Environmental Monitoring Guidance

Selection of Sampling Locations

The selection of the sampling locations involves the determination of the most likely locations for contaminants to accumulate in the environment so that a representative sampling plan can be established to ensure the public health and safety and protection of the environment. Characterization of the physical environment will help identify contaminant transport pathways, which will assure that samples are collected in the most appropriate locations. Biased sampling techniques should be used to ensure that the chosen sample locations will provide information which is reflective of the site conditions and the potential impact of the depleted uranium (DU) on public health and safety and the environment. Radiological assessments within the ranges are understood to be a difficult and potentially deadly task due to unexploded ordnance that may be within the perimeter of the ranges.

Reporting of sample locations

All sampling locations should be identified on a map. In addition, a table should be provided which contains the geographic positioning system coordinates for each sampling location.

Action Levels

Action levels should be established for each radionuclide and media. Action levels should not be based on a dose level, but should be indicative of the presence of DU in the environment and thus, should be no more than 2-3 times the background level for the DU in the respective media, in an unaffected area. If contamination is found at any of the sampling locations that exceed the action levels established for the media in which it was found, further investigation must be done to delineate the extent of contamination and to identify the cause. If the initial sample or the delineation of the contamination identifies locations that exceed the residual radioactivity levels for an unrestricted area (i.e., outside of the controlled area of the range) a radiological dose assessment will be performed and, if necessary, a corrective action plan will be submitted to the U.S. Nuclear Regulatory Commission (NRC) for review.

Guidance on Groundwater Sampling and Analysis

The Army ranges containing DU present some unique aspects regarding the location of groundwater monitoring wells. In most cases the DU has been on the ranges for over 40 years. Typical environmental monitoring programs would include both onsite and offsite monitoring wells. The purpose of the onsite program would be to determine if DU is present. The absence of DU does not preclude the fact that DU may have migrated off range and is now in an offsite area. The uniqueness associated with the Army situation is that the personnel on-post are considered as members of the public so monitoring should occur onpost. However, assurance must also be obtained that the DU has not migrated offpost. Therefore, monitoring should also occur at offpost locations which could be pontentially impacted by the migration of DU.

Successful implementation of a groundwater monitoring plan requires a well thought-out approach and a good understanding of site specific characteristics that could affect the quality, validity or representativeness of groundwater samples. This understanding should be based on an analysis of the subsurface environment and groundwater chemistry and hydrogeologic data from field exploration, literature reviews and experience with similar hydrogeologic settings.

Soil, unconsolidated material, and rock samples should be collected and analyzed by a laboratory to determine if subsurface conditions are capable of oxidizing any depleted uranium that was initially buried or may have become buried due to ongoing range activities. Oxidation of the depleted uranium rounds is of critical importance for understanding its transport through the subsurface and eventually to the groundwater. As the depleted uranium rounds undergo weathering, small particles are likely to adsorb to clay minerals and organics. The adsorbed particles will undergo further oxidation and form uranium oxides that can readily dissolve and possibly seep into the groundwater. The rate of oxidation and ultimately the possibility for transport into the groundwater is dependent on particle size, pH, area precipitation, humidity, soil moisture content, soil chemistry and the oxygen content of the soil. The understanding of these conditions and their potential impact will help determine the extent of groundwater monitoring needed at each site.

An understanding of the hydrostratigraphic units, both locally and regionally, should be obtained prior to permanent monitoring well installation. Aquifer parameters such as hydraulic conductivity, vertical and horizontal hydraulic gradient, transmissivity, porosity and direction of groundwater flow are a few of the parameters that should be well understood to ensure proper placement of the monitoring wells. Temporary monitoring wells should be installed to establish the parameters listed above unless permanent wells are locally available. Performing pumping tests and water level elevation measurements are essential for the understanding of groundwater flow direction and to establish the rate of transport of any contaminants, should contaminants be found during site characterization or at a sometime in the future. Background wells should be established to determine the level of natural uranium in the aquifer. The background wells can be newly installed wells or existing wells that are unimpacted by site activities which could have spread the DU and are at hydraulically upgradient locations.

Guidance on Surface Water Sampling & Analysis

Determination of the number and location of surface water samples should be made after all surface water environments (e.g. rivers, lakes, wetlands) and discharge points have been identified. Surface water samples from locations with the greatest potential for contaminant accumulation should be sampled within each aquatic system. The number of samples that will be required is dependent on the number of potentially impacted aquatic environments at each site. Surface water and sediment samples should be taken concurrently with respect to time and space since low surface water velocity allows sediments to readily deposit and for contaminants to concentrate in the water.

Drainage pathways at the perimeter of each range should be surveyed biannually to identify if contaminated sediments are being transported away from areas that contain known or suspected contaminated soils. This may reduce the amount of sampling and characterization needed within the ranges and will provide confidence that contamination, if present, will be detected in the early stages of transport by means of surface water and depositional transport.

Guidance on Air Sampling

The transport of DU via the air transport pathway will typically be associated with the resuspension of DU already present on the ranges. When resuspended, the form of DU is almost exclusively a particulate. The high density of DU in most particulate forms limits air transport to relatively small particles. Some studies have estimated that most of the

resuspended DU will be deposited within 100 meters of the source based on the characteristics of particulate DU. However, considerations must be given to the potential for aerosolization of the DU due to past use of the ranges for high-explosives munitions testing or to conducting burn operations to control grasses and/or overgrowth or as a part of a program to expunge defective or excess ammunition. Therefore, assessments need to be made to determine if DU has been transported off of the ranges as a result these past activities or whether future actions may result in off-range transport.

Analysis for DU should be conducted on the dust blown from the range impact areas. Sampling results may be used to estimate the deposition contribution of dust on soils and plants to food chain pathways as well as to the inhalation and inadvertent ingestion pathways. Continuous air sampling is required. However, as such sampling data is acquired, it may be appropriate to modify the program. Modifications may range from discontinuing the continuous air sampling to increasing the number of air sampling locations. However, the generation of such data may not be the basis for eliminating the periodic sampling program. In addition, there may need to be an enhancement of the air sampling program during the times that the range is used for live weapons firing.

Sampling for DU deposition can be performed using a variety of collection methods, including passive dust collectors (e.g., filters contained in petri dishes) and large-volume portable air samplers.

Initial Air Sampling Guidelines

If there is not an existing air sampling program, a detailed air sampling program should be developed to determine whether DU is being re-suspended and re-deposited on the range, or on locations on or off the installation. The sampling program should include a determination of background DU concentrations. Selection of background monitoring locations should be chosen with due consideration given to DU existing on the ranges for several decades and may have been dispersed during these times. The selection of background locations should be at locations which would not have been impacted by the spread of DU.

A continuous air sampling program should be developed to determine whether DU is being re-suspended and re-deposited off the range. Ideally, air samples should be collected from all 16 compass sectors. The information collected during the continuous monitoring program should be used to determine whether the sampling program needs to be enhanced or if it can be safely reduced.

Using the information collected from the initial air sampling activities, a periodic air sampling program to evaluate DU re-suspension and deposition or volatilization processes should be considered for implementation for those periods when the range is active. Samplers should be placed near the expected impact areas as well as at different locations downwind. Samplers should also be placed at designated locations, such as populated or environmentally sensitive areas. Samples should be collected for a sufficient amount of time to ensure that enough material is collected for analysis. Depending on the characteristics of the site and the current weather conditions, collection times could range from hours to days. Sample sizes are also dictated by the analytical methods and the detection limits of the instruments used. For a more accurate assessment of the contributions of DU to the exposure pathways, air sampling should be conducted at the same time as soil, water, and vegetation sampling.

Analytical Analyses

Numerous analytical techniques can be used to evaluate the U and DU concentrations in the air/dust samples collected. Efforts should be made during sampling to ensure that sufficient quantities of samples are collected to allow for the analysis of duplicate samples. Analytical methods used for determining concentrations should be consistent with the specifications in 40 CFR Part 61, Appendix B. A quality assurance program should be included to assure that the samples are representative and are of known precision and accuracy.

References

U.S. EPA, Office of Indoor Air and Radiation Protection Division. "Depleted Uranium – Technical Brief." EPA 402-R-06-011. December 2006.

Guidance on Vegetation, Food, and Fish Sampling

Initial Surveys

The following surveys should be conducted to identify potential human ingestion pathways:

- A land use survey to determine the location of milk animals and farm/garden areas greater than 50 square meters. The survey should identify all such locations that are within 5 miles of an area impacted by the presence of DU. In some cases, this might be 5 miles from the range itself. In other cases, it may be five miles from a downstream or downwind location which is off range but impacted or could be impacted by DU. A similar survey should also be conducted annually during the growing season.

- An initial surface water survey should be conducted to determine the location of bodies of water within (or crossing) DU range areas. This survey should also determine the location of any off-range areas that may be subject to seepage or surface drainage from DU contaminated areas.

- Where land and water surveys identify a significant pathway to a potential receptor(s), initial baseline samples of vegetation, food, and fish should be collected and analyzed for isotopic uranium. The methodology used for periodic sampling (as given below) should be used for these initial samples.

- An initial survey of game animals should be conducted to determine if DU range areas are accessible to game which are hunted or harvested on post or which are harvested off-post but have access to ranges containing DU.

Periodic Sampling for Vegetation, Food, and Fish

Where vegetation, food, or fish pathways have been identified, periodic sampling for isotopic uranium should be collected as follows:

- Vegetation should be collected quarterly at DU range boundaries and at any vegetable garden, pasture, or animal vegetative food source located within 5 miles as described above. Samples should also be taken of those crops grown on land which may be potentially contaminated with DU and subsequently harvested and fed to livestock or poultry.

- Meat samples should be collected at the time of harvest or slaughter for livestock raised on land which may be impacted by DU. The milk from milch animals within 5 miles of the DU range area should be collected monthly during the grazing periods or during those periods when the animals are fed feedstock grown on land potentially contaminated with DU. If range areas are accessible to game which traverse the DU contaminated area, an annual game sample should be taken.

- Fish, mollusks, or crustacean samples should be collected quarterly from any bodies of water within a DU range area and from areas that may be subject to seepage or surface drainage from potentially contaminated DU areas.

Guidance on Soil Sampling

Initial Sampling

An initial land survey should be conducted to identify surface-soil and sediment sample locations at DU range boundaries which represent the 16 compass sectors around the range.

Additionally, a survey should be conducted to determine if there are potential human exposure pathway areas within 5 miles of DU range boundaries. Such pathway areas may include homes, recreation areas, businesses, or public highways etc.

A baseline analysis of uranium isotopes shall be performed at the areas identified in the land survey.

Periodic Sampling

Based upon the locations identified in the initial land survey, soil samples should be collected quarterly and analyzed for uranium isotopes at range boundaries and at selected offsite locations which may be impacted by range activities. Examples include recreation areas, homes, businesses, etc. Depending upon the demographics associated with the Army facility, periodic soil samples may be required from locations off-range but on the installation. Soil samples should be taken at the same locations where vegetation samples are taken.

Guidance on Sediment Sampling

Initial Sampling

An initial baseline analysis of sediments for isotopic uranium should be conducted. Samples should be taken at the surface-water locations described above as well as upstream and downstream of any water bodies crossing a DU range area or at areas off the installation which might interact with water bodies potentially contaminated with DU.

Periodic Sampling

Sediment samples should be collected quarterly at the sample locations determined from the initial surface water survey. Samples should be collected even if the surface water sample is unavailable due to lack of flow. Sample locations should include downstream locations of any streams that cross the DU range area or locations off the installation which might interact with water bodies potentially contaminated with DU.

Direct Radiation

Gamma exposure rates should be measured quarterly at the sites chosen for continuous air samples. Passive integrating devices (such as thermoluminescent dosimeters), pressurized ionization chambers, or properly calibrated portable survey instruments should be used (see Regulatory Guide 4.13). A suitable direct radiation background area should be identified during initial characterization and land use surveys.

References

Groundwater

NUREG/CR-6948, Vol.1, Integrated Ground-Water Monitoring Strategy for NRC-Licensed Facilities and Sites: Logic, Strategic Approach and Discussion, 2007

American Society for Testing and Materials, *ASTM Standards on Ground Water and Vadose Zone Investigations, sponsored by ASTM Committee D-18 on Soil and Rock*, *second edition*, ASTM West Conshohocken, Pennsylvania, 1994.

American Society for Testing and Materials, *Standard Guide for Documenting a Ground Water Sampling Event*, ASTM D6089-97e1

Barcelona, M.J., J.P. Gibb, J.A. Helfrich, and E.E. Garske, *Practical Guide for Ground-Water Sampling*, Illinois State Water Survey, ISWS Contract Report 314, 1985.

Environmental Research Laboratory, Robert S. Kerr, *Practical Guide for Ground Water Sampling*, Ada. OK, US Government Printing Office, EPA-600/2-85/104, 1985.

Lapham, W.W., F.D. Wilde, and M.T. Koterba, *Guidelines and Standard Procedures for Studies of Ground-Water Quality: Selection and Installation of Wells, and Supporting Documentation*, U.S.G.S. Water-Resources Investigations Report 96-4233, 1997.

USEPA, *Handbook for Sampling and Sample Preservation of Water and Wastewater*, EPA-600/4-82-029 Environmental Monitoring and Support Laboratory, Cincinnati OH, 1982.

USEPA, *Suggested Operating Procedures for Aquifer Pumping Tests*, EPA/540/S-93/503, Office of Research and Development, Washington, DC, 1993.

USGS, *Ground-Water Data – Collection Protocols and Procedures for the National Water-Quality Assessment Program: Selection, Installation, and Documentation of Wells, and Collection of Related Data*, U.S. Geological Survey, Report 95-398, 1995.

USGS, *Techniques of Water-Resources Investigations, Book 9, Handbooks for Water-Resources Investigations, National Field Manual for the Collection of Water-Quality Data,* August, 1998.

Surface Water

USGS, *Quality-Control Design for Surface-Water Sampling in the National Water-Quality Assessment Program*, US Geological Survey Report 97-223, 1997.

Soil

American Society for Testing and Materials, *Test Method for Particle-Size Analysis of Soils*, ASTM D422-63

American Society for Testing and Materials, *Practice for Soil Investigation and Sampling by Auger Borings*, ASTM D1452-80, 1996

American Society for Testing and Materials, *Classification of Soils for Engineering Purposes (Unified Soil Classification System),* ASTM D2487-93

American Society for Testing and Materials, *Practice for Description and Identification of Soils (Visual- Manual Procedure), ASTM D2488-93.*

American Society for Testing and Materials, *Guide for Field Logging of Subsurface Explorations of Soil and Rock, ASTM D5434.*

Sediment

Blomquist, S. 1985. Reliability of Core Sampling of Soft Bottom Sediment - an *in-situ* study. Hydrobiology

Burton, G. A., Jr. and Landrum, P. F. 1990. ASTM Standard Guide For Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing

Mudroch, A. and MacKnight, S. D. 1994. Handbook of Techniques for Aquatic Sediment Sampling. Lewis Publishers, Chelsea, Michigan

U.S EPA 1985 Sediment Sampling Quality Assurance User's Guide Environmental Monitoring and Support Laboratory, EPA 600/4/85/048, Las Vegas, Nevada

General Decommissioning

NUREG 1757, Vol. 1, *Consolidated NMSS Decommissioning Guidance, Decommissioning Process for Materials Licenses*, 2002

NUREG 1757, Vol. 2, *Consolidated NMSS Decommissioning Guidance, Characterization, Survey, and Determination of Radiological Criteria*, 2003

Burgess, P.H. *Handbook on measurement methods and strategies at very low levels and activities*. European Commission, Nuclear Safety and the Environment; Report EUR 17624; February 1998.

Environmental Characterization

American Society for Testing and Materials, *Standards Related to Environmental Site Characterization, Sponsored by ASTM Committee D-18 on Soil and Rock*, ASTM, West Conshohocken, Pennsylvania,1997.

American Society for Testing and Materials, *Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process*, E 1527-00, 2000.

NUREG-1575 (MARSSIM). "*Multiagency Radiation Survey and Site Investigation Manual (MARSSIM*)." December 1997.

Salbu, B., Janssens, K., Lind, O.C., Proost, K., Danesi, P.R., 2003. Oxidation states of uranium in DU particles from Kosovo. Journal of Environmental Radioactivity 64, 167e173