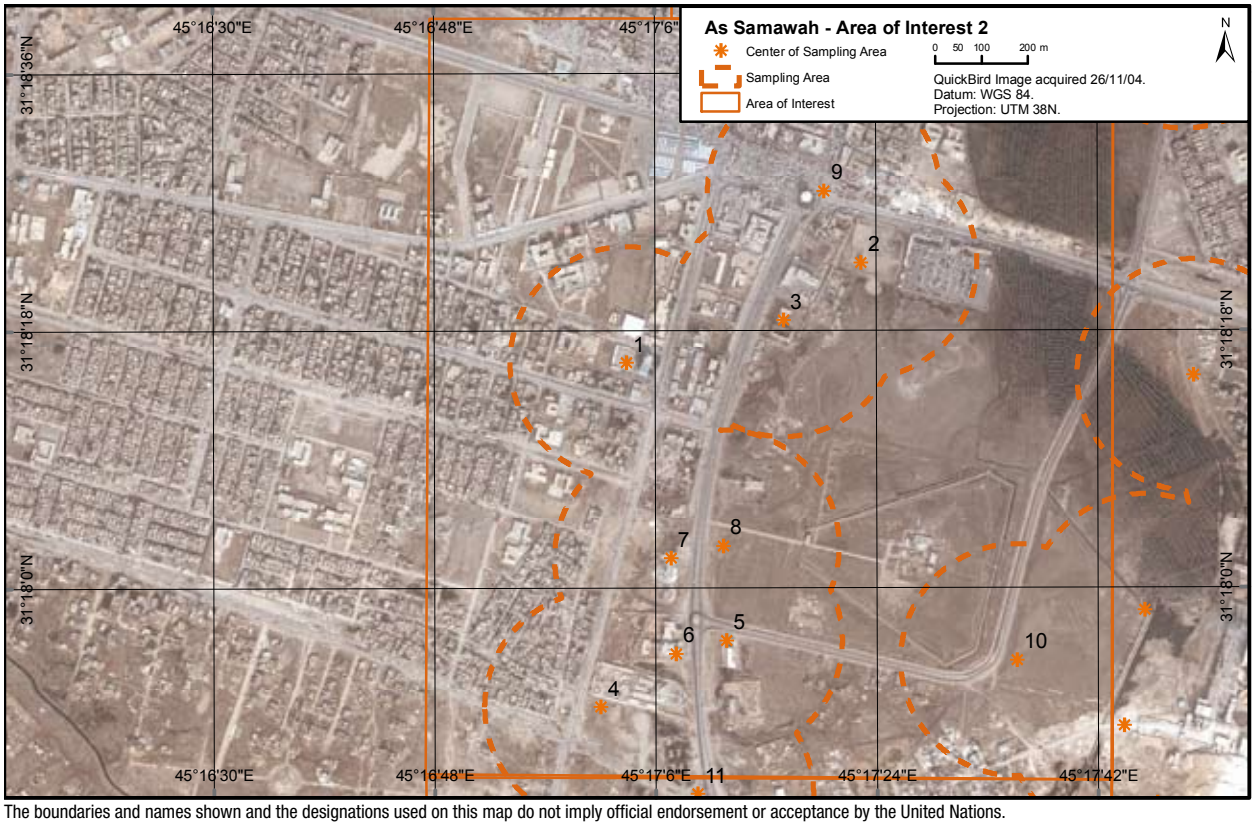
The main road in As Samawah approaches the main bridge across the Euphrates River from the south. The area surrounding the upper section of the road was the site of intense conflict involving the reported use of DU munitions. Conflict in this area occurred between 29 March and 2 April 2003. Tank positions along the road were subject to A-10 aircraft attacks.

Based on observations taken during field investigations AOI-2 is within an urban area, predominantly consisting of commercial and residential properties. The ground surface cover consists of paved roads, bare sandy soil and grassy vegetated areas. Traffic along the main road is typically heavy.

City/Town	As Samawah
Area of Interest	AOI-2
Description	The main road (upper section)
UTM Coordinates (Centroid)	527453 E 3463193 N
Area Size	1700 m x 1200 m
Investigation Dates	6 – 7 February 2006 9 May 2006
Infrastructure	The main north-south road, bordered by buildings to the west and predominantly open space to the east.
Conflict Dates	March-April 2003
Conflict Description	It is believed that Iraqi tanks were positioned along both sides of the road to give protection to the main bridge and the town.
Samples	SAMA 201 – SAMA 210

AOI-2 was subdivided into 10 sampling areas, based on the available conflict information and inferred areas of interest. Each sampling area was sampled for one or more of soil, water, vegetation and surface presence of DU.

As Samawah, AOI-2



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

A2.2 Field data

A total of 39 samples (12 soil samples, 5 water samples, 20 smear samples, and 2 vegetation samples) was collected in this Area of Interest (*Samples include re-visits (2nd mission)*).

The ambient dose rates (measurements about 1 metre above ground) were measured between 0.06 – 0.15 μSv/h.

No residues of DU were detected.

A3. Area of Interest 3 – Cement Factory

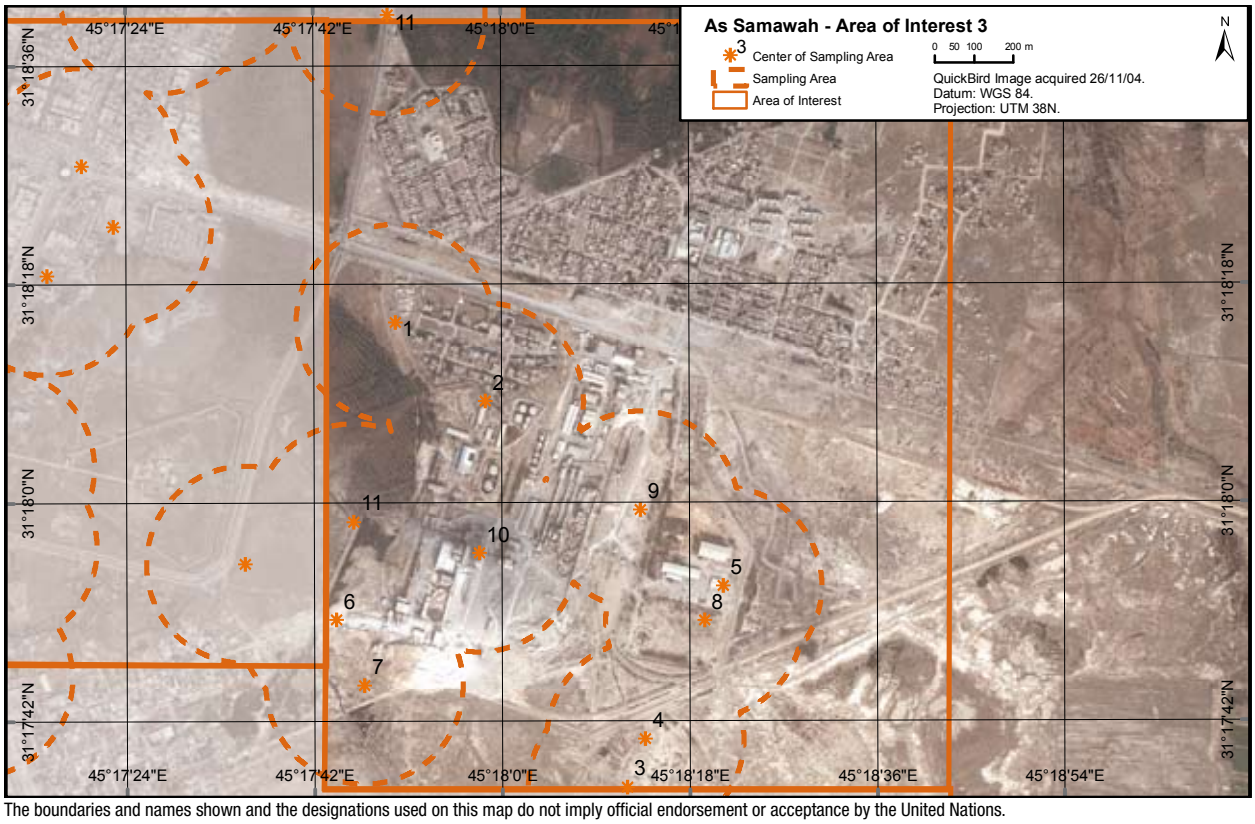
A3.1 General information

A large cement factory is located northeast of the main road and south of the main bridge in As Samawah. It is believed that the factory was used as a strategic location of tank positions for the protection of the main bridge. Iraqi tanks were placed on the southern and south-eastern sides of the factory, and thus the area was reportedly subject to attacks involving DU munitions.

City/Town	As Samawah
Area of Interest	AOI-3
Description	The cement factory
UTM Coordinates (Centroid)	5286230 E 3462766 N
Area Size	2000 m x 1500 m
Investigation Dates	5 – 7 February 2006 7 – 8 May 2006
Infrastructure	A cement factory consisting of multiple buildings and roadways.
Conflict Dates	March-April 2003
Conflict Description	It is believed that the cement factory was used as a strategic location by the Iraqi forces for the protection of the main bridge. Tanks were placed on the south and south-eastern sides of the factory.
Samples	SAMA 301 – SAMA 311

Field observations indicate that AOI-3 is within an abandoned industrial area, consisting of multiple buildings. The ground surface cover consists of paved roadways and bare sandy soil. Only very sparse vegetation is present in this area, and no surface water was observed. The cement factory is no longer operational and is enclosed by fences.

As Samawah, AOI-3



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

AOI-3 was subdivided into 11 sampling areas, based on the available conflict information and inferred areas of interest. Each sampling area was sampled for one or more of soil, vegetation and surface presence of DU.

A3.2 Field data

A total of 38 samples (14 soil samples, 20 smear samples, and 4 vegetation samples) were collected in this Area of Interest (*Samples include re-visits (2nd mission)*).

The ambient dose rates (measurements about 1 metre above ground) were measured between 0.03 – 0.18 μSv/h.

No residues of DU were detected.

City/Town	As Samawah
Area of Interest	AOI-4
Description	The main road (lower section)
UTM Coordinates (Centroid)	5288355 E
	3461856 N
Area Size	3000 m x 1000 m
Investigation Dates	7 – 12 February 2006 10 May 2006
Infrastructure	The east-west curve of the main road, sparsely bordered by buildings to the north and south.
Conflict Dates	March-April 2003
Conflict Description	It is believed that Iraqi tanks were positioned along both sides of the road to give protection to the town.
Samples	SAMA 401 – SAMA 411

A4. Area of Interest 4 – The Main Road (Lower Section)

A4.1 General information

The main road in As Samawah curves toward the east for approximately 3 kilometres at the southern edge of the city. Tanks were positioned along both sides of the road to give protection to the town and the main bridge, and thus the area was the site of intense conflict involving the reported use of DU munitions.

Based on observations taken during field investigations, AOI-4 consists of predominantly vacant land to the north and south of the main road. Sparse residential and commercial buildings are present in the area, and the ground surface cover is primarily bare soil and grassy vegetation. Surface water was not observed in the area. Traffic along this section of the main road is typically heavy.

AOI-4 was subdivided into 11 sampling areas, based on the available conflict information and inferred areas of interest. Each sampling area was sampled for one or more of soil, vegetation and surface presence of DU.

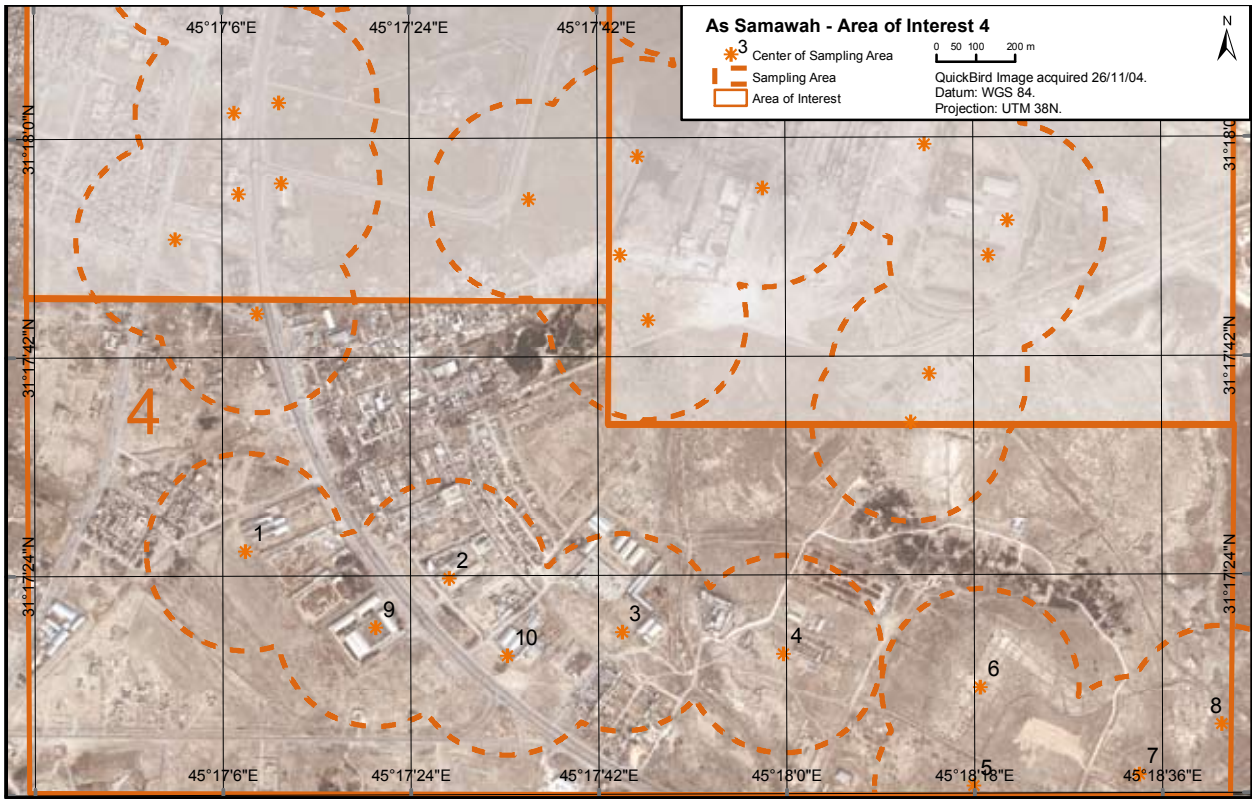
A4.2 Field data

A total of 32 samples (11 soil samples, 19 smear samples, and 2 vegetation samples) was collected in this Area of Interest (*Samples include re-visits (2nd mission)*).

The ambient dose rates (measurements about 1 metre above ground) were measured between 0.10 to 0.18 μSv/h.

No residues of DU were detected.

As Samawah, AOI-4



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

A5. Additional Points of Investigation

City/Town	As Samawah
Area of Interest	Additional Points
Description	Various areas
UTM Coordinates (Centroid)	see field data
	see field data
Area Size	NA
Investigation Dates	7 – 12 May 2006
Infrastructure	Investigated areas included vacant land, a train station, a scrap yard and areas of waste piles.
Conflict Dates	March-April 2003
Conflict Description	Conflict may have occurred at the various investigated areas.
Samples	SAMA-Intact tank-smear-03-S, SAMA-cannon 1-smear-a-S - SAMA-cannon 2-smear-d-S, SAMAWA-sample-a-smear-T, SAMAWA-sample-b-smear-T, SAMAWA-sample-c-smear-T

A5.1 General information

Additional investigations were conducted in areas where DU contamination was suspected based on field observations. These areas included vacant land on the outskirts of As Samawah, the train station in the Al-Khafora region, a scrap yard near the cement factory and areas in which piles of waste and debris were observed. Intact and bombarded tanks were observed at several of these locations. Samples of soil and surfaces were collected from the tanks and the immediate areas.

It was reported by field staff that as per the information they received by the railway staff, the bombarded tanks and cannons were being carried on railway between several stations, including Al-Khafora and Al-Khder stations. However, neither their origin nor the final destination were known, and therefore no location coordinates could be reported.

A5.2 Field data

A total of 37 samples (20 soil samples and 17 smear samples) was collected at the additional investigation points.

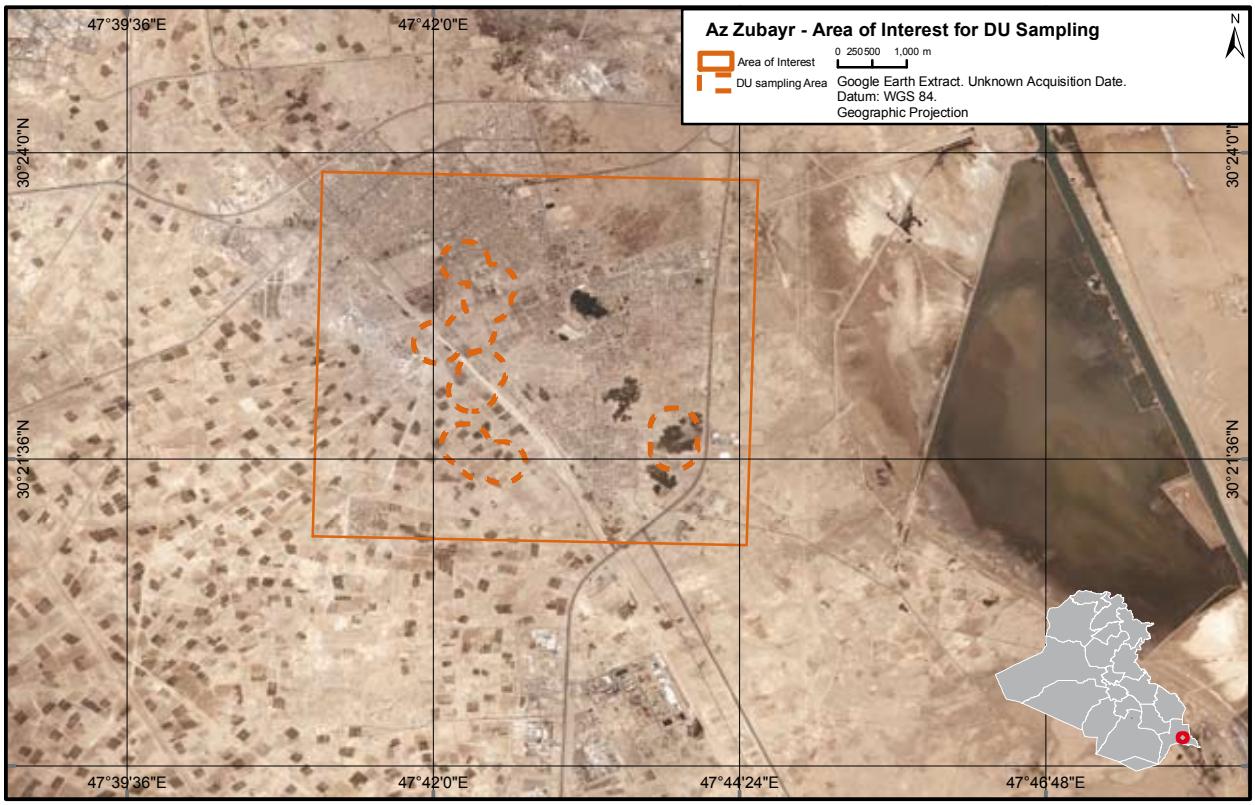
Sample Code	GPS Coordinate (UTM)	
SAMA-Intact tank-smear-02-S	526308 E	3461598 N
SAMA-Intact tank-smear-03-S	526479 E	3461391 N
SAMA-Intact tank-smear-05-S	527469 E	3463755 N
SAMA-Intact tank-smear-05-W	527463 E	3463756 N
SAMA-Intact tank-soil-01	527078 E	3462939 N
SAMA-Intact tank-soil-04	526485 E	3461333 N
SAMA-Intact tank-soil-07	528929 E	3462959 N
SAMA-Intact tank-soil-08	528891 E	3462890 N
SAMA-Intact tank-soil-09	528907 E	3462835 N
SAMA-bombarded tank-smear-19-S	526366 E	3461335 N
SAMA-bombarded tank-soil-10	530629 E	3461058 N
SAMA-bombarded tank-soil-11	530585 E	3461080 N
SAMA-bombarded tank-soil-12	530509 E	3461091 N
SAMA-bombarded area-soil-15	529145 E	3462974 N
SAMA-bombarded area-soil-16	529237 E	3462888 N
SAMA-bombarded area-soil-17	529369 E	3462827 N
SAMA-bombarded area-soil-18	527023 E	3461500 N
SAMA-bombarded-tank-soil-19	526366 E	3461335 N
SAMA-bombarded-tank-soil-20	527940 E	3461247 N
SAMA-bombarded-tank-soil-21	528939 E	3460295 N
SAMA-bombarded-area-soil-22	531607 E	3460320 N
SAMA-bombarded-area-soil-23	530545 E	3461084 N
SAMA-bombarded-area-soil-24	530550 E	3461065 N

The ambient dose rates (measurements about 1 metre above ground or the object) were measured in the range of 0.03 and 0.22 μSv/h.

Surface dose rates (measurements directly taken millimetres above the surface) of up to 50 μSv/h were measured on the surface of tanks hit by DU.

Appendix B: Site-specific information - Az Zubayr

Az Zubayr – General Map



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

B1. Area of Interest – Az Zubayr

B1.1 General information

Field observations indicate that AOI is within an urban area, including residential, commercial and industrial land uses. The ground surface cover consists of paved roads, bare sandy soil and grassy vegetated areas. Intact and bombarded tanks were observed at several of these locations within AOI. Samples of soil and surfaces were collected from the tanks and the immediate areas.

AOI was subdivided into 13 sampling areas, based on the available conflict information and inferred areas of interest. Each sampling area was sampled for one or more of soil, water, vegetation and surface presence of DU.

City/Town	Az Zubayr
Area of Interest	AOI
Description	Locations throughout the city
UTM Coordinates (Centroid)	4771263 E 3038117 N
Area Size	5000 m x 6000 m
Investigation Dates	6 – 9 February, 2006 26 June 2006
Infrastructure	Residential, commercial and industrial areas including roads, buildings and open areas. Several tank parts investigated during 2nd mission.
Conflict Dates	March-April 2003
Conflict Description	Coalition forces performed precision strikes at various strategic locations in the city.
Samples	ZUBA 101 to ZUBA 113, Zubayr 01-02, Zubayr 01-03, Zubayr 01-05 A to Zubayr 01-05 H, Zubayr 01-11

B1.2 Field data

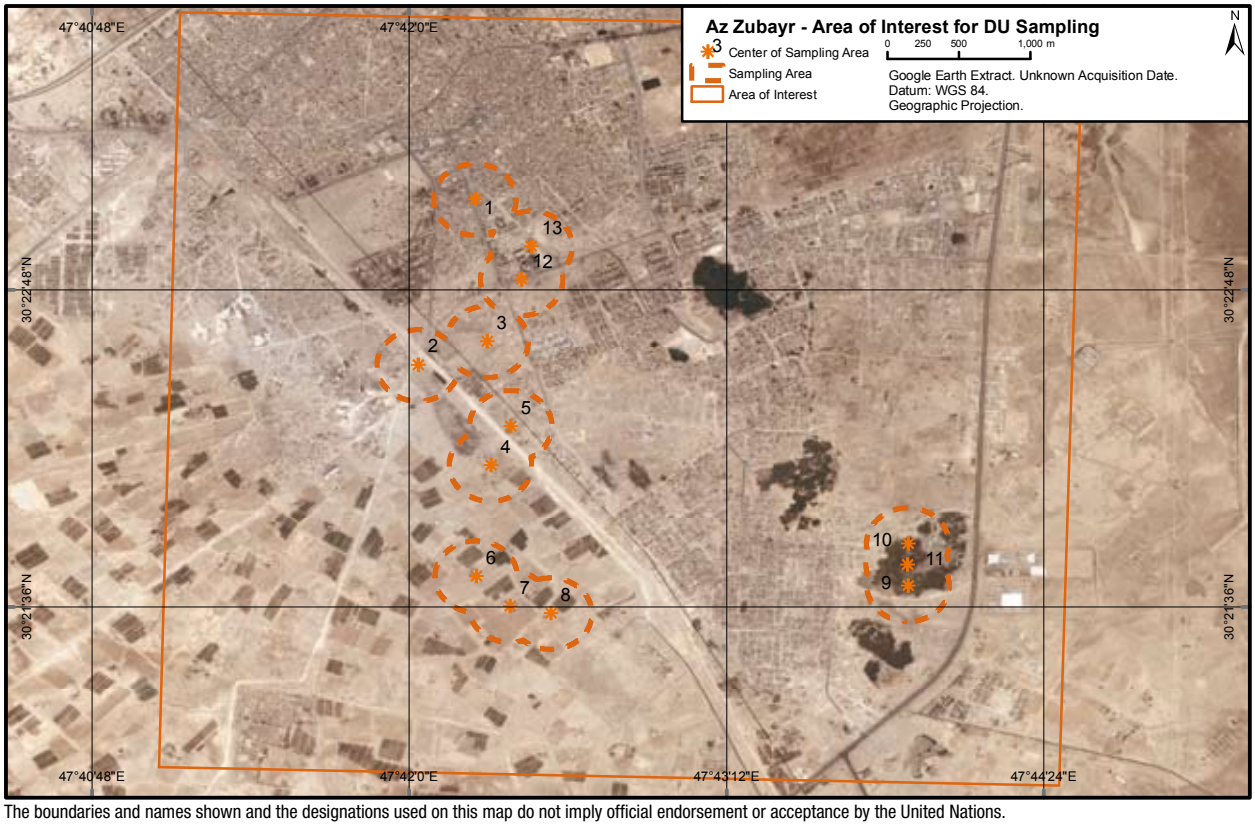
A total of 62 samples (22 soil samples, 1 water sample, 29 smear samples, and 10 vegetation samples) was collected in this Area of Interest (*Samples include re-visits (2nd mission)*).

The ambient dose rates (measurements about 1 metre above ground or the object) were measured in the range of 0.1 μSv/h.

On surfaces of tanks or on surfaces nearby areas where tanks were treated (e.g. tank dump sites, steel recycling) ambient dose rates (measurements directly taken millimetres above the surface) up to 346 μSv/h were measured.

Residues of DU were detected on military equipment hit by DU ammunition.

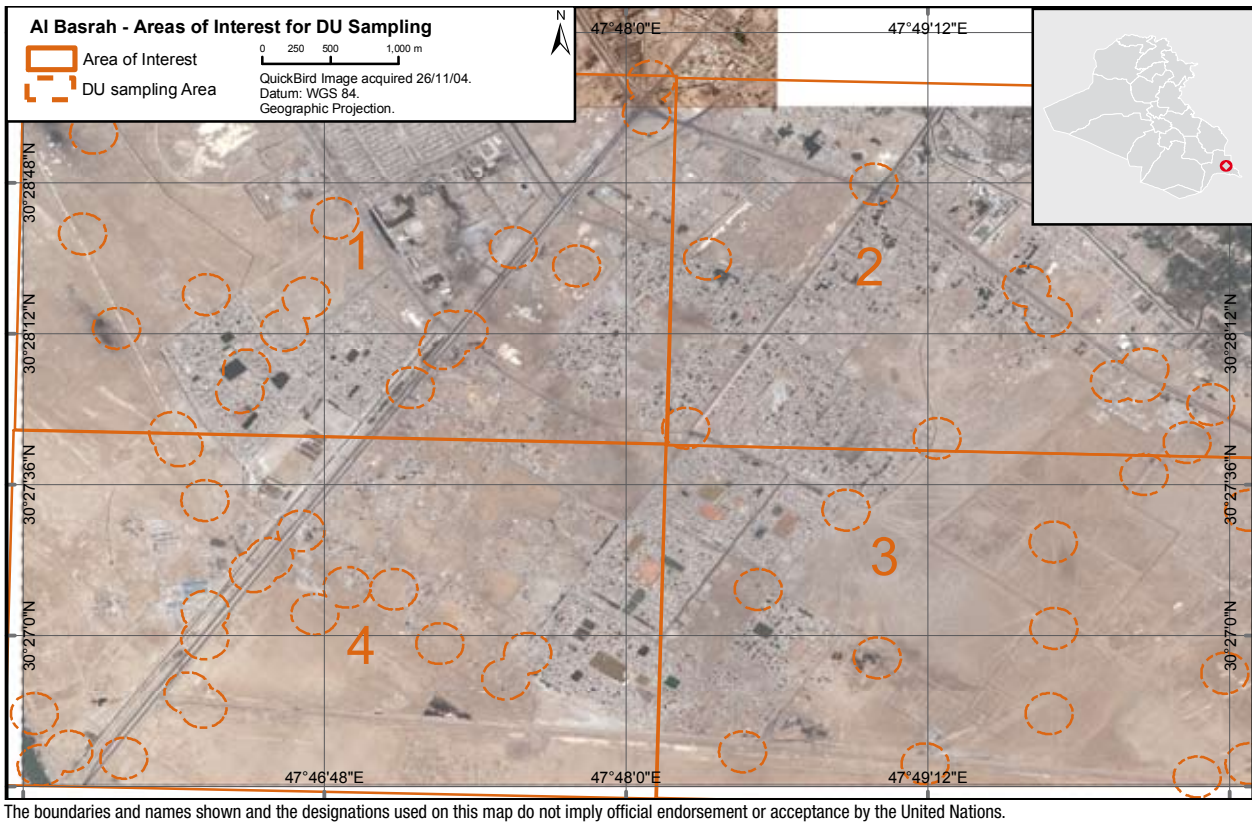
Az Zubayr, AOI



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Appendix C: Site-specific information - Al Basrah

Al Basrah - General Map



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

C1. Area of Interest 1 (AOI-1)

City/Town	Al Basrah
Area of Interest	AOI-1
Description	Northwest quadrant
UTM Coordinates (Centroid)	767050 E
	3374750 N
Area Size	4.2 km x 2.7 km
Investigation Dates	21 – 22 June 2006
Infrastructure	Urban area including the main southwest-northeast road. Includes industrial, commercial and residential areas.
Conflict Dates	March-April 2003
Conflict Description	Heavy fighting primarily occurred along the main road, but included locations throughout the area.
Samples	BASRA 101 – BASRA 118

C1.1 General information

AOI-1 is located south of the city centre. Between 25 March and 6 April the area was the location of intense conflict, including tank battles and air strikes. DU munitions were reportedly used during the conflict, but the number of rounds remains unknown.

Field observations indicate that AOI-1 is within an urban area, and the predominant land uses are commercial, industrial and residential. The ground surface cover consists of paved roads, bare sandy soil and grassy vegetated areas.

AOI-1 was subdivided into 18 sampling areas, based on the available conflict information and inferred areas of interest. Soil samples were collected from each sampling area, and water and smear samples were collected at select locations.

C1.2 Field data

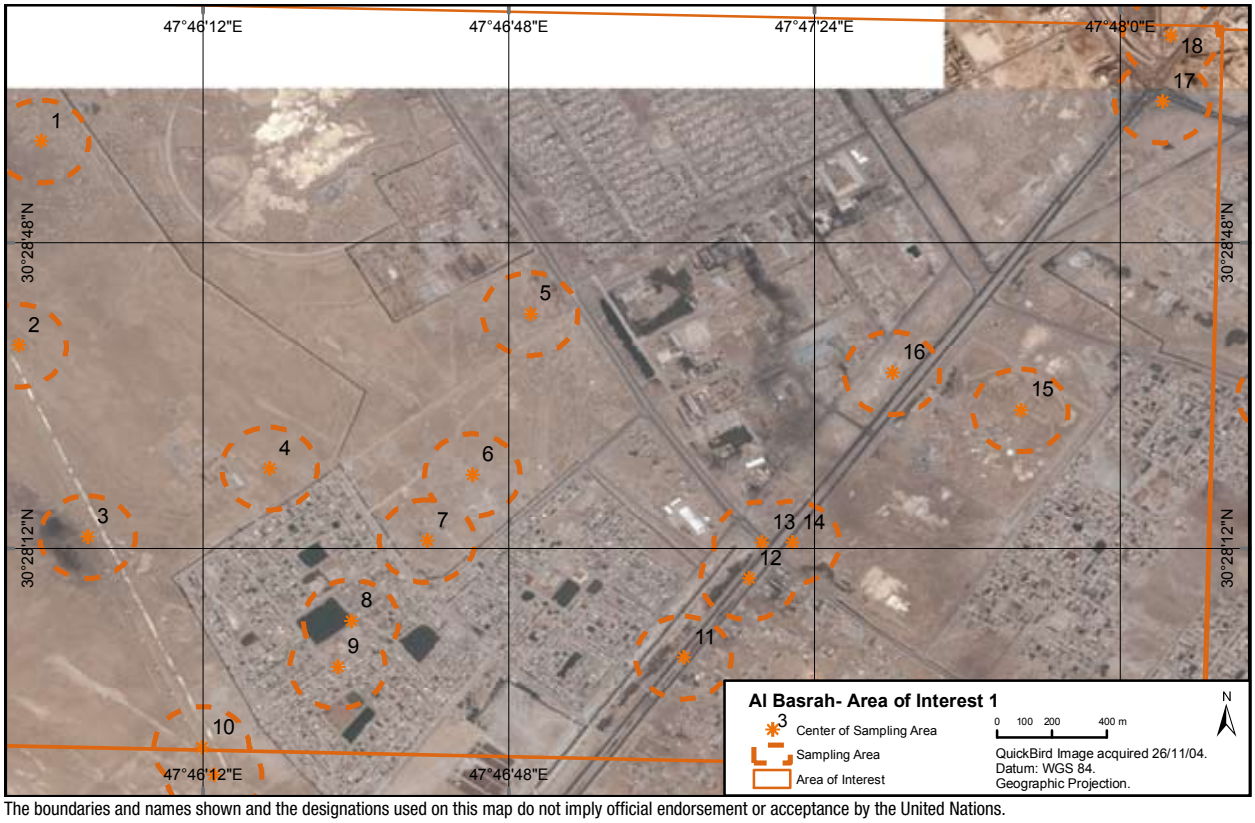
A total of 39 samples (21 soil samples, 2 water samples, and 16 smear samples) were collected in this Area of Interest.

The ambient dose rates (measurements about 1 metre above ground) were measured between 0.06 and 0.25 μSv/h.

Surface dose rates (measurements directly taken millimetres above the surface) of up to 42.2 μSv/h were measured on surfaces in the area of a bombarded broadcast tower.

No residues of DU were detected.

Al Basrah, AOI-1



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

C2. Area of Interest 2

City/Town	Al Basrah
Area of Interest	AOI-2
Description	Northeast quadrant
UTM Coordinates (Centroid)	771150 E
	3374750 N
Area Size	4.2 km x 2.7 km
Investigation Dates	22 – 23 June 2006
Infrastructure	Urban area including the main east-west road. Includes industrial, commercial and residential areas.
Conflict Dates	March-April 2003
Conflict Description	Heavy fighting primarily occurred along the main road.
Samples	BASRA 201 - BASRA 211

C2.1 General information

AOI-2 is an urban area located south of the city centre. Between 25 March and 6 April the area was the location of intense conflict, including tank battles and air strikes. Conflicts primarily occurred along the main east-west road. DU munitions were reportedly used during the conflict, but the number of rounds remains unknown.

Land uses at AOI-2 include residential, commercial and industrial. The ground surface cover consists of paved roads, bare sandy soil and grassy vegetated areas.

AOI-2 was subdivided into 11 sampling areas, based on the available conflict information and inferred areas of interest. Soil samples were collected from each sampling area, and water and smear samples were collected at select locations.

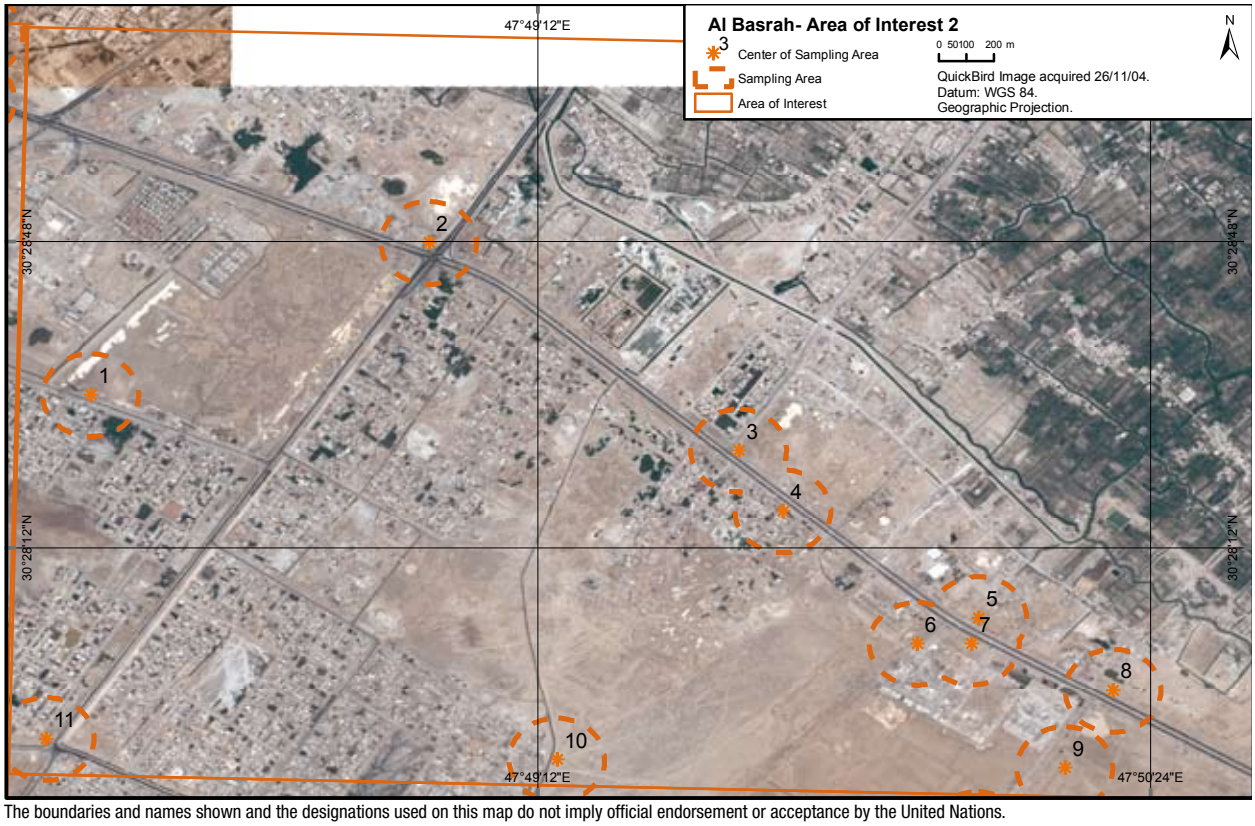
C2.2 Field data

A total of 17 samples (11 soil samples, 1 water sample, and 5 smear samples) was collected in this Area of Interest.

The ambient dose rates (measurements about 1 metre above ground) were measured between 0.10 and 0.25 μSv/h.

No residues of DU were detected.

Al Basrah, AOI-2



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

C3. Area of Interest 3

City/Town	Al Basrah
Area of Interest	AOI-3
Description	Southeast quadrant
UTM Coordinates (Centroid)	771150 E
	3372150 N
Area Size	4.2 km x 2.7 km
Investigation Dates	23 -24 June 2006
Infrastructure	Residential, commercial and industrial properties on the western side of the area, vacant land on the eastern side of the area.
Conflict Dates	March-April 2003
Conflict Description	It is believed that conflict occurred throughout the area.
Samples	BASRA 301 - BASRA 314

C3.1 General information

AOI-3 includes the edge of the urban area in Al Basrah. Residential, commercial and industrial neighbourhoods are located at the western side of AOI-3. Between 25 March and 6 April the area was the location of intense conflict, including tank battles and air strikes. DU munitions were reportedly used during the conflict, but the number of rounds remains unknown.

AOI-3 was subdivided into 14 sampling areas, based on the available conflict information and inferred areas of interest. Soil samples were collected from each sampling area, and water and smear samples were collected at select locations.

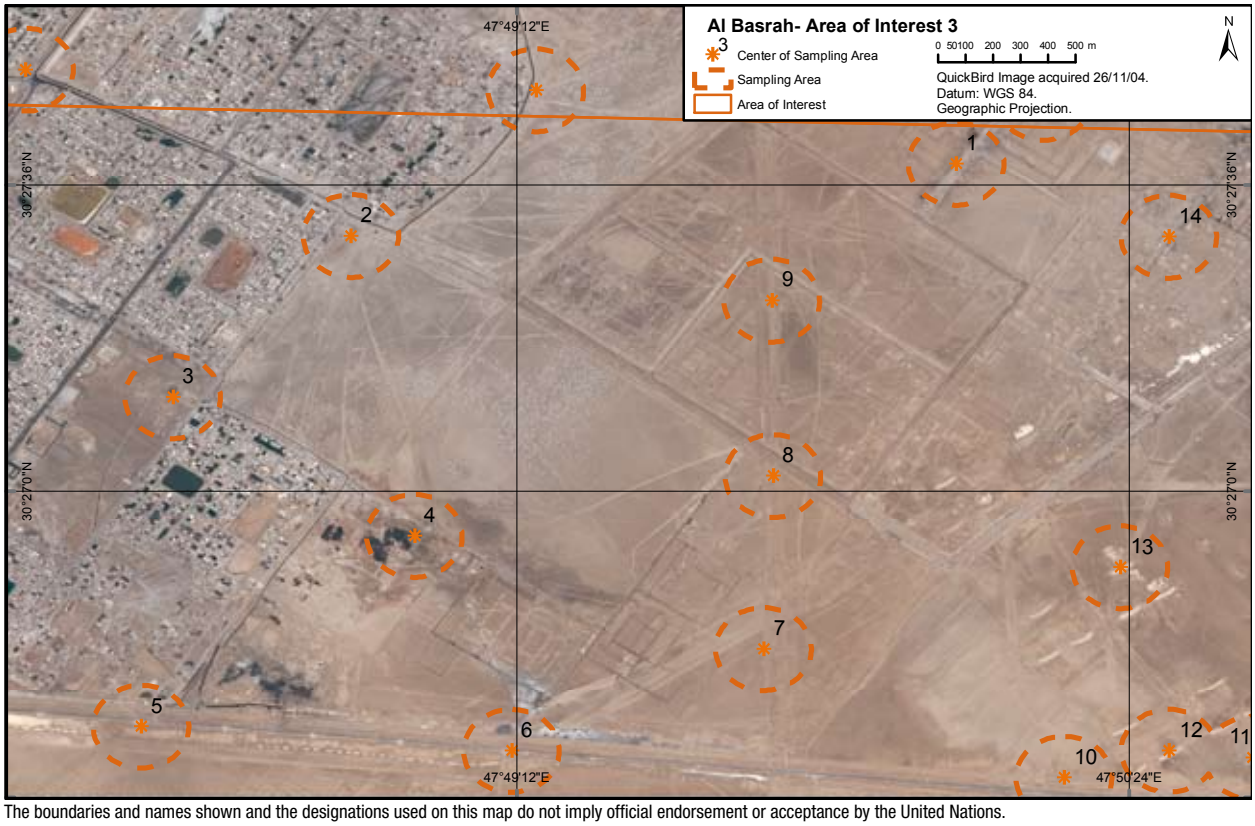
C3.2 Field data

A total of 17 samples were collected in this Area of Interest, with the following breakdown: 14 soil samples, 1 water sample and 2 smear samples.

The ambient dose rates (measurements about 1 meter above ground) were measured between 0.09 and 0.22 μSv/h.

No residues of DU were detected.

Al Basrah, AOI-3



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

C4. Area of Interest 4

C4.1 General information

AOI-4 is located southwest of the city centre. Between 25 March and 6 April the area was the location of intense conflict, including tank battles and air strikes. DU munitions were reportedly used during the conflict, but the number of rounds remains unknown.

Field observations indicate that AOI-1 is within an urban area, and the predominant land uses are commercial, industrial and residential. The ground surface cover consists of paved roads, bare sandy soil and grassy vegetated areas.

AOI-4 was subdivided into 19 sampling areas, based on the available conflict information and inferred areas of interest. Soil samples were collected from each sampling area, and smear samples were collected at select locations.

C4.2 Field data

A total of 30 samples (19 soil samples and 11 smear samples) was collected in this Area of Interest.

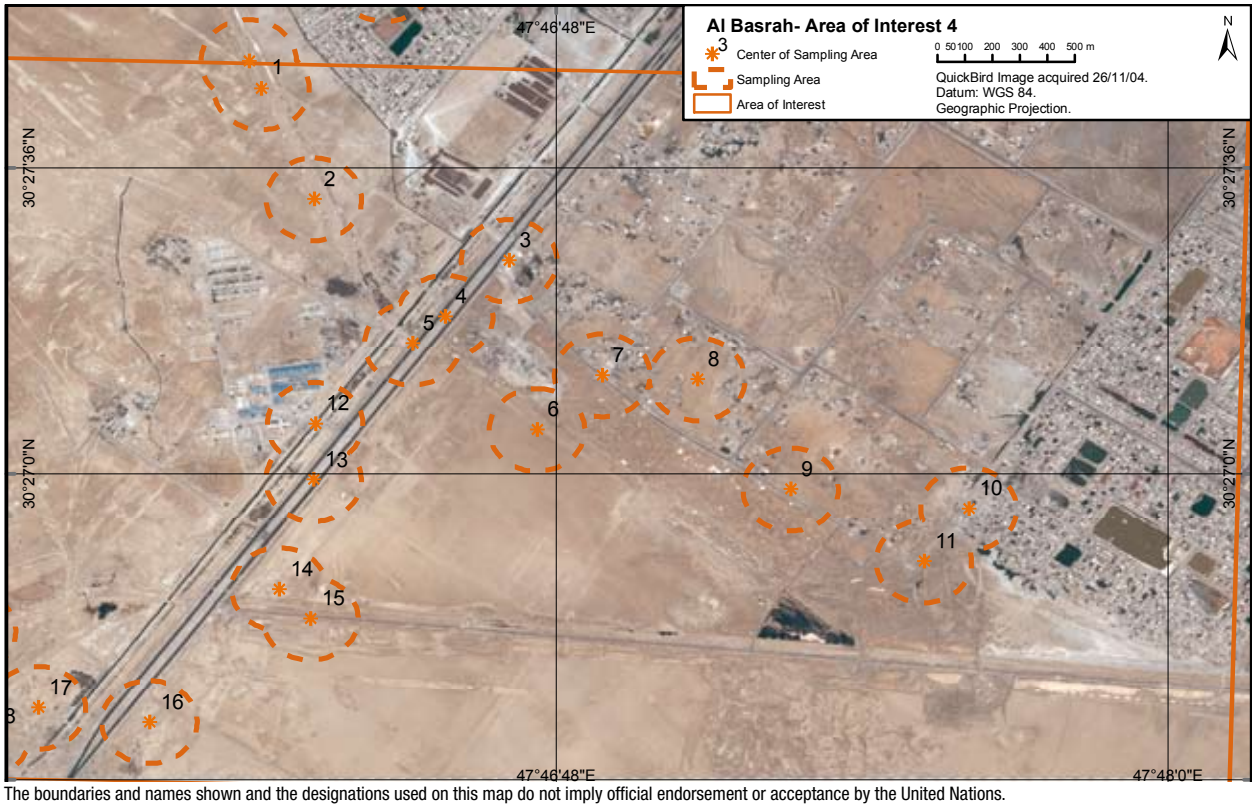
City/Town	Al Basrah
Area of Interest	AOI-4
Description	Southwest quadrant
UTM Coordinates (Centroid)	767050 E
	3372150 N
Area Size	4.2 km x 2.7 km
Investigation Dates	24 – 25 June 2006
Infrastructure	Urban area including the main southwest-northeast road. Includes industrial, commercial and residential areas.
Conflict Dates	March-April 2003
Conflict Description	Heavy fighting primarily occurred along the main road, but included locations throughout the area.
Samples	BASRA 401 - BASRA 419

The ambient dose rates (measurements about 1 metre above ground or the object) were measured between 0.09 and 0.31 μSv/h.

On a surface of a tank up to 4.6 μSv/h were measured (measurements directly taken millimetres above the surface).

No residues of DU were detected.

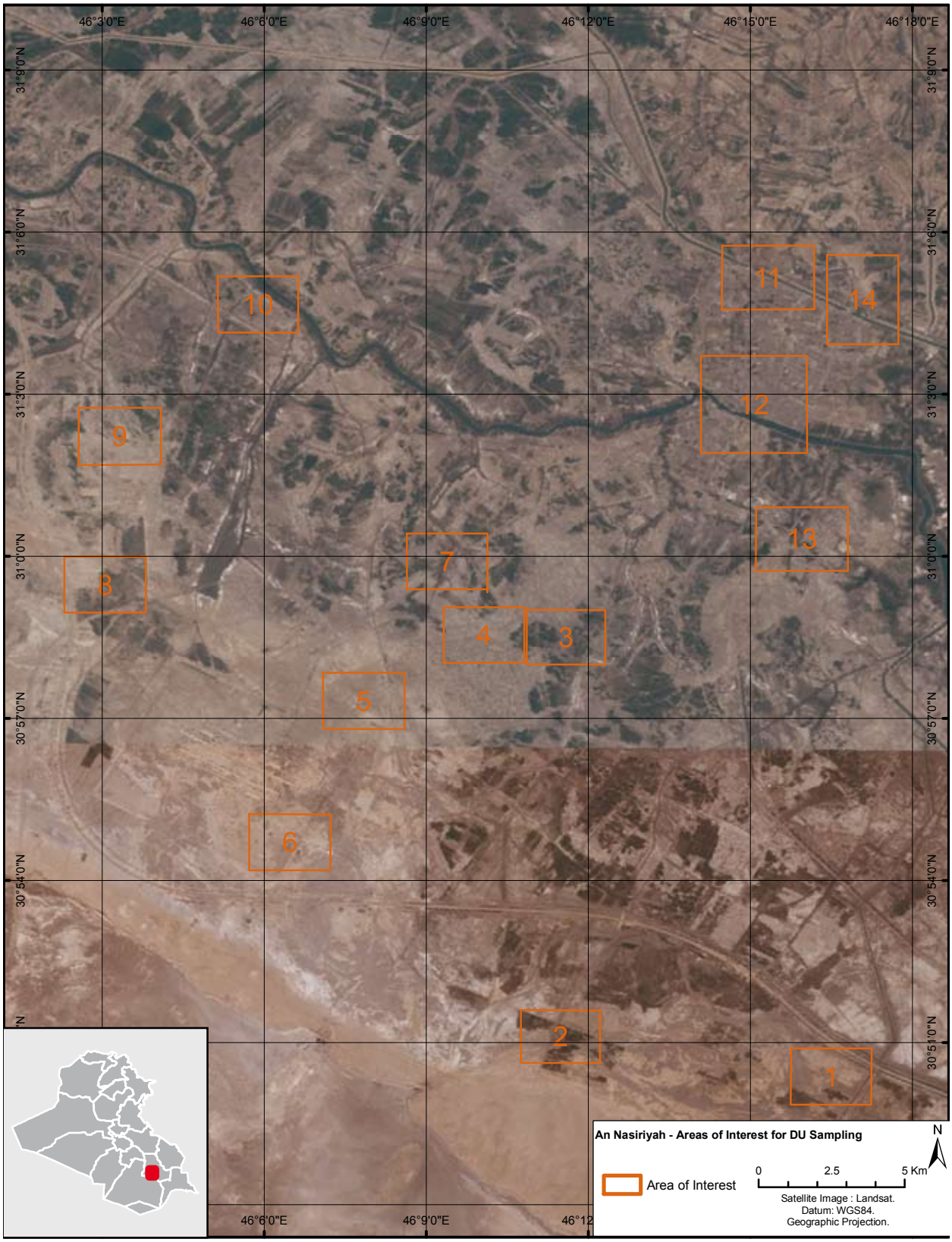
Al Basrah, AOI-4



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Appendix D: Site-specific information - An Nasiriyah

An Nasiriyah - General Map



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

D1. Area of Interest 1

City/Town	An Nasiriyah
Area of Interest	AOI-1
Description	Southeast
UTM Coordinates (Centroid)	621900 E
	3412500 N
Area Size	1.8 km x 2.4 km
Investigation Dates	24 July 2006
Infrastructure	Open land south of main road, includes earth berms for tank defence.
Conflict Dates	March-April 2003
Conflict Description	Tanks were positioned in this area to defend the main road. Conflict is believed to have occurred throughout the area.
Samples	NASIR 101 – NASIR 108

D1.1 General information

AOI-1 is located south of the city centre, along the main road. During March and April 2003 the area was the location of intense conflict, including tank battles and air strikes. DU munitions were reportedly used during the conflict, but the number of rounds remains unknown.

Field observations indicate that AOI-1 is an open, vacant area, and includes abandoned agricultural lands. The ground surface cover consists of the main paved road and bare sandy soil.

AOI-1 was subdivided into 8 sampling areas, based on the available conflict information and inferred areas of interest. Soil samples were collected from each sampling area and one surface water sample was collected.

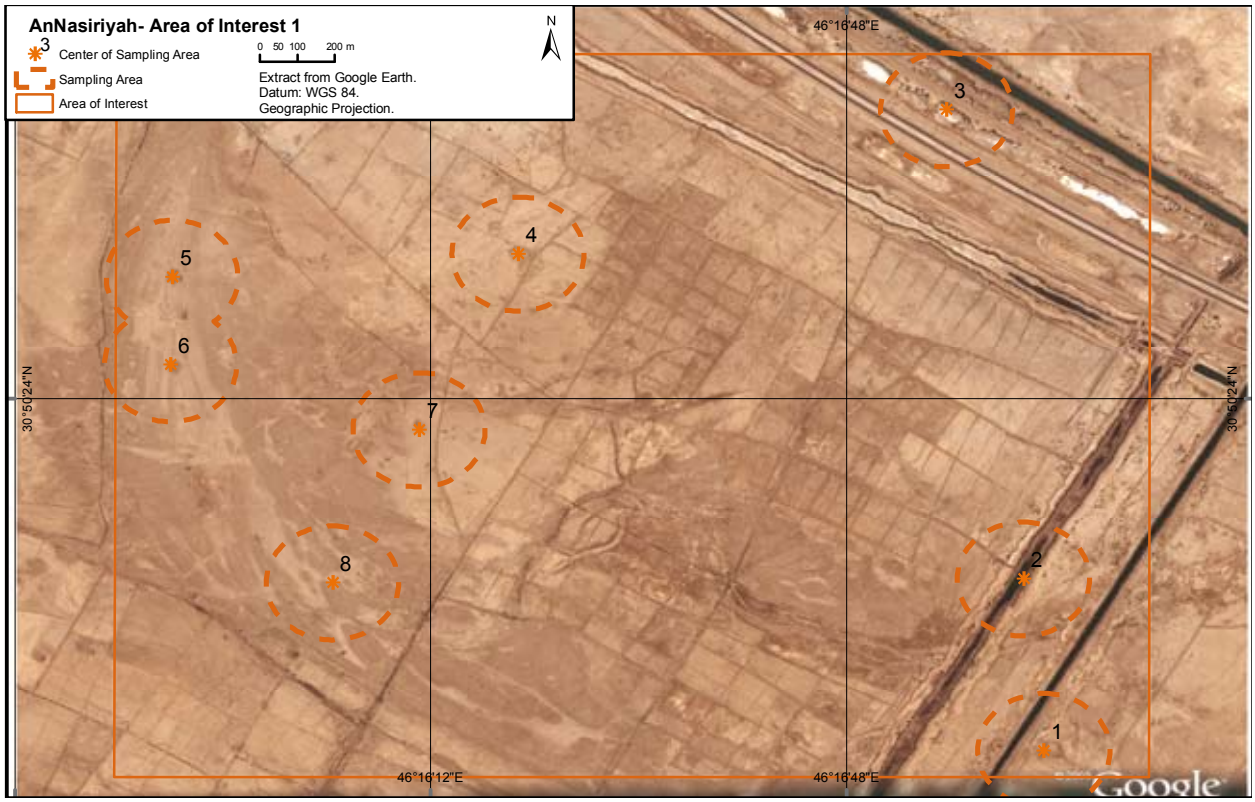
D1.2 Field data

A total of 7 samples (6 soil samples and 1 water sample) was collected in this Area of Interest.

The ambient dose rates (measurements about 1 metre above ground) were measured between 0.09 and 0.19 μSv/h.

No residues of DU were detected.

An Nasiriyah, AOI-1



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

D2. Area of Interest 2

City/Town	An Nasiriyah
Area of Interest	AOI-2
Description	South of main road
UTM Coordinates (Centroid)	614175 E
	3413800 N
Area Size	1.8 km x 2.4 km
Investigation Dates	23 July 2006
Infrastructure	Open land, including an abandoned railway and earth berms for tank defence.
Conflict Dates	March-April 2003
Conflict Description	Tanks were positioned in this area to defend the main road. Conflict is believed to have occurred throughout the area.
Samples	NASIR 201 – NASIR 210

D2.1 General information

AOI-2 is located south of the city centre, south of the main road. An abandoned railway is located within this area. During March and April 2003 the area was the location of intense conflict, including tank battles and air strikes. DU munitions were reportedly used during the conflict, but the number of rounds remains unknown.

Field observations indicate that AOI-2 is an open, vacant area, and includes abandoned agricultural lands. The ground surface cover primarily consists of bare sandy soil.

AOI-2 was subdivided into 10 sampling areas, based on the available conflict information and inferred areas of interest. Soil samples were collected from each sampling area.

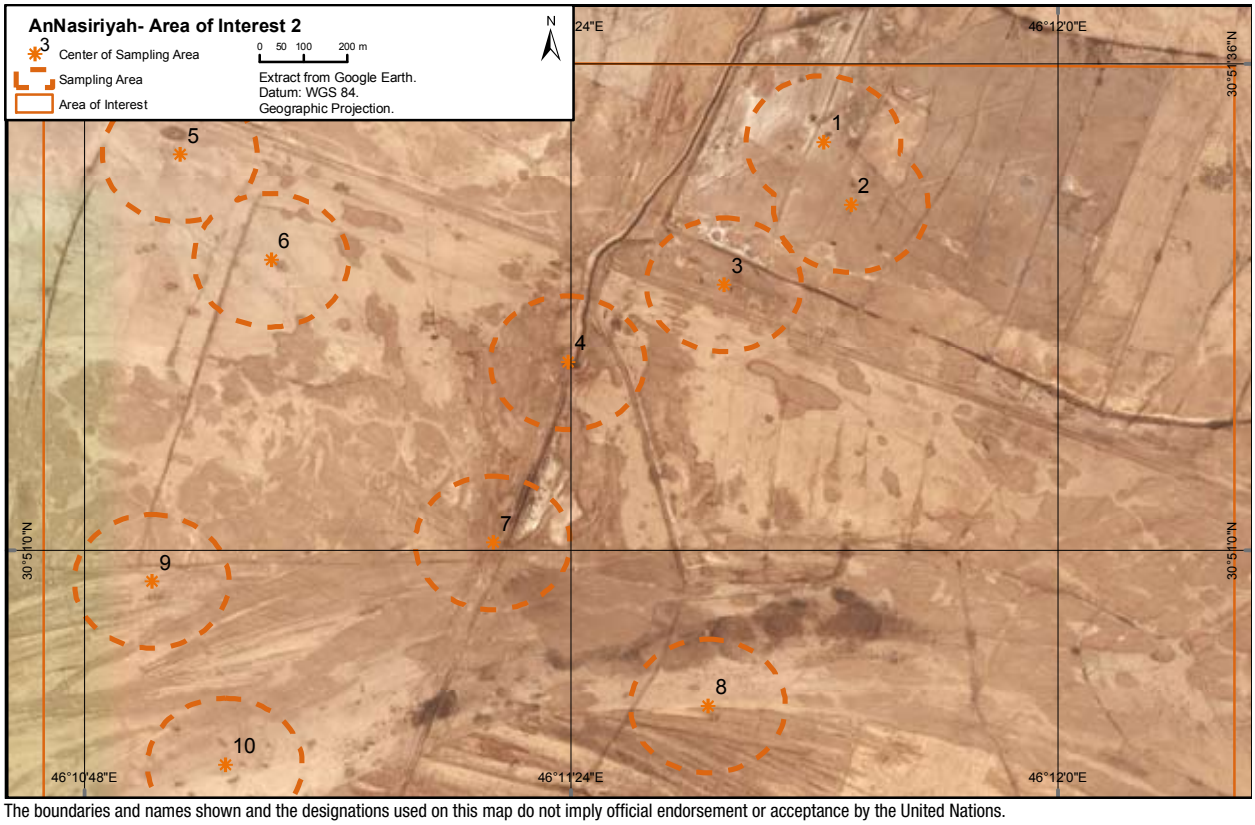
D2.2 Field Data

A total of 10 soil samples was collected in this Area of Interest.

The ambient dose rates (measurements about 1 metre above ground) were measured between 0.03 and 0.20 μSv/h.

No residues of DU were detected.

An Nasiriyah, AOI-2



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

D3. Area of Interest 3

City/Town	An Nasiriyah
Area of Interest	AOI-3
Description	Army Camp/Warehouse
UTM Coordinates (Centroid)	613900 E
	3427500 N
Area Size	1.8 km x 2.4 km
Investigation Dates	25 July 2006
Infrastructure	Open land, includes a former camp and warehouse of the Iraqi Army.
Conflict Dates	March-April 2003
Conflict Description	It is believed that conflict occurred throughout the area.
Samples	NASIR 301 – NASIR 310

D3.1 General information

AOI-3 consists of an open area located to the south of An Nasiriyah. The area reportedly includes a former Iraqi Army camp and a military warehouse. It is believed that conflict involving the use of DU munitions occurred in this area, but the number of rounds remains unknown.

AOI-3 was subdivided into 10 sampling areas, based on the available conflict information and inferred areas of interest. Soil samples were collected from each sampling area, and water and smear samples were collected at select locations.

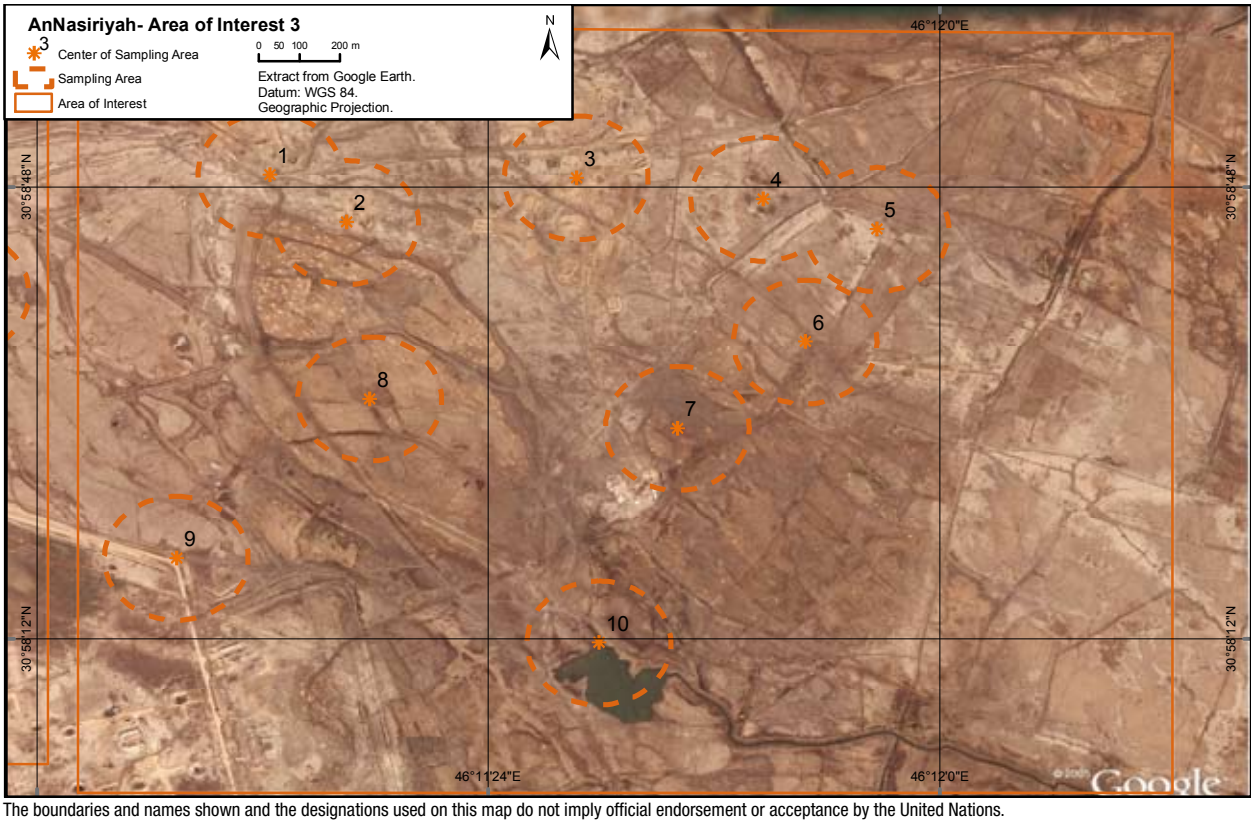
D3.2 Field data

A total of 12 samples (10 soil samples, 1 surface water sample and 1 smear sample) was collected in this Area of Interest.

The ambient dose rates (measurements about 1 metre above ground) were measured between 0.09 and 0.25 μSv/h.

No residues of DU were detected.

An Nasiriyah, AOI-3



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

D4. Area of Interest 4

City/Town	An Nasiriyah
Area of Interest	AOI-4
Description	Munitions storehouse
UTM Coordinates (Centroid)	611500 E
	3427500 N
Area Size	1.8 km x 2.4 km
Investigation Dates	25 July 2006
Infrastructure	Open land, includes a former munitions storehouse.
Conflict Dates	March-April 2003
Conflict Description	It is believed that conflict occurred throughout the area.
Samples	NASIR 401 – NASIR 410

D4.1 General information

AOI-4 consists of an open area located to the south of An Nasiriyah. The area includes a former munitions storehouse. It is believed that conflict involving the use of DU munitions occurred in this area, but the number of rounds remains unknown.

AOI-4 was subdivided into 10 sampling areas, based on the available conflict information and inferred areas of interest. Soil samples were collected from each sampling area, and smear samples were collected at select locations.

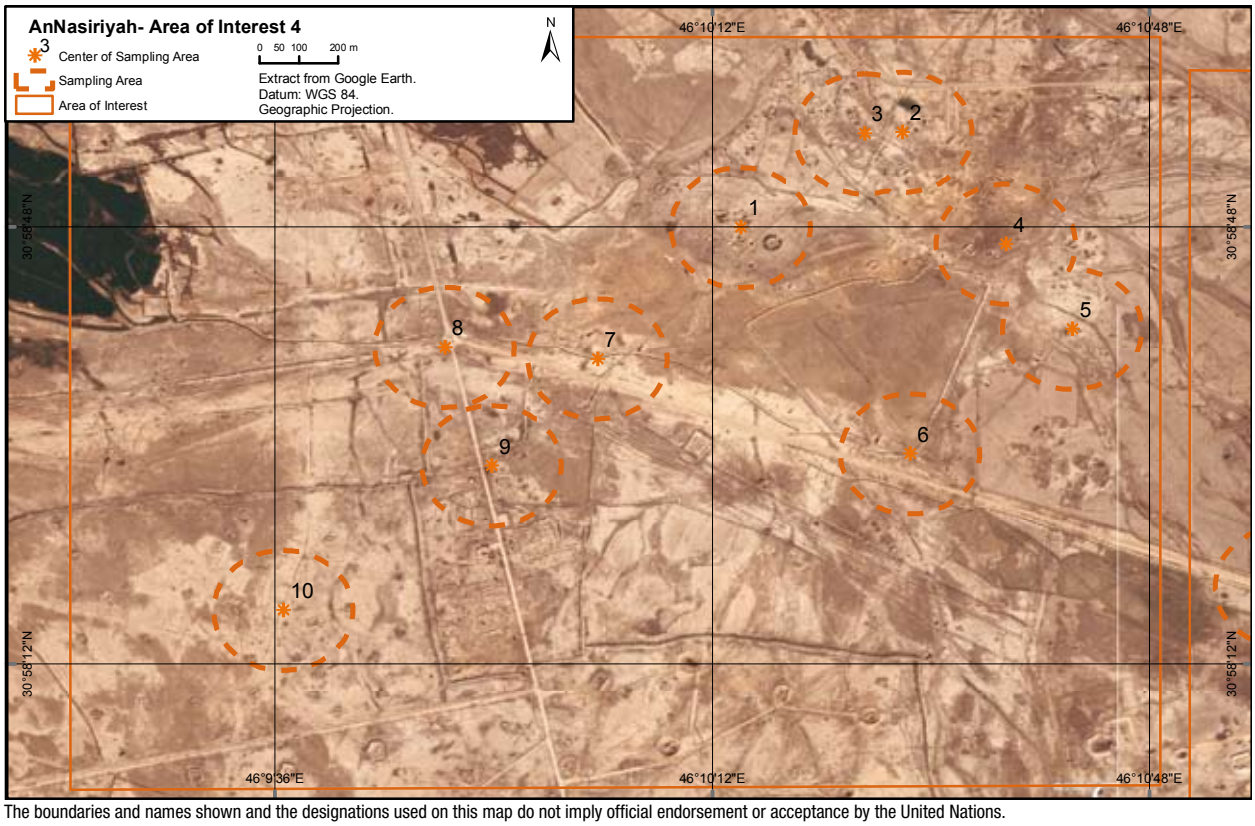
D4.2 Field data

A total of 12 samples (10 soil samples and 2 smear samples) was collected in this Area of Interest.

The ambient dose rates (measurements about 1 metre above ground) were measured between 0.10 and 0.19 μSv/h.

No residues of DU were detected.

An Nasiriyah, AOI-4



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

D5. Area of Interest 5

DU investigations were planned for an area of interest located to the south of An Nasiriyah (AOI-5). However, field observations and sampling activities could not be conducted due to access restrictions implemented by US military forces in the area during the study period.

D6. Area of Interest 6

DU investigations were planned for an area of interest located to the south of An Nasiriyah (AOI-6). However, field observation and sampling activities could not be conducted due to access restrictions implemented by US military forces in the area during the study period.

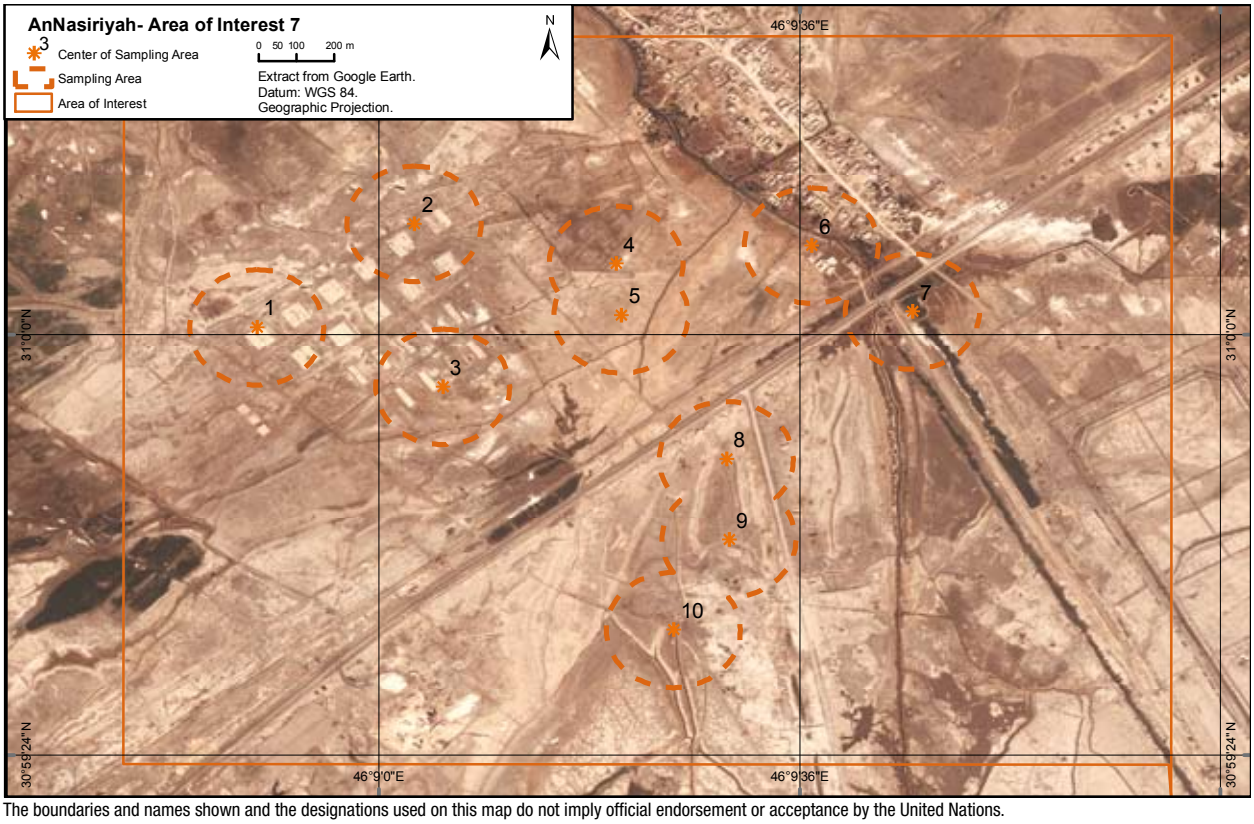
D7. Area of Interest 7

D7.1 General information

AOI-7 primarily consists of an open area located to the south of An Nasiriyah. The area includes a former munitions storehouse facility, with associated roads and buildings. It is believed that conflict involving the use of DU munitions occurred in this area, but the number of rounds remains unknown.

City/Town	An Nasiriyah
Area of Interest	AOI-7
Description	Munition storehouse
UTM Coordinates (Centroid)	610400 E
	3430000 N
Area Size	1.8 km x 2.4 km
Investigation Dates	25 July 2006
Infrastructure	Open land, includes a former munitions storehouse and road.
Conflict Dates	March-April 2003
Conflict Description	It is believed that conflict occurred throughout the area.
Samples	NASIR 701 – NASIR 710

An Nasiriyah, AOI-7



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

AOI-4 was subdivided in 10 sampling areas, based on the available conflict information and inferred areas of interest. Soil samples were collected from each sampling area, and smear samples were collected at select locations.

D7.2 Field data

A total of 12 samples (10 soil samples and 2 smear samples) was collected in this Area of Interest.

The ambient dose rates (measurements about 1 metre above ground) were measured between 0.12 and 0.38 μSv/h.

No residues of DU were detected.

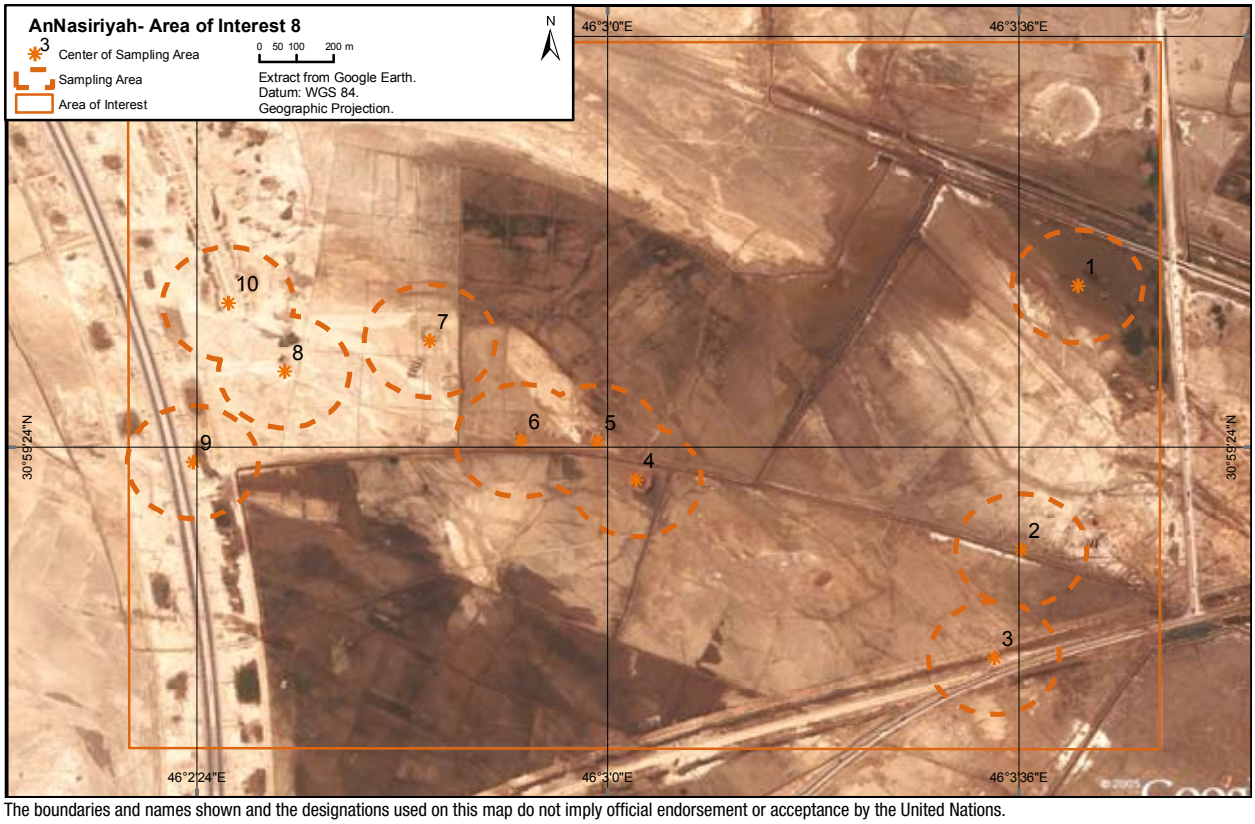
D8. Area of Interest 8

D8.1 General information

AOI-8 consists of an open area located to the southwest of An Nasiriyah. The area is situated near a former coalition military camp, and the main road is located at the western edge of AOI-8. It is believed that conflict involving the use of DU munitions occurred in this area, but the number of rounds remains unknown.

City/Town	An Nasiriyah
Area of Interest	AOI-8
Description	Southwest of city
UTM Coordinates (Centroid)	600250 E
	3429100 N
Area Size	1.8 km x 2.4 km
Investigation Dates	24 July 2006
Infrastructure	Open land, near a former coalition military camp, east of the main road.
Conflict Dates	March-April 2003
Conflict Description	It is believed that conflict occurred throughout the area.
Samples	NASIR 801 – NASIR 810

An Nasiriyah, AOI-8



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

AOI-8 was subdivided into 10 sampling areas, based on the available conflict information and inferred areas of interest. Soil samples were collected from each sampling area, and smear samples were collected at select locations.

D8.2 Field data

A total of 14 samples (10 soil samples and 4 smear samples) was collected in this Area of Interest.

The ambient dose rates (measurements about 1 metre above ground) were measured between 0.10 and 0.22 μSv/h.

No residues of DU were detected.

City/Town	An Nasiriyah
Area of Interest	AOI-9
Description	Southwest of city
UTM Coordinates (Centroid)	600700 E
	3434150 N
Area Size	1.8 km x 2.4 km
Investigation Dates	26 July, 2006
Infrastructure	Open land, near former coalition military camp, east of the main road.
Conflict Dates	March-April 2003
Conflict Description	It is believed that conflict occurred throughout the area.
Samples	NASIR 901 – NASIR 909

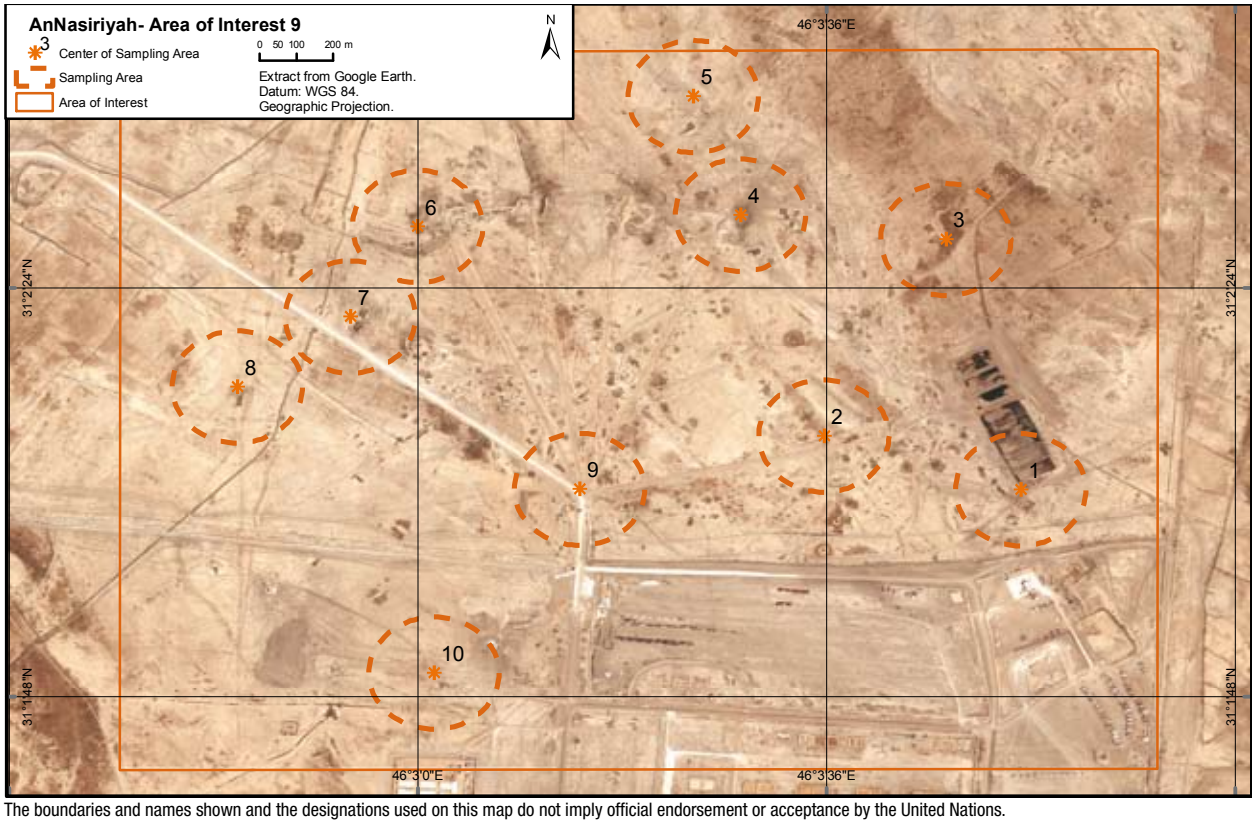
D9. Area of Interest 9

D9.1 General information

AOI-9 consists of an open area located to the south-west of An Nasiriyah. The area is located near a former coalition military camp. It is believed that conflict involving the use of DU munitions occurred in this area, but the number of rounds remains unknown.

AOI-9 was subdivided into 8 sampling areas, based on the available conflict information and inferred areas of interest. Soil samples were collected from each sampling area, and smear samples were collected at select locations.

An Nasiriyah, AOI-9



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

D9.2 Field Data

A total of 10 samples (8 soil samples and 2 smear samples) were collected in this Area of Interest.

The ambient dose rates (measurements about 1 metre above ground) were measured between 0.12 and 0.19 μSv/h.

No residues of DU were detected.

D10. Area of Interest 10

D10.1 General information

AOI-10 consists of an open area located to the west of An Nasiriyah, south of the Euphrates River. It is believed that conflict involving the use of DU munitions occurred in this area, but the number of rounds remains unknown.

AOI-10 was subdivided into 7 sampling areas, based on the available conflict information and inferred areas of interest. Soil samples were collected from each sampling area, and smear samples were collected at select locations.

City/Town	An Nasiriyah
Area of Interest	AOI-10
Description	West of city, south of Euphrates
UTM Coordinates (Centroid)	604700 E
	3438800 N
Area Size	1.8 km x 2.4 km
Investigation Dates	26 July 2006
Infrastructure	Open land south of the Euphrates river. Includes various roadways.
Conflict Dates	March-April 2003
Conflict Description	It is believed that conflict occurred throughout the area.
Samples	NASIR 1001 – NASIR 1007

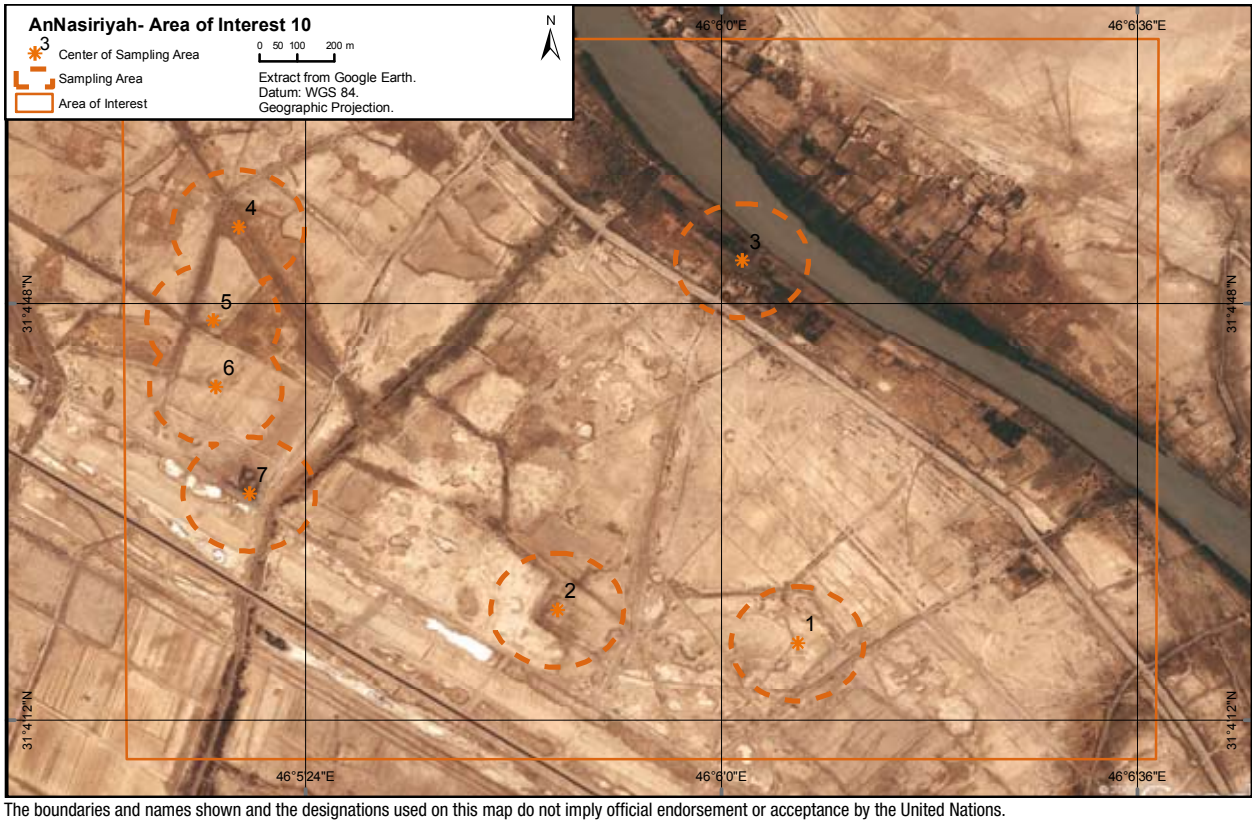
D10.2 Field data

A total of 9 samples (7 soil samples and 2 smear samples) was collected in this Area of Interest.

The ambient dose rates (measurements about 1 metre above ground) were measured between 0.09 and 0.20 μSv/h.

No residues of DU were found and localized.

An Nasiriyah, AOI-10



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

D11. Area of Interest 11

City/Town	An Nasiriyah
Area of Interest	AOI-11
Description	North of city
UTM Coordinates (Centroid)	619700 E
	3439700 N
Area Size	1.8 km x 2.4 km
Investigation Dates	24 July 2006
Infrastructure	Northern edge of urban area, includes residential, commercial and industrial properties, as well as roads and waterways.
Conflict Dates	March-April 2003
Conflict Description	It is believed that conflict occurred throughout the area, and primarily in the vicinity of the bridge across the waterway.
Samples	NASIR 1101 – NASIR 1109

D11.1 General information

AOI-11 is located at the northern edge of the urban area of An Nasiriyah. In March and April 2003, conflict involving DU munitions is believed to have occurred throughout the area, although the number of rounds remains unknown. The DU investigation focussed on the areas surrounding the main north-south road and the bridge across the waterway. Samples were also collected from an open area located to the northeast of the bridge.

AOI-11 was subdivided into 9 sampling areas, based on the available conflict information and inferred areas of interest. Soil samples were collected from each sampling area, and smear samples were collected at select locations.

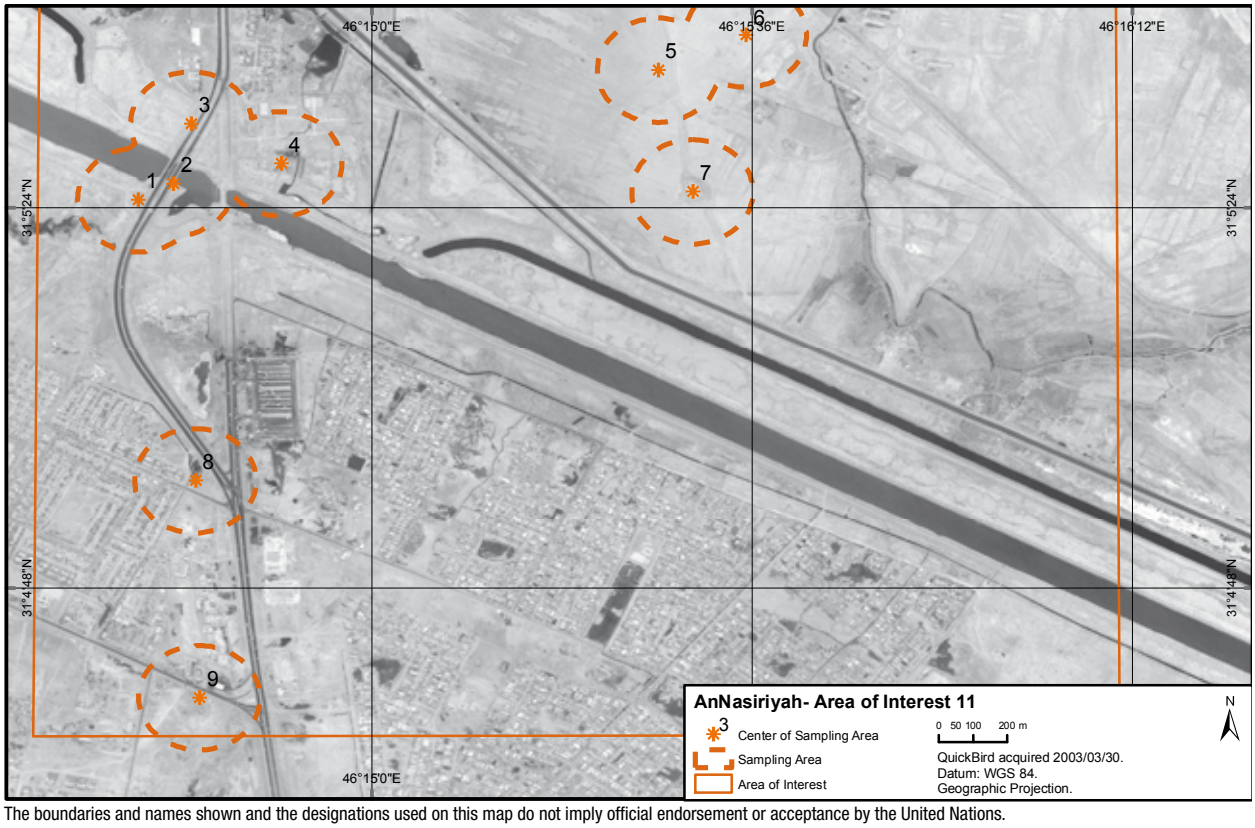
D11.2 Field data

A total of 14 samples (9 soil samples and 5 smear samples) was collected in this Area of Interest.

The ambient dose rates (measurements about 1 metre above ground) were measured between 0.10 and 0.38 μSv/h.

No residues of DU were detected.

An Nasiriyah, AOI-11



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

D12. Area of Interest 12

City/Town	An Nasiriyah
Area of Interest	AOI-12
Description	City centre
UTM Coordinates (Centroid)	619400 E
	3435450 N
Area Size	1.8 km x 2.1 km
Investigation Dates	25 July 2006
Infrastructure	Urban area, includes residential, commercial and industrial properties, as well as roadways. The Euphrates River flows from west to east, and three bridges crossing the river are located within AOI-12.
Conflict Dates	March-April 2003
Conflict Description	It is believed that conflict occurred throughout the area, and primarily along the main roads and in the vicinity of the bridges across the Euphrates.
Samples	NASIR 1201 – NASIR 1216

D12.1 General information

AOI-12 is located within the urban area of An Nasiriyah. In March and April 2003, conflict involving DU munitions is believed to have occurred throughout the area, although the number of rounds remains unknown. The DU investigation focussed on the areas surrounding the main roadways and the bridges across the Euphrates River. Also investigated was a former Iraqi military camp located to the south of the river.

AOI-12 was subdivided into 16 sampling areas, based on the available conflict information and inferred areas of interest. Soil samples were collected from each sampling area, and smear samples were collected at select locations.

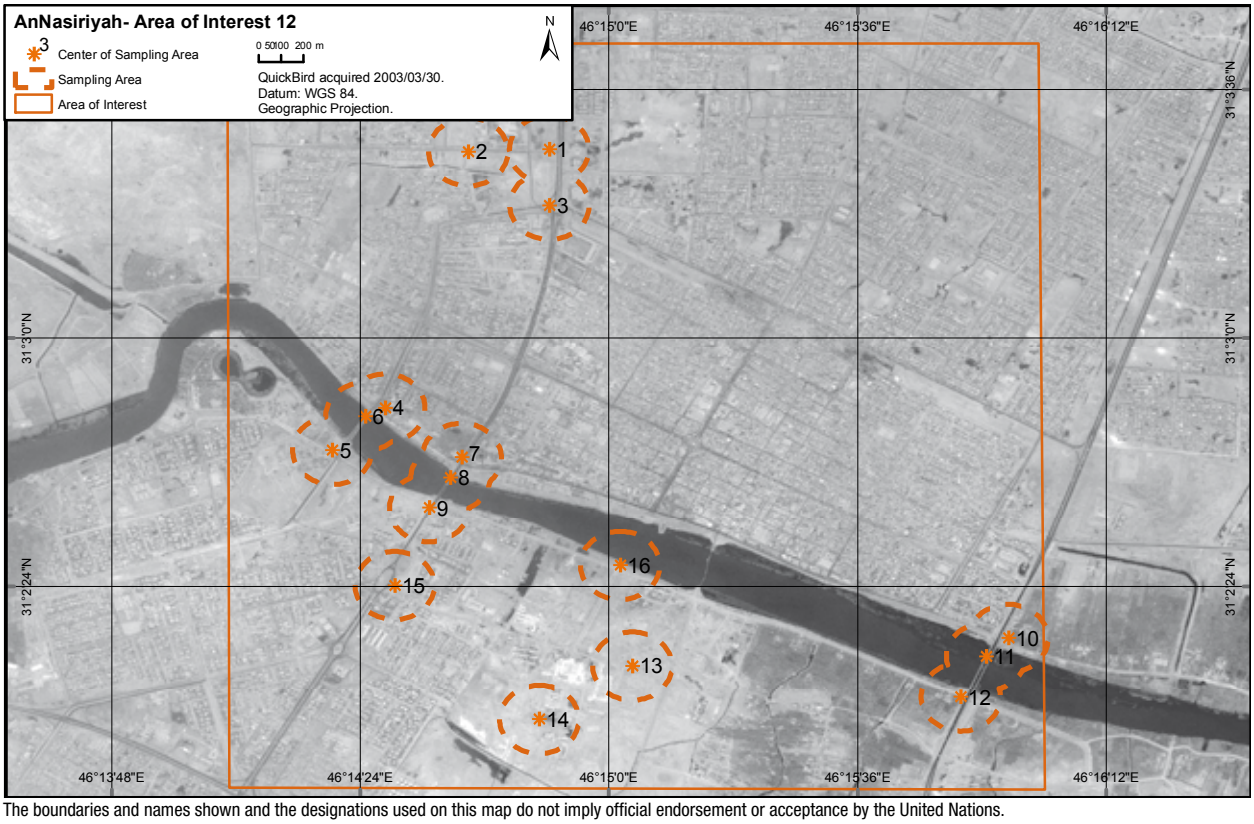
D12.2 Field data

A total of 26 samples (13 soil samples and 13 smear samples) were collected in this Area of Interest.

The ambient dose rates (measurements about 1 metre above ground) were measured between 0.10 and 0.22 μSv/h.

No residues of DU were detected.

An Nasiriyah, AOI-12



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

D13. Area of Interest 13

City/Town	An Nasiriyah
Area of Interest	AOI-13
Description	South of city
UTM Coordinates (Centroid)	620850 E
	3430900 N
Area Size	1.8 km x 2.4 km
Investigation Dates	26 July 2006
Infrastructure	Area south of the city, primarily industrial properties and open land.
Conflict Dates	March-April 2003
Conflict Description	It is believed that conflict occurred throughout the area.
Samples	NASIR 1301 – NASIR 1306

D13.1 General information

AOI-13 is located to the south of An Nasiriyah, in a primarily industrial area with open land and bare, sandy soil. A main road runs north-south through AOI-3. The remains of a bombarded tank were also identified in the area. In March and April 2003, conflict involving DU munitions is believed to have occurred throughout the area, although the number of rounds remains unknown. The DU investigation focussed on the areas surrounding the main road, and on the bombarded tank.

AOI-13 was subdivided into 6 sampling areas, based on the available conflict information and inferred areas of interest. Soil samples were collected from each sampling area, and smear samples were collected at select locations.

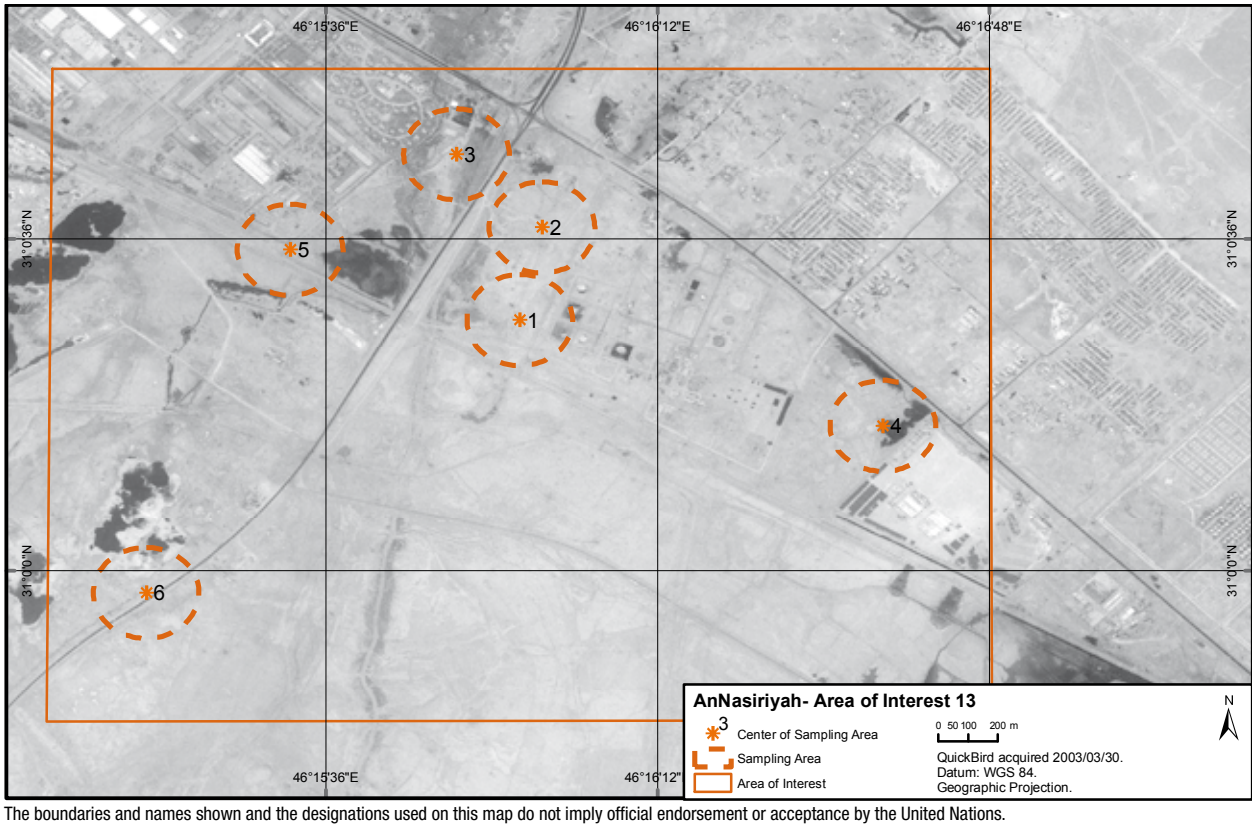
D13.2 Field data

A total of 11 samples (6 soil samples and 5 smear samples) was collected in this Area of Interest.

The ambient dose rates (measurements about 1 metre above ground) were measured between 0.01 and 0.18 μSv/h.

No residues of DU were detected.

An Nasiriyah, AOI-13



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

D14. Area of Interest 14

City/Town	An Nasiriyah
Area of Interest	AOI-14
Description	Northeast of city
UTM Coordinates (Centroid)	622500 E
	3439300 N
Area Size	1.8 km x 1.8 km
Investigation Dates	23 July 2006
Infrastructure	Northeast edge of the city. Includes a main north-south road and a bridge across the waterway. Primarily open land, forested areas and wetlands.
Conflict Dates	March-April 2003
Conflict Description	It is believed that conflict occurred primarily along the main roadway.
Samples	NASIR 1401 – NASIR 1406

D14.1 General information

AOI-14 is located to the northeast of An Nasiriyah, along a main north-south road with a bridge across the waterway. The area is primarily open land and wetlands, although the southwest corner of AOI-14 includes residential areas. In March and April 2003, conflict involving DU munitions is believed to have occurred throughout the area, although the number of rounds remains unknown. The DU investigation focussed on the areas surrounding the main road and bridge.

AOI-14 was subdivided into 6 sampling areas, based on the available conflict information and inferred areas of interest. Soil samples were collected from each sampling area, and surface water and smear samples were collected at select locations.

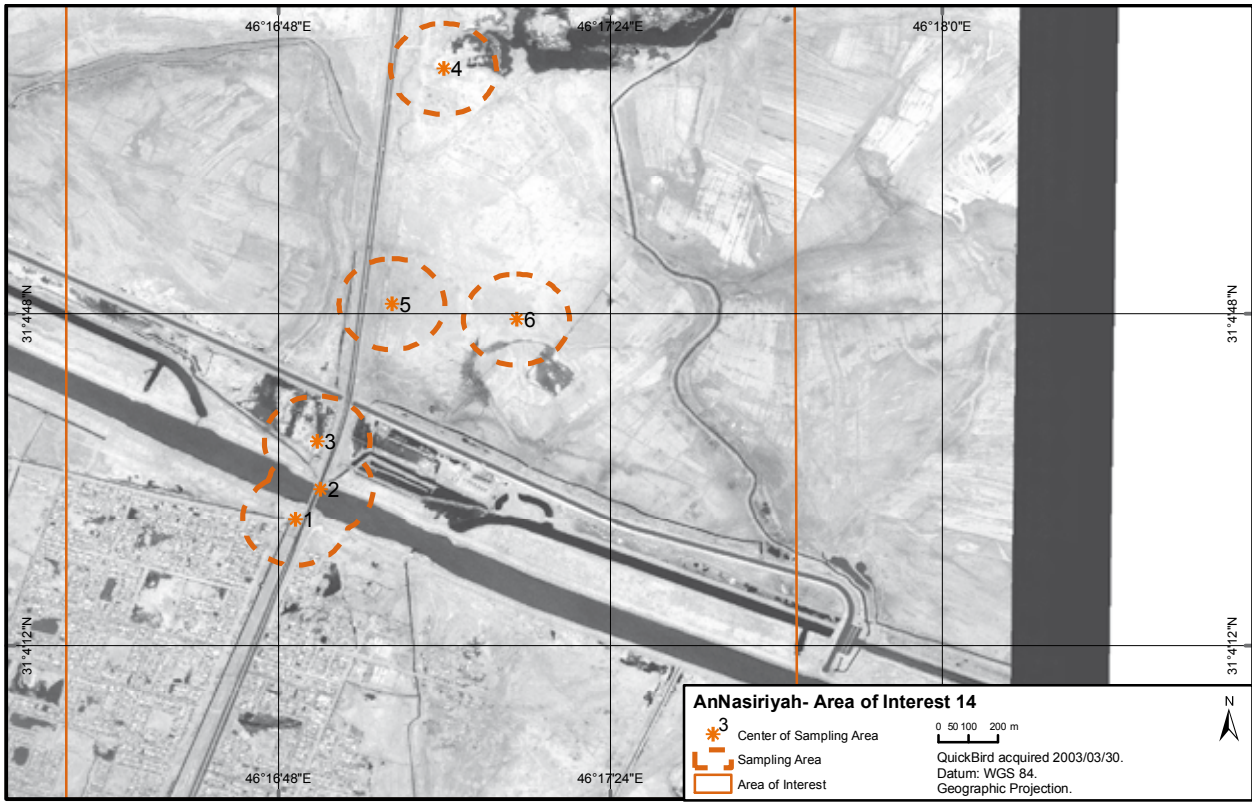
D14.2 Field data

A total of 9 samples (5 soil samples, 1 surface water sample and 3 smear samples) was collected in this Area of Interest.

The ambient dose rates (measurements about 1 metre above ground) were measured between 0.11 and 0.22 μSv/h.

No residues of DU were detected.

An Nasiriyah, AOI-14



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

D15. Additional Points of Investigation

City/Town	An Nasiriyah
Area of Interest	Additional points
Description	City area
UTM Coordinates of bombed tank	620617 E
	3431554 N
UTM Coordinates of scrap yard	619503 E
	3429394 N
Investigation Dates	26 July 2006
Infrastructure	One bombarded tank located in North of city and one scrap yard located south of the city
Conflict Dates	March-April 2003
Conflict Description	It is believed that conflict occurred at location of bombed tank, but not in the area of the scrap yard
Samples	Nasir-soil-scraps, Nasir-soil-bombarded tank, smear-bombarded tank (entry), smear-bombarded tank (outlet), smear-scraps A - smear-scraps C

D15.1 Field data

A total of 7 samples (2 soil samples, and 5 smear samples) was collected at the additional investigation points.

The ambient dose rates (measurements about 1 metre above ground) were measured between 0.11 to 0.22 μSv/h.

Up to 12.7 μSv/h on tank surfaces and up to 34.8 μSv/h at a scrap yard location was measured (measurements directly taken millimetres above the surface).

Residues of DU were found in relation to the military objects investigated.

Appendix E: Units

E1. International System of Units (SI); SI Base Units

Base quantity	SI base unit	
	Name	Symbol
length	metre	m
mass	kilogramme	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

E2. SI Derived Units

SI Derived Units		
Derived quantity	Name	Symbol
Activity (ionizing radiations)	Becquerel	Bq = 1/s
Absorbed dose, specific energy (imparted), kerma	Gray	Gy = J/kg = m^2/s^2
Absorbed dose rate	Gray per second	Gy/s = m^2/s^3
Dose equivalent, ambient Dose equivalent, directional Dose equivalent, personal Dose equivalent, organ Equivalent dose	Sievert	Sv = J/kg = m^2/s^2
Dose equivalent rate	Sievert per second	Sv/s = m^2/s^3
Volume	cubic metre	m^3

E3. SI Prefixes

Exponent (base 10) of decimal numbers:
E $n = 10^n$

Factor	Name	Symbol
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10^{1}	deka	da

Factor	Name	Symbol
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	µ
10^{-9}	nano	n
10^{-12}	pico	p

Appendix G: List of Contributors

Iraq DU Site Assessment Leading Team Members

Dr. Bushra A. Ahmed – Director General, Ministry of Environment, Radiation Protection Centre
Dr. Ibrahim Kh. D. Al-Haddad – Senior Expert, Ministry of Environment, Radiation Protection Centre
Dr. Khaleed J. Khaleel – Senior Expert, Ministry of Environment, Radiation Protection Centre

UNEP DU Project Team

Mr. Henrik Slotte – Chief of Branch
Dr. Muralee Thumarukudy – Operations Manager
Dr. Mario Burger – Senior Scientific Advisor
Mr. Alain Wittig – Associate Programme Officer

Special Thanks

Dr. Stephan Röllin – Laboratory Expert, SPIEZ LABORATORY
Mr. Markus Astner – Field and Laboratory Expert, SPIEZ LABORATORY
Mr. Yves Barthélemy – GIS and Remote Sensing Expert, Paris
Mr. B. R. Ravishankar – Report Writer, Dillon Consulting Limited
Mr. Jogchum Finnema – UNOPS, Geneva
Dr. Didier Louvat – IAEA, Vienna
Dr. Zhanat Carr – WHO, Geneva
United Nations Office for Project Services, Amman, Jordan
SPIEZ LABORATORY, Switzerland

UNEP Post-Conflict and Disaster Management Branch

Henrik Slotte – Chief of Branch
Muralee Thumarukudy – Operations Manager
David Jensen – Policy and Planning Coordinator
Andrew Morton – Programme Development and Assessment Coordinator
Richard Wood – Technical Coordinator
Mario Burger – Senior Scientific Advisor
Silja Halle – Communications Advisor
Hassan Partow – Senior Environmental Expert
Glenn Dolcemascolo – Disaster Management Expert
Gabriel Rocha – Systems Administrator
Satu Ojaluoma – Administrative Officer
John Carstensen – Senior Programme Officer
David Meadows – Programme Officer
Alain Wittig – Associate Programme Officer
Maliza van Eeden – Associate Programme Officer
Mani Nair – Project Assistant
Anne-Cecile Vialle – Research and Operations Assistant
Rachel Dolores – Project Assistant
Matija Potocnik – Media Assistant
Joanne Stutz – Administrative Assistant
Elena Orlyk – Project Assistant
Dawit Yared – Project Assistant

Further information

Further technical information may be obtained from
the UNEP Post-Conflict and Disaster Management Branch website:
http://postconflict.unep.ch/


UNEP