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ENVIRONMENTAL SURVEILLANCE IN KOSOVO

Prepared by Dr D M Smith
DERA Radiation Protection Services

Crescent Road, Alverstoke
Hants, PO12 2DL

☎ 023 92 768130   Fax 023 92 768150

Authorised for Release by:

D G Cowling
for Head of DRPS

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EXECUTIVE SUMMARY

This paper describes proposals for addressing potential radioactive contamination and other environmental health issues in Kosovo by means of an enhancement to the existing environmental health programme established to discharge MOD's statutory responsibilities in respect of the health and safety of its employees. It has been produced in response to an undertaking to address veterans concerns made by the Minster Armed Forces in the House of Commons on 9 January 2001. Although this announcement was made in response to concerns about possible health effects from contamination arising from the use of depleted uranium (DU) munitions, the commitment made was to assess all potential risks.

There is already an established health and safety and environmental health regime in Kosovo and Army Environmental Health Officers and Technicians are deployed in the area. Assessments of the potential risks from the use of DU munitions were made before UK troops entered Kosovo and the risks from DU residues were assessed as very low. Subsequent findings have confirmed the validity of this initial assessment, but there is clearly a need for further work to address veterans concerns. The intention is that future work will build on the existing arrangements and that the specialist staff in Kosovo will be fully involved in the project.

The paper summarises the results of a reconnaissance visit to Kosovo in January 2001. This survey highlighted the need for a more thorough assessment of the potential risks from low levels of caesium contamination that probably results from the Chernobyl accident as well as any DU residues. The visit also highlighted some of the practical problems likely to arise during future work. These included uncertainty regarding the exact location of DU attacks and the presence of other known physical and environmental hazards such as unexploded ordnance and asbestos. The radiological issues and important pathways by which DU and caesium contamination may affect humans are also identified and discussed.

This paper focuses on the radiological issues, but also indicates that surveys for radiological contamination provide opportunities for gathering information on other hazardous materials (such as heavy metals) at little additional cost. The strategy takes into account the available field monitoring and laboratory analysis techniques as well as the results of work by other NATO partners and organisations such as the United Nations to provide thorough and cost effective coverage of the potential hazards.

The purpose of the survey is to collect data on the concentration of potentially hazardous materials in soil, water and air and to measure radiation levels in the environment. This information can then be compared with guidance levels produced by organisations such

as the National Radiological Protection Board and the Department of the Environment, Transport & the Regions. This is primarily a screening assessment that allows a generic assessment of the potential risks from environmental contaminants. It is neither practical nor necessary to investigate “every square metre” of land and the survey will focus on areas of greatest risk. BRITFOR sites will be surveyed in accordance with their location and size and there are particular proposals to investigate at least one (and preferably two) known DU attack sites as such sites represent “worst case” conditions. The reasonable expectation is that conditions in other areas will be less severe and that this will be tested against the results from the other locations surveyed. A third DU attack site is potentially extremely useful in terms of the information that might be obtained, but is contaminated with asbestos and therefore considered unsuitable for further investigations at this stage.

INTRODUCTION AND BACKGROUND

Introduction

1. Following recent concerns expressed by veterans of the Kosovo, Bosnia and Gulf conflicts where DU munitions have been used, the Minster for Armed Forces announced on 9 January 2001 that the UK would identify an additional appropriate voluntary screening programme for service personnel and civilians who had served in the Balkans and would enhance the existing environmental surveillance programme. This paper describes how this requirement will be met in respect of radioactive contamination issues in Kosovo and includes a brief report of the results of a reconnaissance visit during the period 19-23 January 2001. The wider environment/occupational health issues are being dealt with separately by the Royal Army Medical Corps (RAMC), in conjunction with Environmental Health technicians and officers in Kosovo. However, some comments on other types of hazardous material that were noted in areas where enhanced levels of radioactivity were found are included in this report for completeness.

2. Whilst the proposals in this paper are primarily directed towards the development of an enhanced environmental monitoring programme, they are also designed to inform whenever possible the Corporate Research Programme on Depleted Uranium (DU) which is being formulated under the direction of the MOD Chief Scientific Adviser. Proposals for the voluntary screening programme are being taken forward by a separate working party which has published three papers on this topic (*References 1- 3*).

Reconnaissance Visit to Kosovo

3. Prior to the reconnaissance visit, NATO sources confirmed that there were eight locations in the British sector in Kosovo where DU munitions had been used and that only one of these locations was close to an area where there is Temporary Field Accommodation (TFA) for British troops. Accommodation on TFA sites consists mainly of modular “Portacabin” type units. It was also confirmed that DU use in Kosovo had been restricted to the firing of 30mm DU rounds by US A-10 “Thunderbolt” aircraft with about 225 DU penetrators being fired in a typical attack. Each penetrator weighs approximately 300g and is about 95mm long and 16mm in diameter.

4. The purpose of the reconnaissance was to gain an understanding of conditions in Kosovo that would assist in the development of future monitoring strategies and the principal monitoring equipment used was the Exploranium Mini Spec GR130 surveying gamma ray spectrometer. This instrument was used in survey mode (in which raw counts from the detector were displayed as a function of time in bar chart display), in the dose rate mode (with a sensitivity down to nanosieverts per hour) and as a low resolution gamma spectrometer. A Mini Instruments Model 900 ratemeter with 44B low energy X-

ray probe was also used. Army Environmental Health Technicians were present throughout the visit to address non-radiological health issues.

5. Only 7 of the 8 sites where DU munitions had been used in the British led Sector could be visited during the reconnaissance, as the eighth was inaccessible by road. Most attention was given to one site close to a British TFA site known as Waterloo Lines, and a site where some DU penetrators were recovered.

6. The survey procedure involved a walkover of each site with the GR130 being used in survey mode to provide an indication of average radiation levels and evidence of enhanced radioactivity. Monitoring was also carried out with the Type 44B probe and soil samples were collected for radiochemical and chemical analysis.

7. There was only one location where the presence of DU was confirmed. This was at a former military site known as Old VJ Barracks where 3 penetrators were located. Personnel equipped with the Type 44B probe found one penetrator lodged in a brick wall under 1 - 2cm of debris; another was discovered protruding from concrete building foundations during a visual inspection of battle damage; and the third was found under approximately 150mm of debris and soil by personnel using the GR130 in survey mode. Some localised areas of enhanced gamma activity measuring about 30cm x 30cm were detected at Old VJ Barracks site and at the site of another DU attack north of Glavnick. Gamma spectrometry carried out with the GR130 confirmed that the penetrators recovered were made of DU and a spectrum of the gamma ray emissions discovered at Glavnick suggested that the increased activity was due to the presence of caesium–137. The discovery and identification of caesium-137 with the Exploranium was not anticipated prior to the visit and shows the value of portable gamma spectroscopy equipment.

8. Twenty-two soil samples were collected from various locations by the MOD team and taken to the UK for more detailed analysis. The samples underwent an initial screening by gamma spectrometry and uranium–235 and the decay products of uranium-238 (i.e. thorium-234 and protactinium-234) were found in debris and soil samples from the immediate vicinity of the recovered penetrators. The uranium-238 content was inferred from the decay product concentrations and the uranium-238 to uranium-235 activity ratio was suggestive of the presence of DU. This analysis technique is useful for screening purposes, but it is not sufficiently sensitive for measuring uranium at typical environmental levels. It is also able to confirm that the samples do not present a significant contamination risk in the laboratories where more sophisticated analyses will be carried out. The detailed gamma spectrometry analysis results are in Appendix 1.

9. Significant concentrations of Caesium-137 were detected in samples from Glavnick and the old VJ Barracks, and lesser amounts in most other samples. Caesium-

137 deposits in the soil were observed to be highly localised and were typically present over areas of the order of 300mm radius and 150mm depth. Caesium-134 was also found in some samples and the ratio of the activities of caesium-134 and caesium-137 suggests that the material is likely to have been deposited as a result of the Chernobyl accident. These concentrations of caesium-137 (ranging from 100 up to 1241 Becquerels per kilogram ($Bqkg^{-1}$)) are significant when compared with the National Radiological Protection Board's Generalised Derived Limits (NRPB's GDLs) (*Reference 4*) for caesium-137 in soil which is 1000 $Bqkg^{-1}$. Using pessimistic assumptions, it has been calculated that continuous exposure at the GDL results in a person receiving an annual radiation dose of 1 millisievert (mSv) which is the current UK statutory dose limit for a member of the public. The corresponding annual dose limit for employees is 20mSv (*Reference 5*).

10. NRPB recommend that activity concentrations in excess of 10% of the GDL (100$Bqkg^{-1}$) require further investigation to assess the applicability of the dose modelling to the actual scenario at the location of interest. Two of the caesium-137 activity concentrations in the samples collected exceed the GDL and this suggests the need for some further investigations during future survey work. However, the average activity concentration for all soil samples is well below the GDL and the concentrations in soil from locations close to the British camps at Waterloo Lines and Slim Lines are 98 and 11$Bqkg^{-1}$ respectively and less than 10% of the GDL.

11. The gamma spectroscopy results in Appendix 1 indicate, that, with the exception of samples from the immediate vicinity of DU penetrators, all uranium in soil activity concentrations are well below the appropriate GDL. However, further analysis of the soil samples collected during the reconnaissance visit will be carried out using techniques such as X-ray fluorescence (XRF) and inductively coupled plasma mass spectroscopy (ICPMS) to provide more accurate measurements of uranium and DU concentration. All samples will be examined by XRF and the results of these analyses will be used to determine which samples should be analysed by ICPMS so that information can be obtained on the uranium isotope ratios. The samples will also be analysed for other heavy metals to provide information that will be of assistance in the wider examination of occupational health issues mentioned in paragraph 1 above.

12. A major finding from the reconnaissance visit was that the coordinates given for the locations where DU was used are only accurate to plus or minus 1 nautical mile. The chances of detecting DU in such a large area are very low unless there are other indications of the point of attack (e.g. visual clues). Such indications existed at the Old VJ Barracks site, where there were a number of buildings showing signs of battle damage. This focussed attention on this area and triggered the subsequent discovery of DU penetrators during the radiation monitoring survey. Field measurements with the GR130

indicated that detection of a DU penetrator buried under much more than 150mm of soil was unlikely. In the case of a DU penetrator on the surface, detection was just possible over a distance of about 400mm. The obvious conclusion is that penetrators are unlikely to be detected by the use of radiation monitoring equipment unless they are on or close to the surface and there are visual clues or more accurate grid references for the attack location. However, information from UN sources *(Reference 6)* indicates that DU rounds from A-10 aircraft are likely to penetrate more than 50mm into the soil. The exact depth is difficult to predict as it depends on the soil conditions and the aircraft's approach.

13. There was evidence of asbestos contamination at the Old VJ Barracks site and the presence of chrysotile asbestos was confirmed by subsequent laboratory analysis. Discussions with Theatre Environmental Health Technicians revealed that the widespread use of asbestos in roofing materials in the Balkans was well known. RAMC advice is that the presence of the asbestos makes further work at this site problematical, as any future investigation would inevitably involve disturbance of asbestos contaminated ground. Conditions were wet and there was negligible risk from resuspended asbestos fibres during the reconnaissance visit, but this would not be the case during drier weather. Removal of the asbestos prior to a DU survey would almost certainly require stripping of the topsoil to a depth of 150mm - 300mm and this could destroy much of the evidence relating to DU.

14. Unexploded ordnance is also a major issue at some locations where DU munitions were used. Army Explosive Ordnance Disposal (EOD) teams were required to lead the search in these areas and progress was very slow. At one site it took about 20 minutes to progress 20m linearly into the wood and monitoring and sampling was difficult because of the restricted area of cleared ground. Access was attempted using an armoured personnel carrier (APC), but this was of limited usefulness in terms of access through woods and access to the ground for monitoring and sampling purposes. Surveying such areas on foot or using an APC would clearly not be practicable.

15. In conclusion, the reconnaissance visit has highlighted certain key issues that need to be borne in mind when considering the proposals for future surveys. Whilst the reason for the survey is in response to concerns about DU, the issue of caesium-137 contamination also needs to be properly addressed. However, any proposals for environmental surveys need to be considered in the wider context of risks arising from other hazards in the Kosovo theatre. Two such hazards identified during the visit were unexploded ordnance and asbestos. These hazards must be considered as part of a comprehensive generic risk assessment, which will be required to be completed before the survey mission commences. The generic assessment will need to be reviewed

dynamically in theatre in the light of local circumstances. These risk assessments are not within the scope of this document.

RADIOLOGICAL ISSUES TO BE ADDRESSED IN KOSOVO

Depleted Uranium

16. DU is defined by the International Atomic Energy Agency as a low specific activity material and DU munitions have typical alpha activities of 14 – 15MBqkg^{-1} arising from all uranic radionuclides. Material used in the manufacture of munitions also contains trace quantities of transuranic elements and fission products that may be disregarded for health effects assessments as they contribute only an extra 0.8% to the dose. DU analyses and health assessments have been carried out by a variety of organisations (*References 7-9*).

17. External radiation dose rates from bulk DU are relatively low and this potential exposure route would only be significant if someone spent hundreds of hours handling a DU penetrator or carrying it in a pocket. The difficulties experienced in finding DU during the reconnaissance visit and the widespread knowledge of the hazards of handling *any* munitions also serve to allay any fears about the external radiation hazard to troops and the public. However bulk DU will eventually corrode in soil, water or air and present potential internal radiation hazards. Similar hazards will also exist from any particulate material generated during the initial attack. DU particulates may enter the body by inhalation of dust, by the ingestion of contaminated food or water or soil or by the contamination of cuts or abrasions. All these potential exposure pathways may be characterised by analysing the uranium or DU content of foodstuffs, water, and respirable dust.

18. Uranium is naturally occurring and is present in rocks soils and water (not forgetting air, plants and animals) throughout the world. The top 300mm of cultivated soil is the main source for uranium entering man via inhalation or food ingestion and soil below this depth has little impact on these pathways *(Reference 10).* The ingestion of uranium in drinking water can also present a significant route of intake in some areas. Hence, characterisation of the uranium or DU content of soils, dusts and watercourses will provide information about potential pathways for human exposures. The concentration of uranium in soils and watercourses depends on the geographical location and is extremely variable. Typical soils contain 20 Bqkg^{-1} (1 – 2 parts per million (ppm) by mass) of uranium, whereas granites can contain 200 Bqkg^{-1} (10-20 ppm) of uranium. The mobility of uranium in the soil depends upon its form, and the chemical environment in the soil. Surveys and analysis procedures will need to take account of the natural abundance of uranium in the environment and comparisons of the ratios of uranium radionuclides will be required to determine any contribution from DU.

19. The European Commission Group of Experts, established according to Article 31 of the EURATOM Treaty, published its opinions on the potential hazards from DU munitions on 6 March 2001 *(Reference 11)*. It concludes that in general it will be more appropriate to monitor the environment rather than individuals, and that such environmental monitoring should focus on soil, air and surfaces.

Caesium

20. As already noted, the caesium-137 activity concentrations in some soil samples collected during the reconnaissance visit indicate a need for further investigations. The objective of these investigations are: (a) to establish that the generic modelling used by NRPB to calculate the GDL's for caesium-137 in the environment does not underestimate the risks in the actual situation in Kosovo and (b) to demonstrate the pessimism of the NRPB modelling when applied to the Kosovo scenario. Work by NRPB (*Reference 4*) indicates that exposures from caesium-137 in the environment are dominated by gamma ray emissions from caesium-137 on or in the ground and the ingestion of contaminated foodstuffs.

21. Caesium-137 differs from DU in that it emits relatively penetrating gamma radiation which can readily pass through the air and clothes and irradiate the whole body. Caesium-137 at depths up to about 150mm will contribute to this exposure pathway, although the deeper the deposit, the more the gamma radiation is attenuated in passing through the soil. The NRPB work mentioned previously considers caesium-137 in well-mixed soils to a depth of 300mm. The factors affecting gamma ray exposures from the ground are the quantity of caesium-137 in the soil (the *specific activity*), the time spent near the contamination, the time spent outside versus the time in buildings and the presence of any materials (such as concrete or tarmac) above the contamination. This potential pathway can be characterised by analysing the caesium content of soils, measuring external dose rate, or by the issue of dosemeters that record external radiation dose.

22. The other important pathway is the ingestion of contaminated food. Information provided during the reconnaissance visit indicated that virtually all food consumed by UK troops is imported from EU sources outside Kosovo. The only known exception is bread, which is baked locally using flour from an unknown source. The possible ingestion of contaminated water also merits some consideration although imported bottled water is often used for drinking. These potential pathways can be characterised by analysing the caesium content of locally purchased foodstuffs and drinking water.

SURVEY STRATEGY

Introduction

23. Although the survey will need to address the two key areas of radiological interest identified above, it must be remembered that a variety of naturally occurring and man-made radioactive materials are used in industrialised societies. Items containing such materials may have been damaged during the conflict and screening for these other radionuclides (principally radium-226, cobalt-60, caesium-137 and iridium-192) should form part of future surveys. The survey strategy should be sufficiently flexible to cope with site-specific circumstances and allow for the unexpected, such as the discovery of enhanced levels of caesium-137 and asbestos at some sites. Wherever possible, it should allow collection of information useful to the broader environmental assessment programme, for example by providing information on the presence or absence of heavy metals. The gathering of environmental samples also allows for subsequent analysis of samples at a later date, for reassurance purposes or if further concerns arise.

24. The primary purpose of the survey is to identify any radiological hazards and, wherever possible, quantify those hazards in a form that enables a risk assessment to be carried out later. This risk assessment may sometimes need to be site specific, but will more likely be based on a "screening assessment" if levels of radionuclides are such that national and internationally recognised standards and guidelines (such as the NRPB GDLs) can be used for comparative purposes. The future strategy for the management of these risks, whilst a subsequent issue, should be borne in mind in the design of the survey programme.

25. Levels of radionuclides, both naturally occurring and man made, will vary from site to site and spatially within a site. Radionuclides in soils will vary with depth and be dependant on soil characteristics and mixing patterns since deposition. Made-up ground will not necessarily contain materials characteristic of other areas on the site and civil engineering works and occupancy and site usage (ie industrial verses residential) will influence resultant pathways to man. It is important to recognise this variability in distribution as evidence of this was obtained during the reconnaissance visit when localised concentrations of caesium-137 were discovered (see paragraph 9). Whilst it is possible, indeed likely, that other similar areas exist and may even be present near sites occupied by British troops, their radiological significance must not be over-stated. Their dose contributions will almost certainly be negligible and such highly localised areas of elevated radionuclide concentrations must not be used selectively as a basis for modelling doses. Indeed such an approach is contrary to the guidance offered by NRPB.

26. It is feasible to monitor and sample every single "square metre" of an area of interest, given enough time and resource. However, such an approach is impractical

when surveying large areas of ground and especially where the risks of encountering radioactive contamination have been demonstrated to be low as around the Old VJ Barracks a site of known DU usage. In essence, only minimal additional benefit is obtained for very great cost. The scientific “added value” of such an approach over a properly planned sampling programme is also questionable and any survey should be designed to characterise the area of interest site by means of representative sampling and measurement programme that takes account of the likely background levels of naturally occurring radionuclides.

Detection and Measurement of Uranium in Soils

27. Uranium isotopes and their decay products give off a range of alpha, beta, gamma and X-ray radiation and in theory any of these emissions could be used to characterise an area for such deposits. Unfortunately, detection of alpha particles in the field is fraught with difficulties as alpha particles are readily absorbed by a few centimetres of air and the merest film of moisture or dust will attenuate alpha particles completely. Hence, for anything other than an undisturbed fresh deposit, detection of alpha radiation in the field is inappropriate.

28. The technique of alpha spectrometry may be used in laboratories to identify individual uranium isotopes and has typical limits of detection of $0.5mBqg^{-1}$. As discussed later, the technique may be considered for some samples but it is relatively expensive and the analysis is time consuming.

29. The use of the beta emissions for characterisation of uranium in soils is also of limited value unless the material is freshly deposited and present in very significant quantities. This is because emissions from anything but the first few millimeters of soil will not be detected due to attenuation of the beta radiation by the soil. Beta spectrometry is fraught with difficulties and is not practicable under field conditions. X-ray emissions could be used, but the emissions are of low energy and will be difficult to detect against the relatively high natural background of low energy scattered gamma radiation.

30. The most practicable way of detecting uranium in the field and especially when the material is buried is by using the gamma emissions arising from the decay products. Protactinium has characteristic high energy gamma emissions at 733keV and 946keV and emissions at these energies are not so readily attenuated by the soil and are easily detected. There are also other gamma emissions that contribute to a general increase in count rate when uranium isotopes are present and portable, ruggedised compact and relatively inexpensive gamma monitors and gamma spectrometers are available. Indeed, one such instrument was used to great advantage in the reconnaissance visit.

31. Soil samples (including vegetation and root mat) can be screened for uranium and many other natural and artificial radionuclides in the field or in the laboratory by using gamma spectroscopy. The technique is relatively inexpensive as sample preparation is minimal and results for a wide range of radionuclides can be obtained within hours. However, the technique has typical uranium-238 detection thresholds of the order of 500-1000 $Bqkg^{-1}$. Whilst this may be just satisfactory for screening purposes with respect to NRPB recommended GDL's for uranium-238 (20,000 $Bqkg^{-1}$) (*Reference 10*), this is unsuitable for the analysis of typical environmental levels of tens of $Bqkg^{-1}$ of uranium in soils. The technique is however useful for ensuring heavily contaminated samples are not sent to low level counting facilities.

32. X-ray fluorescence (XRF) is a useful technique for measuring *total* uranium content down to typical environmental levels of the order of 1 part per million (ppm). However it is not capable of measuring individual isotope concentrations and therefore it is not possible to state whether the material detected is natural uranium or DU. Whilst it is essentially a near-surface analytical technique, appropriate sample preparation will yield results that are statistically significant with respect to the bulk sample. The technique is relatively cheap and will also give information on other metals (such as lead) that will be relevant to the wider environmental monitoring surveillance programme. A further consideration is that a sample prepared for XRF can be submitted for more sensitive forms of analysis at a later date.

33. Information about the isotopic concentration of uranium in soil samples can be obtained using mass spectroscopy techniques such as inductively coupled plasma mass spectrometry (ICPMS). This is a very sensitive technique, capable of yielding information at the parts per billion (ppb) level and more than adequate for determining environmental levels of uranium. Analysis costs depend on the sophistication of the technique selected. This will depend on any perceived need to separate DU from the much larger quantities of natural uranium present in soil samples other than those from the immediate vicinity of a DU strike or under a corroded penetrator.

34. The mobility of uranium in soil is influenced by soil type and chemistry and it is necessary to obtain such information to understand fully the environmental impact of uranium. This involves determination of acidity, electrochemical reactivity, colour and size fractions on representative soil samples from different sites.

Detection and Measurement of Uranium in Water and Foodstuffs

35. Field monitoring for environmental levels of uranium in water is not practical and samples must be taken from water courses and from potable water. Samples need to be taken under controlled conditions for laboratory analysis. Uranium concentrations are

likely to be low so sensitive analysis techniques need to be used if useful information is to be obtained. Many mass spectrometry techniques offer the advantages of minimal sample preparation and simultaneous detection of other metals relevant to the wider surveillance programme, all to p.p.m./p.p.b. levels. This is more than adequate with respect to relevant NRPB GDL's for uranium (e.g. 30 Bq l^{-1} for U in drinking water) (*Reference 10*).

36. As already discussed, the reconnaissance visit indicated that locally baked bread is the foodstuff of most significance for UK troops in Kosovo. Once again uranium concentrations are likely to be very low and sensitive analytical techniques will be required for meaningful results.

Airborne Dust Sampling

37. Previous work (*References 6, 11*) indicates that airborne uranium concentrations from the use of DU munitions will only be a concern in a very localised area during or in the hours following a DU penetrator strike on a hard surface. However, there is merit in collecting some air samples to demonstrate that this is the case. The most comprehensive air sampling programme requires the use of high volume equipment with the capability of sampling hundreds of cubic metres per hour, but such equipment is heavy and requires a mains power supply. Even more complex analysis involving separation of airborne dust into respirable and non-respirable fractions is possible and very useful when estimating inhalation intakes, but this is complex and demands high levels of operator skills under potentially difficult conditions. The value of such detailed monitoring in the UK sector in Kosovo is also questionable given the small number and geographical location of areas where DU munitions were used. A further consideration is that more detailed investigations can be carried out if total airborne dust samples indicate significant quantities of uranium in air. The conclusion is that a cost-effective and practicable monitoring strategy involves the use of portable air samplers with a capacity of the order of 60 litres per minute. Dust collected on this equipment will require laboratory analysis using very sensitive types of analytical equipment.

Uranium in Dust

38. The measurement of uranium levels in dusts provides a useful indication of likely effects from inhalation of resuspended material and complements the air sampling mentioned above. The analysis of dusts involves identical considerations to the analysis of soils and sample collection is unsophisticated and simple involving use of a dustpan and brush to collect samples from roads, vehicle wash areas, offices and recreational areas. Indeed such a technique may be all that can be applied in urban areas if a shortage of undeveloped land restricts the opportunities for soil sampling.

Detection and Measurement of Caesium in Soils

39. Caesium-137 is easily identified and quantified by its distinctive high energy gamma emission at 660keV. Measurements may be carried out in the field or by the collection of samples for subsequent laboratory analysis. Typical limits of detection for gamma spectroscopy techniques are better than 1 $Bqkg^{-1}$ which is far below the GDL of 1000$Bqkg^{-1}$. Samples analysed by gamma spectrometry can be retained for analysis by other techniques and also provide information on the presence or absence of many of the naturally occurring and man made radionuclides used in industrialised societies.

Caesium in Water

40. Environmental levels of caesium-137 in water can only be established by laboratory assessment of samples. Gamma spectrometry allows the determination of caesium-137 concentrations of about 5Bql^{-1} which is below the GDL of 100Bql^{-1}

Caesium in Foods

41. Reference 4 identifies that caesium in foods can be a pathway of potential significance. The reconnaissance visit identified locally produced bread as being the only foodstuff of potential concern with respect to foodstuff consumption by UK troops. The collection and analysis by gamma spectrometry of locally produced bread allows an assessment to be made of the significance or lack of significance of this pathway.

Caesium in Air

42. NRPB (*Reference 4*) concluded that caesium-137 in air, originating from material resuspended from the ground, is not a significant pathway to man. However, if airborne dust samples are being collected for uranium analysis, it is possible to analyse these samples for the presence of any gamma emitting radionuclides.

PROPOSED METHODOLOGY FOR SURVEY

Sites to be Surveyed

43. The survey protocol is based on the strategy outlined by the Construction Industry Research and Information Association (CIRIA) (*Reference 12*), British Standard (*Reference 13*) and soil sampling protocols used by the British Geological Survey in their survey of uranium levels in the UK (*Reference 14*). In applying the guidance in these documents, account has been taken of the earlier conclusion that the primary objective is to undertake a screening assessment that allows generic risk assessments to be applied rather than very detailed survey that examines every “square foot” of land in areas of potential concern.

44. Areas of potential concern are considered to be those where monitoring is required to implement MOD's undertaking to carry out enhanced environmental surveillance. These fall into two groups: locations where BRITFOR troops reside or spend significant periods of time and locations where DU munitions are known to have been used as these areas provide a source of "worst-case" data. It may thus provide valuable information on the environmental effects of DU munitions and information that will be useful to the civil authorities.

45. The main BRITFOR sites have been categorised as Category A – work and residential locations of significant size/population (typically TFA units) and Category B - outstation locations that are often centred around buildings that existed prior to the conflict such as civil police stations. The required enhanced environmental survey programme focusses on Category A sites as these are the most significant in terms of potential exposure through the greatest occupancy times and numbers of potentially exposed persons for which MOD has a direct responsibility. With one exception, there is no significant UK occupancy of areas where DU munitions are known to have been used. The one exception is Waterloo Lines, where a TFA has been built near a location where DU munitions were used.

Survey Protocol for BRITFOR Category A Sites

46. The survey will consist of direct measurements with gamma monitoring equipment and the collection of air, dust, water and soil samples for subsequent analysis in the UK. Protocols for both types of measurement are described below.

Direct Measurements on Site

47. These measurements will consist of a walk-over radiation survey to establish background radiation levels and the spatial variability of activity. This will ensure that locations chosen for non-targeted soil sampling or dose rate monitoring are representative of typical conditions on site. It will also identify locations where there is evidence of enhanced activity and allow targeted soil sampling in these areas. Walk-over surveys can be carried out with any instrument that responds to gamma radiation at typical environmental levels. The instrument need not be calibrated in absolute terms for dose rate or $Bqkg^{-1}$ or Bqm^{-2} as the objective is only to quickly characterise the site and establish locations for non-targeted and targeted sampling. Measurements will also be made of environmental gamma dose rate using a calibrated dose rate meter as this will be an important exposure pathway in areas where elevated levels of gamma emitters such as caesium-137 are found. It is to be noted that gamma exposure is not an issue with uranium/depleted uranium in the Kosovo environment.

48. Sodium iodide (NaI) scintillation detectors are generally regarded as most suitable for this type of gamma monitoring. They are portable, sensitive, reasonably robust and require no external services other than an electrical supply usually provided by batteries. Scintillation detectors can be small enough to carry by hand or larger detectors can be mounted on hand propelled trolleys, on vehicles such as golf-buggies or Landrovers or mounted on aircraft.

49. Airborne surveys allow rapid determination of concentrations of gamma emitters such as caesium-137 at or near the surface of the soil, but will be of very limited use in DU monitoring on account of the low levels of gamma radiation emitted. The Scottish Universities Research & Reactor Centre (SURRC) has airborne monitoring equipment (Reference 15) and quote impressive limits of detection for caesium-137 in soil of the order of $kBqm^{-2}$ when averaged over areas of $10,000m^2$. However, a major consideration is the field of view of these airborne systems. The detectors typically "see" gamma radiation from a circular area with a radius approximately 5 times the height of the detector above the ground. For safety reasons flying is normally carried out above 100m and the field of view at this level is about $8x10^5m^2$. To detect a $1m^2$ area containing caesium-137, the activity concentration of caesium in that area would need to be about 10^4 times greater than the average activity concentration of $500Bqkg^{-1}$ of caesium-137 found during the reconnaissance visit. In fact the altitude of the airborne equipment would need to be reduced to something approaching 1m to detect localised areas of caesium contamination similar to those found during the reconnaissance. This is clearly impractical and a further consideration is that there are no airborne monitoring equipments with a demonstrated capability to detect DU. Furthermore, any gamma emitters present in the environment would be detected during the ground-based surveys needed to detect DU. The conclusion is that airborne surveys may offer a very cost-effective means of rapidly surveying very large areas of land of thousands of hectares for caesium contamination in the immediate aftermath of a reactor accident, but have limited use in the conditions that exist in Kosovo.

50. Sophisticated scintillation detectors linked to GPS systems are commercially available for surveying areas of potentially contaminated land and can be vehicle mounted. However, costs associated with the use of such equipment are generally high and specialist personnel must operate the equipment. It is also better suited to sites with fairly smooth rather than rough surfaces of the type found in locations where DU munitions were used in Kosovo. Use of less sophisticated equipment would allow the monitoring task to be carried out by troops.

51. Consultations with NRPB (*Reference 16*) support the view that a walk-over survey of areas of 1-2 hectares represents a cost-effective approach. NRPB recommend use of the Exploranium GR130 for this type of survey work. Although not the most sensitive scintillation detector, the instrument is robust and sufficiently sensitive to pick up areas of radiological significance when held about 1m from the ground. The bar chart display in "survey" mode had been found particularly effective when covering large areas of ground on foot. NRPB also consider that the GR130 can function as a calibrated dose rate meter for dose rate measurements of the type required in Kosovo. The recommendation is therefore that the Exploranium GR130 (or an instrument of equivalent sensitivity and functionality) is the instrument of choice for walk-over surveys. It is also recommended that environmental dose rate readings averaged over 300 seconds should be taken at locations adjacent to all soil sampling locations. Walk over survey results will be recorded on pre-prepared forms and will include information on the transects covered, the co-ordinates of the start and end points, the range of readings and details of anomalous readings. It would be preferable to capture co-ordinate information via GPS.

52. The transects will need to be determined on a site-by-site basis, taking into account local conditions such as ground disturbance, ground cover, civil engineering features. Decisions on areas to be covered by walk-over surveys will be made on site by a suitably trained individual in charge of the Monitoring Team, after consultation with site personnel during the initial site familiarisation phase of the survey. As a minimum, the walk-over survey will be carried out along the boundary of the site, and over principal areas of ground to which persons have free access.

Environmental Sampling On Site

53. A study of the BGS approach to sampling for uranium in the environment indicates a need to characterise each location for uranium or other radionuclide content, land use and soil conditions by sampling within the site and in the immediate surrounding area. Sampling should be risk based and aimed at characterising the exposure to likely receptors in the environment by the collection and analysis of soil, water, air and dust samples.

Soil

54. This is most important for DU and caesium-137. Existing BGS protocols cover both regional and urban surveys. Regional surveys aim to sample from alternate 1km grid squares and urban surveys from each 500 x 500m sub-cell which means from 4 locations per 1km grid square. Although a typical BRITFOR base would fit into a single 500 x 500m sub-cell, one soil sample per site is clearly insufficient for an adequate characterisation. A minimum of 10 samples is required to generate statistically significant results, but the collection of 20 samples would provide more robust results.

55. Soil samples to establish inherent average levels of uranium should preferably be taken from undisturbed areas of ground. Materials such as hardcore, tarmacadam and concrete will not be of significance because of their “massive” nature and resistance to erosion and so do not need to be sampled for DU. Similarly, soil lying underneath these areas need not be sampled, since any contamination will not contribute to pathways such as inhalation or ingestion in foodstuffs. Furthermore, any contamination migrating out from under these areas will be detected in water samples taken on site, and any gamma ray exposure will be determined by the walk-over survey.

56. A minimum of 20 sampling locations per residential site (possibly fewer in the case of smaller locations) will need to be chosen in consultation with a person familiar with the site layout so that monitoring can be focused on areas of greatest concern such as occupied areas. The locations should be chosen to cover as wide an area as possible, and include a range of samples from just outside the site. Areas of recreational activity should be sampled where these are readily identifiable (eg jogging circuits, football pitches).

57. Soil and root mat samples should be taken using a 50mm diameter hand operated Dutch auger as sample extraction is not too physically demanding and sufficient material is produced to permit a range of analyses. Samples should be obtained from surface vegetation, nominally the top 25mm, from 25mm – 150mm and from 150mm - 300mm as this is compatible with the depth of the Dutch auger. It is possible to auger down to 1m or so in soils, but the bio-availability of uranium and caesium-137 from depths greater than 150mm is not normally significant (*References 4, 10*)

58. Each sample should be a composite of material from the required depth of auger flights from 5 holes located at the corners and centre of a square. Whenever possible, the hole spacing should be 10m, subject to site-specific restrictions due to buildings, trees, shrubs, paved areas and disturbed ground. The grid reference of the centre of the square should be recorded and a sketch map produced showing the environment around each sampling location. A basic description of each location and a description of the visual appearance of each soil core will be recorded. Samples should be collected in polythene bags that should then be sealed and labelled with a unique sample reference number. The reference numbers of samples should be shown on the sketch maps and photographic evidence collected for each sample location.

59. Locations where any “hotspots” (anomalous readings more than twice background) are found during the walk-over survey should be sampled in addition to the 20 samples to characterise the site. This sampling would be at the discretion of the

monitoring staff, subject to a maximum of 20 additional samples from any one site. For example, very small areas of enhanced activity such as the 300mm diameter caesium “hot spots” would only require single auger samples down to 300mm with reference samples being taken from the surrounding area.

60. Past experience indicates a team of 2-3 persons can collect 20-30 samples a day using these protocols.

61. Soil samples will be screened by gamma spectroscopy before dispatch to low level counting or analysis facilities in which analyses such as XRF analysis for total uranium and other heavy metals will be carried out. There is the option of ICPMS analysis of isotopic uranium and other elements once the significance of the XRF results has been assessed. Analysis for other heavy metals such as lead, cadmium, nickel, chromium, arsenic can also be obtained during the same laboratory analysis at very little extra cost.

Dusts

62. Dust samples should be taken from roads, vehicle wash areas and buildings for subsequent analysis for uranium. Sampling should be carried out using a dustpan and brush with at least 20g of material being collected at each location. Six samples will be collected from roads and one sample per vehicle wash facility or major office block. Samples will be analysed using the same methods as for soil.

Airborne Dust

63. The NRPB GDL for uranium-238 in air is 5×10^{-2} Bq m^{-3}. Assuming the use of an L60 mains powered sampling pump with a flow rate of 60 l min^{-1}, and a minimum sampling time of 6 hr, then the volume of air sampled is 21.6 m^3. At the GDL, the activity on the filter is $21.6 \times 5 \times 10^{-2}$ Bq or 1.08 Bq. The limit of detection for uranium by alpha spectroscopy is 0.5 mBq. Hence sampling and analysis will give a limit of detection about 2000 times better than the NRPB GDL. This is sufficient for the purposes of this survey. Whilst DU in air is not reported to be significant after the initial strike period, and is not an issue with respect to potential radiological pathways to man (*Reference 6*), it would be useful to take an air sample whilst on site for reassurance purposes. It is proposed to collect 1 sample per site, with the sampler running for a minimum of 6 hours, longer if compatible with other sampling activities on site.

64. The sampler should be set up downwind and away from turbulence created by buildings, so as to make the sample representative of the whole site. However, the range of the 240v supply may limit the sampling location.

Water

65. Water samples will be taken from surface watercourses. Each sample will have a minimum volume of 30ml and be collected using a disposable syringe and put into a "Nalgene" sample bottle on site. Potable water supplies to UK bases are already sampled by the Army Environmental Health Team in Kosovo and sent to the UK for analysis. Recent samples will still be available and can be analysed for uranium and caesium using ICPMS.

BRITFOR Waterloo Lines

66. As already noted, Waterloo Lines has been built near an area where DU munitions are known to have been used. The original topsoil was removed during construction of the base and dumped on agricultural land adjacent to the site but outside the security fence. A Category A protocol should be followed for Waterloo Lines, with the additional requirement that a further walk-over survey and soil and water sampling should be carried out in the area where the topsoil was dumped. A minimum of 10 composite samples of soil should be taken from this spoil heap and immediately surrounding area.

Survey Protocol for BRITFOR Category B sites

67. These sites tend to be much smaller than the main barrack locations. The protocols proposed in the previous section will need to be modified to suit the particular circumstances as such sites are generally in built up areas with few open spaces of undeveloped ground or water courses.

Direct Measurements On Site

68. These will consist of a walkover survey and dose rate measurements as described in the Category A protocol.

Soil

69. Ideally, a minimum of 4 locations should be sampled by auger using the procedure outlined above. A spacing of 10m is preferred, but this may need to be reduced according to the site dimensions. It is possible that there might be insufficient areas of undisturbed, uncovered soil in certain locations and that sampling will be difficult, impossible or of dubious value. The sketch map and its accompanying annotations and photographic evidence will be particularly important in such circumstances.

Dusts

70. Samples of dust from roads and buildings will be collected, subject to site conditions. At least one sample will be taken from each site.

Airborne Dusts

71. In view of the difficulty in taking meaningful airborne dust samples in urban areas where there is little or no knowledge of local meteorological conditions, air samples will not be collected. Dust samples from paved surfaces will indicate whether an air monitoring programme is required.

Water

72. Water courses running through or in the vicinity of the site will be sampled as for Category A.

Survey Protocol for Areas Where DU Munitions Are Known To Have Been Used

73. The objective of this work is to obtain information that can be used to make a "worst-case" assessment of the possible risks to personnel. However, the task is complicated by factors such as access, difficult or even unsafe ground conditions, uncertainty in the attack co-ordinates and the possible presence of other health and safety hazards such as unexploded ordnance and asbestos. Whilst the site at Old VJ barracks would seem to be ideal in view of the discovery of DU penetrators at this location, it is heavily contaminated with asbestos. It is therefore not appropriate to use this site at this stage as an option for further survey work. The area near Waterloo Lines offers possibilities because it is a high priority on account of its proximity to a UK base. However no evidence of the presence of DU was detected near Waterloo Lines during the reconnaissance and the area where the base is located will be subject to a detailed survey under the arrangements described above. Two further sites are both very difficult to access, show evidence of unexploded ordnance and are fairly remote from any centre of population. It is therefore considered that these latter sites are not a high priority.

74. This leaves three locations worth considering for further environmental survey work, namely the site near Glogovac, the farm near Krajkovo and the road near North Glavnick. The first of these sites is very hilly and not easy to access. Soil cover is also very poor and there are no visual indications as to where the attack might have taken place. The farm near Krajkovo is moderately difficult to access and shows no visual indications of the location where the attack took place. However, there is good soil cover and therefore sampling should be fairly straightforward. The final location is near Glavnick. This is easy to access, fairly flat with good soil cover and shows evidence of possible military activity. There were also signs of enhanced levels of caesium-137 in this area and it is considered suitable for further environmental studies. People live and farm

in the vicinity of the site. It is therefore proposed that road near Glavnick, and if possible, the farm near Krajkovo be selected for environmental sampling surveys as described below.

Protocol for Survey at Glavnick and Krajkovo

75. A walk-over survey should be carried out along transects defined by roads in the vicinity and dose rate measurements should be made at soil sample locations.

Soil Sampling On Site

76. Special samples should be collected from the area where elevated levels of radiation were detected and at 0.5m intervals up to a distance of 1m. Thereafter samples should be collected at 1m intervals up to a distance of 3m. All samples will be from a single auger hole and taken to a depth of 300mm on account of the generally greater mobility of caesium. When the source of the contamination is unknown, or the presence of DU is suspected , the sampling depths should be as described in paragraph 57. Over the rest of the area samples will be collected as per the "urban survey" with one composite sample being collected from the centre of each 500m x 500m grid square centred on the area of elevated caesium activity. A total of 16 samples covering an area of 2 x 2km will be collected.

Dust

77. Four samples will be collected along the road near Glavnick at approximately 500m intervals on either side of the area showing visible signs of military activity. A composite sample consisting of dust removed from either side of the road will be taken.

Airborne Dust

78. In view of the lack of access to mains power supply and the likely heavy (ie non-respirable) dust loading near the road due to vehicle movement, it is not proposed to carry out airborne sampling at this stage at this location. Dust samples taken alongside the road will indicate whether an air monitoring programme is required

Water

79. Watercourses running through or in the vicinity of the site will be sampled as per the Category A protocol.

RESOURCES REQUIRED

80. Estimates of the manpower required are in Appendix 5. This is based on the use of 2 teams to provide operational flexibility and some redundancy if equipment problems are encountered. It is estimated that two teams will need about 14 days to complete the

monitoring and sampling work. Equipment requirement for these teams is identified in Appendix 6.

CONCLUSIONS

81. The initial assessment indicated that there would be no significant risks to UK personnel from DU munitions residues in Kosovo. Subsequent work by NATO partners and the United Nations support this conclusion, but further work is required to address veteran’s concerns. The survey proposals represent a pragmatic and cost-effective approach for obtaining additional information on environmental conditions. The need for any further work can be assessed when the results of this work and future monitoring by other organisations have been assessed.

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RESULTS OF LABORATORY ANALYSIS

UKAS TESTING
1305

DERA Radiation Protection Services
Institute of Naval Medicine
Crescent Road, Alverstoke
Gosport, Hants. PO12 2DL
Tel. (023)92768164 Fax (023)92768150

Certificate of Testing

of a radiological sample issued by
DERA Radiation Protection Services

7 ADMINISTRATION

Customer Name:	D Smith	Customer Address:	DRPS
Date of Issue:			
Date of Receipt:	2/1/1	Date of Testing:	2/1/1

8 ANALYSIS AND REPORTING

Analysis Type and Technical Comments: The sample has been analysed by Gamma Spectrometry.

Date Reported:	5/2/1	Reporter:	M Simpson	Signature:
Date Countersigned:		Countersigner:		Signature:

The reported uncertainty is calculated from both the counting and preparation. The confidence level is 95% (k factor or 1.96). The certificate is issued in accordance with the requirements of the United Kingdom Accreditation Service as specified in the UKAS Accredited Standard and UKAS regulations. It provides traceability of measurement to recognised national standards and to the units realised by the National Physical Laboratory or other recognised National Standards Laboratory. This certificate may not be reproduced other than in full, except with the prior approval of the issuing laboratory.

DERA Radiation Protection Services
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Crescent Road, Alverstoke
Gosport, Hants. PO12 2DL
Tel. (023)92768164 Fax (023)92768150

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Sample Analysis Reference No.	Customer's Reference	^{40}K	^{134}Cs	^{137}Cs	^{234}Th	^{234}U	^{235}U	^{238}U	^{234}Pa	^{234M}Pa	
		Reporting Units $Bqkg^{-1}$									
1B061001	1A	737±64	≯0.4	≯1	602±148	≯1121	≯8	≯1742	≯3	1474±388	VJ Barracks debris from wall
1B061002	1B	556±51	≯0.4	≯1	228±61	≯837	≯5	≯1267	≯3	481±201	VJ Barracks ditto
1B061003	2	480±72	≯2	≯2	36686±8691	≯6351	681±90	52477±26290	102±50	90230±16150	VJ Barracks concrete debris
1B061004	3A	343±32	1.1±0.6	72±5	1816±433	≯1100	38±9	≯2075	28±14	4456±848	VJ Barracks debris on top of soil nr penetrator
1B061005	3B	411±37	≯1	119±9	10271±2434	≯2239	174±24	≯4387	44±22	21066±3778	VJ Barracks soil from around penetrator
1B061006	4A	306±29	6±1	1241±83	≯16	≯1477	≯9	≯1567	≯2	382±220	VJ Barracks soil from contam. area –top 100mm
1B061007	4B	350±34	3±1	533±36	≯14	≯719	≯7	≯1370	≯2	≯69	VJ Barracks soil from contam. area –next 100mm
1B061008	5A	275±31	2±1	328±23	≯13	≯763	≯7	≯1268	≯4	≯62	VJ Barracks reference sample –top 50mm
1B061009	5B	436±39	≯0.3	82±6	≯11	≯549	≯5	≯999	≯3	≯68	VJ Barracks reference sample - 50mm -150mm
1B061010	W1	328±30	≯0.4	106±8	≯14	≯1005	≯6	≯1279	≯2	≯72	Waterloo Lines under side concrete slab
1B061011	W2	329±31	0.9±0.5	68±5	40±24	≯852	≯5	≯1189	≯2	≯67	Waterloo Lines outside fence – removed soil
1B061012	W3	267±28	≯0.3	121±9	≯12	≯750	≯5	≯1183	≯1	≯59	Waterloo Lines outside fence – removed vegetation
1B061013	G1	615±55	≯0.4	≯1	≯14	≯844	≯6	≯1231	≯4	≯94	North Glavnick - tarmac
1B061014	G2	274±28	2±1	446±30	≯12	≯736	≯6	≯1127	≯2	≯53	North Glavnick – ploughed field
1C061015	G3	290±29	5±1	927±61	≯29	≯1987	≯4	≯6532	≯2	≯48	North Glavnick – burnt area –top 100mm
1C061016	G4	317±28	5±1	1081±71	≯26	≯2021	≯4	≯6152	≯2	≯42	North Glavnick – burnt area – 100mm -150mm
Sample Analysis Reference No.	Customer's Reference	^{40}K	^{134}Cs	^{137}Cs	^{234}Th	^{234}U	^{235}U	^{238}U	^{234}Pa	^{234M}Pa	

Analysed by: Date:

Countersigned by: Date:

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Institute of Naval Medicine
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Gosport, Hants. PO12 2DL
Tel. (023)92768164 Fax (023)92768150

UKAS TESTING 1305

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Sample Analysis Reference No.	Customer's Reference	^{40}K	^{134}Cs	^{137}Cs	^{234}Th	^{234}U	^{235}U	^{238}U	^{234}Pa	^{234M}Pa	
		Reporting Units Bqkg-1									
1C061017	G5	325±33	≯03	155±11	≯20	≯1362	≯3	≯3910	≯1	≯45	North Glavnick – background sample
1C061018	H1	504±43	≯0.3	2±1	≯19	≯1246	≯2	≯3577	≯1	225±140	Hill Top – soil & shale
1C061019	T1	706±56	≯0.3	27±2	≯16	≯1077	≯2	≯3490	≯1	≯46	Site near Glogovac – near dug-out shelter
1C061020	T2	605±49	≯0.3	39±3	≯22	≯1449	≯3	≯4435	≯1	≯59	Site near Glogocav - background
1C061021	K1	161±20	≯0.3	19±2	≯20	≯1234	≯3	≯4054	≯1	≯55	Reputed position of artillery
1C061022	K2	181±22	≯0.3	21±2	≯20	≯1338	≯3	≯4196	≯1	270±154	Soil adjacent to Serb gun wreckage
1C061023	ST1	222±24	≯0.3	23±2	≯17	≯1059	≯2	≯3618	≯1	≯44	Stimlje forest – dug-in position
1C061024	Fly Ash	95±20	≯0.3	≯0.3	≯19	≯1061	≯2	≯3526	≯1	≯50	Fly ash
1C061025	Unknown	252±26	≯0.2	11±1	≯15	≯1032	≯2	≯3017	≯1	≯41	Slim Lines soil sample
Sample Analysis Reference No.	Customer's Reference	^{40}K	^{134}Cs	^{137}Cs	^{234}Th	^{234}U	^{235}U	^{238}U	^{234}Pa	^{234M}Pa	

Analysed by:	Date:
Countersigned by:	Date:

APPENDIX 2

SURVEY PROTOCOL FOR CATEGORY A SITES

CATEGORY	ITEM	DESCRIPTION	OCCURRENCE	OUTPUT
Direct Measurement	Walk-over Survey	Survey of undisturbed areas of land inside and just beyond site boundary using GR130 or equivalent scintillation detector	Once per site	Qualitative information characterising non-targeted sampling sites Identification of sites for targeted sampling
	Dose rate monitoring	Environmental dose rate measurement using GR130 or Mini Instruments 6-80 over a 300 second integration time	Once at every soil sampling site location	Dose rate measurement to allow calculation of gamma doses from radionuclides in the ground
Environmental Sampling	Soil	Samples taken from identified locations by auger with 5 auger flights per composite sample Samples from surface vegetation at 0 - 25mm and soil from 25mm –150mm and 150mm -300mm	20 samples per site Additional samples from areas identified as anomalous during walk-over survey	Soil samples for laboratory analysis for radionuclides and heavy metals Gamma spectroscopy for common radionuclides XRF analysis for total uranium and heavy metals ICPMS for uranium isotope ratios when indicated by XRF
	Dusts	Samples of road dust and dust from office and accommodation blocks	6 samples per base from roads 1 sample from major office and accommodation blocks	Analysis as for soil samples
	Airborne dust	Sample of airborne dust taken at 60 litres per minute, subject to availability of power supply	1 downwind sample away from sources of dust such as roads	Analysis for uranium by alpha spectrometry and for caesium by gamma spectrometry
	Water	30ml samples taken from water courses and filtered on site	1 per water course entering and leaving the site	ICPMS analysis for uranium and heavy metals

NB Protocol for Waterloo Lines will be identical to the above, except for *additional* direct measurements and soil and water sampling around land where topsoil was deposited during construction of the site.

SURVEY PROTOCOL FOR CATEGORY B SITES

CATEGORY	ITEM	DESCRIPTION	OCCURRENCE	OUTPUT
Direct Measurement	Walk-over Survey	Survey of undisturbed areas of land inside and just beyond site boundary using GR130 or equivalent scintillation detector	Once per site	Qualitative information characterising non-targeted sampling sites Identification of sites for targeted sampling
	Dose rate monitoring	Environmental dose rate measurement using GR130 or Mini Instruments 6-80 over a 300 second integration time	Once at every soil sampling site location	Dose rate measurement to allow calculation of gamma doses from radionuclides in the ground
	Soil	Samples taken from identified locations by auger with 5 auger flights per composite sample Samples from surface vegetation at 0 - 25mm and soil from 25mm –150mm and 150mm -300mm	Not less than 4 samples per site, up to a maximum of 10 samples for larger sites Additional samples from areas identified as anomalous during walk-over survey	Soil samples for laboratory analysis for radionuclides and heavy metals. Gamma spectroscopy for common radionuclides XRF analysis for total uranium and heavy metals ICPMS for uranium isotope ratios when indicated by XRF
	Dusts	Samples of road dust and dust from office and accommodation blocks	Not less than 1 sample of road dust per site 1 sample from major office and accommodation blocks	Analysis as for soil samples
	Airborne dust	N/A	N/A	N/A
	Water	30ml samples taken from water courses and filtered on site	1 per water course entering and leaving the site	ICPMS analysis for uranium and heavy metals

SURVEY PROTOCOL FOR KNOWN AREAS OF DU USE – ROUTE SNAKE

CATEGORY	ITEM	DESCRIPTION	OCCURRENCE	OUTPUT
Direct Measurement	Walk-over Survey	Survey of undisturbed areas of land alongside the road using GR130 or equivalent scintillation detector	Once per site	Qualitative information characterising non-targeted sampling sites. Identification of potential sites for targeted sampling
	Dose rate monitoring	Environmental dose rate measurement using GR130 or Mini Instruments 6-80 over a 300 second integration time	Once at every soil sampling site location	Dose rate measurement to allow calculation of gamma doses from radionuclides in the ground
Environmental Sampling	Soil	Single auger flight samples collected on a 1m grid to 3m in areas where elevated levels of caesium were located Elsewhere – one composite sample from 5 auger flights at the centre of each 500m x 500m grid square over 2km x 2 km Additional samples from areas identified as anomalous during walk-over survey Samples from surface vegetation at 0 - 25mm and soil from 25mm –150mm and 150mm -300mm	13 samples in total 16 composite samples in total	Soil samples for laboratory analysis for radionuclides and heavy metals. Gamma spectroscopy for common radionuclides XRF analysis for total uranium and heavy metals ICPMS for uranium isotope ratios when indicated by XRF
	Dusts	Samples of road dust at 500m intervals to 1km on either side of the attack coordinate. Composite sample from samples taken on either side of road	4 composite samples	Analysis as for soil samples
	Airborne dust	N/A	N/A	N/A
	Water	Samples taken from water courses within the soil sampling area	1 per water course	ICPMS analysis for uranium and heavy metals

APPENDIX 5

ESTIMATE OF MANPOWER RESOURCES FOR KOSOVO SURVEY

Sampling team of 3 persons:

2 for the soil, water and dust sampling with recording of associated data and sample identification etc.
1 person for the walk-over survey and dose rate monitoring.
Past experience suggests 20-30 composite samples can be collected per 8 hr day.

Timing:

Average travel time to Category A sites will be 45 minutes each way.
Average travel time to Category B sites will be 60 –90 minutes each way.
1 hour familiarisiation and site briefing.
1 hour lunch break.
8 hours working day on site.
1 hour administration and sample packing on return to base.

Category A sites:

20 composite soil sample locations plus targeted sampling on anomalies.
Airborne dust sampler runs unattended once set up.
Collection of dust and water samples to be carried out during the walk-over survey.
Estimate 1 day per team per Category A site. This is probably optimistic.
13 sites

Sub-total: 13 team days

Category B sites:

At least 4 composite soil sample locations plus targeted sampling on anomalies.
Collection of dust and water samples to be carried out during the walk-over survey.
Estimate 1 day per team per Category B site. This is probably pessimistic.
17 sites but with some locations close together or co-located and can be covered in 1 team day.
Effectively 12 sites.

Sub-total: 12 team days

Site near Glavnick:

Require at least 29 samples, but with 13 samples very close together.
Collection of dust and water samples to be carried out during the walk-over survey.
Estimate 1 team day

Sub-total: 1 team day

Total requirement:

26 team days

Notes:

Assuming 2 teams, this equates to 13 days for the survey.

The time for the Category A surveys is probably optimistic, but the time for the Category B surveys is likely to be pessimistic.

There is no allowance for contingencies or for travel to and from Kosovo or for transfers to and from the airhead.

Increasing the number of team members from 3 to 4 would facilitate the collection of samples and allow for contingencies or further investigations in other areas (such as the farm near Krajkovo) where DU munitions are known to have been used.

There would be benefits in having at least one professional Health Physics monitor in each team to assist with the technical aspects of the work and decide on the appropriate course of action should unforeseen circumstances arise.

APPENDIX 6

ESTIMATE OF EQUIPMENT RESOURCES FOR KOSOVO SURVEY

Requirements for 2 sampling teams with identical equipment for each team:

Equipment	Number of items	Notes
Radiation survey		
Exploranium GR130 Minispec	2	To be procured
Electra ratemeter and G2 probe with extension handle	2	DRPS to provide
Environmental sampling		
Dutch auger with handle and extension tube	4 – 2 per team to allow for contingency	To be procured
Sample bags, bottles, syringes etc		DRPS to provide
High volume air samplers + filters	3 – one per team and one spare	DRPS to provide

(In addition, GPS, tape measures, notebooks & pens, cameras, sample boxes, labels etc will be required)