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Decommissioning Plan and Environmental Report for DU Impact Area, Jefferson Proving Ground, Indiana

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Project Report for U. S. Army, Test and Evaluation Command

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EXECUTIVE SUMMARY

Jefferson Proving Ground (JPG) is located in southeastern Indiana and spans three counties including Ripley, Jennings and Jefferson. Principal metropolitan areas include Louisville, Kentucky 45 miles southwest, Cincinnati, Ohio 75 miles northeast and Indianapolis, Indiana 85 miles north. Madison, Indiana is the closest major city and is located approximately nine miles south of JPG.

In the latter part of 1940, the site, which is now JPG, was selected to be a proving ground to carry out the proof work of the ordnance manufacturing program. Construction was started immediately and the first round was fired on May 10, 1941. In the mid 1980's, accuracy testing of depleted uranium (DU) tank penetrator rounds began. These penetrator rounds were a result of a research and development program to develop armor defeating kinetic energy weapons. There was no machining or processing of DU at JPG other than the firing of penetrator rounds.

During the fifty-three years of testing which ended in 1994, over 24 million rounds of conventional explosive ammunition were fired at JPG. Nearly 1.5 million rounds did not detonate upon impact, leaving unexploded ordnance (UXO) deposited on the impact area. In addition, it is estimated that there is approximately of 70,000 kilograms of DU remaining in an area contaminated with UXO after several annual field operations to recover DU. Nominally the impact area encompasses about 1900 acres, but analysis of recovery data and anecdotal site information allows reduction of the nominal area. The reduced area measures approximately 1.0 mile wide by 2.0 miles long (1.6 km. wide by 3.2 km long) and encompasses approximately 1280 acres.

The Base Realignment and Closure (BRAC) Commission established by the Secretary of Defense on May 3, 1988, recommended the closure of JPG. This was mandated by Public Law 100-526, dated October 24, 1988. JPG's mission of ammunition acceptance testing for the Army was relocated to the U.S. Army Yuma Proving Ground, Yuma, Arizona. In order to close JPG under BRAC, the facility must be decommissioned. Decommissioning means that JPG will discontinue its use of DU and clean those areas where DU was used. The use of DU is regulated by the U.S. Nuclear Regulatory Commission (NRC) under an NRC license pursuant to the U.S. Code of Federal Regulations (CFR), 10 CFR Part 40. The closure will be phased through 1995.

This decommissioning plan and environmental report serves a number of purposes. It describes the use of DU at JPG. It describes where contamination exists and outlines the process of cleaning up the contamination. The plan also describes what steps will be taken to ensure that the decommissioning process is safe to the workers performing remediation activities and the public.

In addition to the DU impact area, a number of other areas and buildings were used for DU operations at JPG. Three gun positions, J, K5, and 500 Center with their associated lines of fire were used. Twelve buildings were also used. Some were for storage, handling, and assembly of unfired DU rounds. Others were used for storage and handling of fired penetrators and recovered fragments. Others were used for maintaining gun tubes potentially contaminated with DU. The results of the initial scoping survey and a subsequent characterization survey will determine the extent and location of contamination present in the impact area and in the relevant buildings of JPG.

Estimated costs for the DU cleanup at JPG are initially $19 Million and total up to $7.8 Billion. This includes cleanup of buried penetrators over 80 acres of the site, cleanup of surface penetrators over 1200 acres of the site, fixed equipment costs, storage, disposal and shipment of penetrators and contingencies. Estimates will be revised as the full scope of the remediation is known after scoping and characterization surveys. The range of cleanup options and costs is discussed in more detail in various sections.

As of this revision, detailed surveys for site characterization and a comprehensive final survey have been completed. Final radiation surveys were also performed in accordance with NUREG/CR-5849, Manual for Conducting Radiological Surveys in Support of License Termination, and the NRC has completed the final confirmatory survey. Currently JPG is closed and all DU operations occur at Yuma Proving Ground.

1.0 General Information

Jefferson Proving Ground (JPG) is situated in southeastern Indiana and spans three counties including Ripley, Jennings, and Jefferson. Occupying 55,264 acres, JPG includes 27,804 acres in Ripley County, 8,374 acres in Jennings County and 19,805 acres in Jefferson County. Principle metropolitan areas include Louisville, Kentucky 45 miles southwest, Cincinnati, Ohio 75 miles northeast and Indianapolis, Indiana 85 miles north. Madison, Indiana is the closest major city and is located approximately nine miles south of JPG.

In the latter part of 1940, the site, which is now JPG, was selected to be a proving ground to carry out the activities relative to proof work of the ordnance manufacturing program. Construction was started immediately, and the first round was fired on May 10, 1941. In the mid 1980's, accuracy testing of depleted uranium (DU) tank penetrator rounds began. These penetrator rounds were a result of a research and development program to develop armor defeating kinetic energy weapons. There was no machining or processing of DU at JPG other than the firing of penetrator rounds.

During the fifty-three years of testing which ended in 1994, there were over 24 million rounds of conventional explosive ammunition fired at JPG. It is estimated that nearly 1.5 million rounds did not detonate upon impact, leaving unexploded ordnance (UXO) deposited on the impact area. In addition, while there have been annual field operations to recover DU from the impact area, it is estimated that there is approximately of 70,000 kilograms of DU still left in an area contaminated with UXO. Nominally the impact area covers approximately 1900 acres. Evaluation of DU recovery efforts and consideration of operational history at JPG, however, allow reduction of the 1900 acres to a smaller area that is most likely the actual impact area. This reduced area measures approximately 1.0 miles (1.6 km) wide (east to west) by 2.0 miles (3.2 km) long (north to south) and encompasses approximately 1250 acres.

The Base Realignment and Closure Commission established by the Secretary of Defense on May 3, 1988, recommended the closure of JPG. This was mandated by Public Law 100-526, dated October 24, 1988. JPG's mission of ammunition acceptance testing for the Army was relocated to the U.S. Army Yuma Proving Ground, Yuma, Arizona. The closure of JPG will be phased through 1995. The U. S. Army Test and Evaluation Command, Aberdeen Proving Ground, Maryland, has requested to transfer the responsibilities of the licensee to headquarters until the license is terminated.

The name, address, and license number of the licensee whose license is to be transferred or terminated is as follows:

Department of the Army
U.S. Army Jefferson Proving Ground
Madison, IN 47250
License Number SUB-1435

2.0 Objective and Goals

The objective of this document is to provide to the U.S. Army Test and Evaluation Command (TECOM) the information necessary for a decommissioning plan to be submitted to the Nuclear Regulatory Commission (NRC). The Army, under 10 CFR 40.42, is required to submit a decommissioning plan before its license can be terminated. In particular, section 40.42 requires a plan for completion of decommissioning if the procedures necessary to carry out decommissioning have not been previously approved by the NRC and could increase potential health and safety impacts to workers or to the public, such as in any of the following cases:

- Procedures would involve techniques not routinely applied during cleanup or maintenance operations;
- Workers would be entering areas not normally occupied where surface contamination and radiation levels are significantly higher than routinely encountered during operation;

- Procedures could result in significantly greater airborne concentrations of radioactive materials than are present during operation; or

- Procedures could result in releases of radioactive material to the environment significantly greater than those associated with operation.

Regulatory Guide 3.65 (NRC, 1989) is the guidance for preparing an NRC decommissioning plan. This decommissioning plan will provide the information called for in Regulatory Guide 3.65. The information provided will include evaluation of unrestricted and restricted use scenarios and the reasons for selecting the restricted use scenario. Also included will be cost estimates for the unrestricted use scenario cleanup, remediation methods in support of the restricted use of JPG land, and the instrumentation needed for surveys, sampling and analysis during the remediation.

Suggestions from meetings between the NRC and Army Staff included renaming the decommissioning plan to an environmental report. The report would support the decision to transfer JPG to the U. S. Fish and Wildlife Service (USFWS) under restricted use provisions. After consultation with Army staff, however, the decommissioning report will remain in the title and will be updated to include new information from the completed SEG scoping survey and site characterization. This decommissioning plan and environmental report supports the transfer of JPG in the same way the environmental report would.

One goal of this report is to evaluate the release of JPG for restricted use instead of unrestricted use. Release for restricted use has the advantages of providing additional public land for the residents of the JPG area and is much less expensive than releasing the land for unrestricted use. Drawbacks to release for restricted use include leaving residual radioactive material in place in the affected area and the requirement for administrative control of the area of interest. Release for restricted use will be examined and discussed in more detail below.

A second goal is to support the release of JPG land for restricted use. We will give fundamental discussions that show restricted release is far more economical than unrestricted release in terms of potential remediation costs. We will also discuss briefly the risk of cancer death and cancer incidence as a result of exposure to residual DU at JPG. The staggering cost of clean up of UXO and DU at JPG and the already minimal health and ecological risks also support a decision to release JPG for restricted use.

3.0 Description of Planned Decommissioning Activities.

3.1 Unrestricted and Restricted Release

3.1.1 Unrestricted Release

The present NRC position is to decommission the site such that it may be released to the public for unrestricted use. The current requirement in the JPG license is to reduce the concentration of residual radiation of contaminated soil to 35 pCi/g. This concentration level has been established within current guidelines to limit total radiation doses to less than 100 mrem/yr. Criteria for unrestricted release in revision and the new NRC approach will favor goals for decommissioning that reduce residual radioactivity at a site to levels that are indistinguishable from background, or as low as reasonably achievable (ALARA). Efforts to reduce dose from residual radioactive material will be considered successful, that is, no further reduction effort is required, if the total effective dose equivalent (TEDE) is less than 3 mrem/yr to a member of the critical group. Three mrem/yr is well within the variation expected in natural background radiation across the United States and the seasonal variation in background measured at particular sites. Thus, variation of 3 mrem from DU to a critical member is often indistinguishable from the variation in dose from natural radiation. The revised NRC approach also indicates that reduction of residual radioactive material to less than 15 mrem/yr or as low as reasonably achievable is acceptable for release of a site when the 3 mrem/yr dose cannot be met.

An additional consideration in decommissioning at JPG, while not an issue in license termination, is the amount of UXO present in the DU impact area. UXO is present in high concentrations and poses a significant health and safety hazard to workers performing decommissioning activities on the site. Unrestricted release of the site would potentially expose the public to the UXO hazard should the UXO not be addressed in the decommissioning and remediation activities.

3.1.2 Restricted Release

Another option is to decommission the site such that it may be released for restricted use. It is possible that cleaning up to any specified level is technically achievable and is only a function of how much it will cost. It is also possible that decommissioning costs to return some sites to unrestricted use could be so high that the site should be kept under administrative control and maintained as a restricted area. The proposed NRC rule change recognizes that it may not be reasonable to remediate some sites to a level that permits release for unrestricted use. The costs involved, either in dollars or in potential harm to people or the environment, may be prohibitive. In these cases, the proposed rule would provide for termination of the license under restricted conditions. In the case of restricted release, the following criteria must be met:

- Restricted termination would be acceptable if further reductions in residual radioactivity are not technically achievable, would be prohibitively expensive, or would result in net public or environmental harm;

- Residual radioactivity at the site must have been reduced, and institutional controls imposed, so that the TEDE to the critical group is less than 15 mrem/year;

- The TEDE to the critical group, if the institutional controls failed, shall be ALARA and shall not exceed 100 mrem/year;

- The licensee shall provide sufficient financial assurance to support any necessary, continuing oversight activities after license termination.

The Base Realignment and Closure Act provides for screening of closing military bases by Federal agencies for public benefit purposes. The Secretary of the Interior has made a formal request to The Secretary of Defense (March 31, 1994) to transfer Jefferson Proving Ground to the Department of the Interior and the Fish and Wildlife Service under the Park and Recreation Provisions of the public benefit transfer.

Originally the U. S. Fish and Wildlife Service requested the transfer of approximately 53,000 acres of Jefferson Proving Ground for addition to the National Wildlife Refuge System. At this revision, however, the Department of the Interior cannot support the financial expense of maintaining JPG as a refuge. Plans to transfer the land to the U. S. Fish and Wildlife Service have been terminated. Current plans call for transfer of the JPG impact area to the Air force for continued use by the Air National Guard. Regardless of the use of the land, the impact area must be maintained as a restricted area because of the presence of UXO and its associated hazards. Restricted access to the 40,000 acres containing UXO also protects the DU range from access and provides habitat for diverse wildlife even though the site is not managed as a wildlife refuge.

3.2 Suggested Decommissioning Activities

3.2.1 Unrestricted and Restricted Release

3.2.1.1 Scoping Survey

An initial radiological survey (scoping survey) of the impact area was performed to establish the scope of the decommissioning task. The scoping survey showed the location of high concentrations of DU penetrators and hot spots of residual radioactive contamination. The affected area was about 2.9 x 10^6 m^2 (approximately 700 acres) and is located between 3000 m and 8000 m down range from the gun positions. A grid system was established using accepted surveying techniques, and locations of penetrators and fragments were identified on the grid map. Radiological exposure rate data were plotted on the grid overlay in order to correlate ground locations and concentrations (Figure 4-2 of SEG, 1995).

Overall the survey results confirmed the assumption that most of the penetrators landed in the surface soils near the firing lines. Penetrators may be deflected away from the line of fire causing them to increase the size of the affected area. The affected area is symmetrical about the firing line of 500 Center and is roughly approximated by the oval areas in Figure 3-2 and shown in detail in Figure 4-2 of the SEG report (SEG, 1995).

Deposits of penetrator fragments on the soil surface or within a few inches of the surface account for most of the inventory of DU in the impact area. There appears to be little risk of adverse effects to animals and humans in the impact area due to the residual DU fragments on the surface especially when a restricted use scenario is used to assess the possible human health and ecological effects (Ebinger and Hansen, 1994). Occasionally penetrators may be buried in the ground to depths as great as six feet because of the trajectory of the penetrator and the differences in terrain and soil density. Removal of some of the surface fragments was accomplished after the scoping survey, and removal of subsurface fragments was not attempted because of the time available for the scoping survey and the added risk to workers from unexploded ordnance in the impact area. Additional removal of the surface DU will further reduce the source term and thus the radiation dose rates, whereas residual radiation from the buried fragments remains. Radiation from buried penetrators was evaluated during site characterization surveys, and an updated risk assessments were prepared. The surveys and risk assessments show that there is little chance of adverse effects to animals from the presence of buried or surficial DU.

3.2.1.2 Site Characterization Survey

During the scoping survey the affected and unaffected areas were identified, high concentrations of penetrators were located, and hot spots of residual radioactivity were found. Data from the scoping survey guided the more detailed site characterization survey. The average concentration of residual radioactivity in the soil was estimated in the site characterization survey, and sediment and water samples were also included. These data were used in the risk assessments to calculate the TEDE and to estimate the uncertainty in that calculation. Site characterization samples were collected and handled using a rigorous quality assurance/quality control program to ensure sample integrity. Sampling for site characterization was conducted with the same grid system established for the initial survey.

3.2.2 Identification of Affected and Unaffected Areas

The reduced DU impact area measures approximately 1.6 km wide (east to west) by 3.2 km long (north to south; about 1250 acres). Distribution of DU penetrators and fragments within the impact area is not uniform as shown in Figure 4-2 of the SEG report (SEG, 1995). An area of approximately 2.9 x 10^6 m^2 (approximately 700 acres) or about 60% of the entire impact area was shown to have radiation dose rates significantly above background. The affected area is the 2.9 x 10^6 m^2 from which the highest dose rates were measured. The unaffected area is considered the part of the impact area that is at or near background dose rates. The data from the SEG survey were mapped onto the impact area in Figures 4-2 and 5-1 of the SEG report (SEG, 1995), and the affected and unaffected areas are shown in Figure 5-1 of the SEG report (SEG, 1995).

3.2.3 Clean-up Strategy

The clean-up strategy for the DU impact area will be an iterative process and will depend on the UXO cleanup described later in this report. About 400 pounds of penetrators were collected after the scoping survey; additional recovery will be conducted as part of the different surveys for decommissioning. Recovered penetrators and fragments shall be placed in heavy-duty poly bags, sealed and placed in wooden crates suitable for shipping. Site characterization data showed that residual activity, though elevated, was not enough to cause significant increase of risk adverse effects to the ecosystem. Therefore, no further remediation is required unless the DU impact area changes from restricted use.

will directly evaluate if the residual radioactivity has been reduced to allow the site to be released or if further remediation is required.

3.2.4 Final Survey

A survey to determine the final condition of the site will be performed after decontamination activities are complete. This survey will provide data to demonstrate that all radiological parameters (total surface activity, removable surface activity, exposure rate, and radionuclide concentrations in soil) satisfy the established guideline values and conditions. Results of the survey are documented in a detailed report, which becomes part of the licensee's application to terminate the license and thereby release the facility for unrestricted or restricted use. The final survey shall be designed using the scoping survey, site characterization survey and NUREG/CR-5849 as guidance. The final survey methods and procedures shall closely follow those used during the initial and characterization surveys so that all data collected will be relevant to the decommissioning.

3.3 Additional Decommissioning Topics

In addition to the topics listed above, Reg. Guide 3.65 identifies information needed in the decommissioning plan. The additional information is listed below.

3.3.1 Schedules and Organization Charts

Current milestones for the decommissioning are given in Appendix A. For the purposes of this report, an activity is an organized unit of work for performing a function and may consist of several tasks. A task is a specific work assignment or job. The schedules for accomplishing interrelated activities and tasks shall be presented. Schedules or diagrams should clearly indicate the estimated time for completion of decommissioning.

The project organization shall be described. Because the Base Closure and Realignment Act will alter the present organization of JPG to an unknown degree, the project organization may not be fully defined when the decommissioning plan is submitted to the NRC for review (Appendix B).

Positions with responsibilities related to decommissioning safety shall be identified and their functions described. The minimum qualifications for these positions shall be presented. The discussion shall address the project team, decommissioning staff, worker health and safety training, and the use, control and management of subcontractors.

3.3.2 Final Radiation Survey

The amended sections of the proposed rule on decommissioning require that the decommissioning plan contain a description of the planned final radiation survey. The decommissioning plan, as outlined in Reg. Guide 3.65, states that the licensee shall describe the strategy for demonstrating that the site will meet criteria for release for unrestricted or restricted use. The final radiation survey plan shall include 1) the proposed method for ensuring that all equipment, systems, structures, and the site are included in the survey (diagrams, plot plans and layout drawings should be used to facilitate presentation) and that sufficient data are included for a meaningful statistical survey, 2) a description of and the data on background radiation, 3) the type, specifications, and operating conditions of instruments to be used, and 4) methods to be used for reviewing, analyzing, and auditing data. Areas south of the firing line at JPG have been remediated and surveyed and will be released for use. All buildings have been surveyed and are scheduled to be released because there was no radioactive contamination found or remediated accordingly. The NRC final survey was completed in June, 1995, and a report provided to the U. S. Army in September 1995. All waste from remediation activities and surveys was collected and shipped for burial to the Defense Consolidation Facility in Barnwell, SC, in the fall of 1995 since the Midwest Compact was not operational. About 7.5 cubic feet of waste was generated and disposed of.

3.3.3 Funding

Funding for the decommissioning will be requested by the U. S. Army through Congress under the Base Relocation and Closure Act (BRAC). To date approximately $14 million has been approved for the initial part of the UXO remediation as described elsewhere (Mason and Hanger, 1992). Additional funding for the DU decommissioning and the remaining parts of the UXO remediation will be requested at the appropriate time. The U.S. Army will show the availability of adequate funding for the decommissioning.

3.3.4 Physical Security

NRC Regulatory Guide 3.65 calls for consideration of the physical security of the facility during the decommissioning. The DU impact area is surrounded by a security fence and requires verbal authorization before entry is granted. While in the impact area, workers are in contact with range control. Personnel in the area are monitored by range control, and must be cleared out on leaving the area. The JPG reservation is patrolled by armed guards routinely, and access to the interior of the site is through guarded gates. The measures in place at JPG appear to be adequate to limit access to the impact areas and to account for all personnel during the decommissioning. Additional physical security is not necessary at this time. Range control is no longer active since the closing of the base in September, 1995. Two temporary employees restrict access during business hours until their employment terminates in March, 1996. Local law enforcement from neighboring counties conduct random checks of the perimeter fence against intruders. Physical security is addressed in the site security plan at the appendix.

3.3.5 Compliance with 10 CFR 20 and 10 CFR 40

Public participation is well established for JPB. The Army operates a Restoration Advisory Board (RAB), with meeting held six times per year for the benefit of the public who are interested in JPG. There are over 200 members of the public on the RAB mailing list who are invited to each meeting. The Army has a complete file of RAB meeting minutes, dating from the establishment of the RAB in April 1994. Depleted uranium has been a topic at RAB meetings with presentations that describe what DU s and what DU penetrators are.
Representatives from the NRD have been present at RAB meetings to 1) explain the NRC role at JPG; 2) describe the decommissioning process; 3) state opportunities for public involvement; and 4) report on progress to terminate JPG's NRC license.

An Administrative Record was established for JPG in 1996. The file contains almost 300 key documents relating to the cleanup and reuse of JPG. The record serves three purposes: 1) Forms the basis for selection of cleanup actions; 2) satisfies the statutory requirement of the National Contingence Plan; 3) acts as mechanism for informing and involving the public. The Administrative Record file is accessible to the public at the following location: Hanover College, Dugan Library, 121 Scenic Drive, Hanover, Indiana 47243, phone (812) 866-7160.

Radiological criteria for restricted use have been established. The Army had performed a risk assessment (LA-UR-98-5053, dated November 1998) that shows all conditions have been met for license termination under restricted conditions.

4.0 Evaluation of Unrestricted and Restricted Use Scenarios

4.1 Unrestricted Use Scenario

Guidelines in 10 CFR 40 state the purpose of decommissioning is to "reduce residual radioactivity to a level that permits release of the property for unrestricted use and termination of that license." Unrestricted use means that the land previously affected by testing can be used with little to no health effects caused by the residual radioactivity on the site. For the purposes of DU at JPG, the amount of residual radioactivity must result in doses of 15 mrem/y or less to the users of the site. Site users are covered by three land use scenarios: 1) light industrial use of the site; 2) residential use where the resident works away from home; 3) resident-farmer who consumes groundwater from the site and crops grown on the site. The goal of decommissioning a site is to assure that "future uses of any licensed facility will not result in individuals being exposed to unacceptable levels of radiation and/or radioactive materials" (Berger, 1992).

Currently, release of the JPG DU test area for unrestricted use involves removing soil contamination to less than 35 pCi/g. The impact area covers about 2 square miles or approximately 1250 acres, and large proportion of the range is free of DU contamination. As discussed earlier, the strip of forest that has been removed by repeated penetrator tests should contain the largest concentration of DU fragments at the site. Areas adjacent to the target areas will also contain fragments of DU and complete penetrators on occasion. Initially the affected area was considered the entire 1250 acres of the impact area. The scoping survey, however, showed that the affected area is more appropriately about 700 acres (SEG, 1995).

Remediation for unrestricted use means that DU will be removed by a multiple-phase remediation process. First, manual extraction of large DU fragments or complete penetrators will be conducted in the impact area. This method is currently used to retrieve spent penetrators and visible fragments. There is minimal impact to the ecosystem as a result of collecting fragments and penetrators by this technology. Second, a radiological survey after the initial fragment collection will show the areas of concern that remain in the impact area. Pathway analysis for the affected area will indicate if further remediation is necessary for release of the site for unrestricted use. If further remediation is necessary, several inches to several feet of soil would be removed and the DU in the soil would be extracted for off-site disposal. Three extraction technologies are a bicarbonate soil washing process, vacuuming soil into a collection vehicle and packaging it for disposal, and gravity-based separation of DU fragments from excavated soil. These technologies remove the small, more mobile DU component. However, the consequences of using these technologies include the high cost, potential adverse impact to the ecosystem during implementation, and rendering the treated soil ineffective to support plant growth. The costs to reclaim the excavated land must be considered in addition to the costs of excavation and the technology chosen to remove DU from soil. The result of further remediation will be a landscape cleaned to acceptable standards suitable for release of the site for unrestricted use and a landscape that has been significantly altered with regard to the native ecosystem.

Risk assessment calculations showed that the risk of adverse effects to humans or to the ecosystem from exposure to residual DU were minimal (Ebinger and Hansen, 1996). Doses to humans were significant, i.e, greater than 15 mrem/y, only when the impact area was farmed and the water from the shallowest aquifer was used as the primary drinking water for the farmers. Neither scenario is realistic since the hazards associated with UXO preclude farming, and the water from the shallowest aquifer is of undesirable quality for reasons other than DU contamination. The risk assessment calculations were made using the ERM data and SEG (1995) radiological survey data.

4.1.1 Advantages and Disadvantages of Unrestricted Use

One advantage of decommissioning under the present NRC guidance is that the site would be released for unrestricted use. Ideally, release for unrestricted use is a goal of remediation activities because the future health risks from using the released site would not differ from sites where no DU testing occurred.

There are also several important disadvantages to unrestricted release. First, the cost of added remediation must be weighed against the benefit of reducing the risk of adverse health effects of radiologically-induced or toxicologically-induced disease caused by exposure to DU. Also, the risk of injury and/or exposure to workers increases during remediation activities. When the ratio of cost to benefit is high, the value of continuing remediation decreases. When benefits outweigh the costs of clean-up, the remediation activities may be justified and should continue.

Extensive remediation for unrestricted release holds additional disadvantages. Excavation and treatment of the soil or excavation and disposal of the soil result in disturbance of the native soil and plants to a depth of a few inches to several feet. The excavated areas must be reclaimed in order to restore the ecosystem. Disturbed areas of several square meters may not require reclamation and may provide no significant alteration to the immediate ecosystem. If areas of several acres or more are contaminated or the residual contamination is in high concentration, continuing the remediation must be considered. The remediation activities that should be conducted depend on cost/benefit analysis so that the site can be cleaned without unnecessary expense to the U. S. Army, without introducing undue risk to workers and to the environment, and without destroying the local ecosystem. Destruction of wetlands that lie within the DU impact area would also be a result of extensive remediation. Remediation efforts shall be controlled in and around wetlands since alteration of wetlands is a sensitive political issue and because wetlands provide a natural barrier to DU migration.

Another disadvantage of continued remediation is the potential to increase DU concentrations in streams because of erosion from excavated or reclaimed areas. Soil used in reclamation tends to be less compacted than the original soil. Thus, increased erosion of the soil used in reclamation results, and the reclaimed areas erode more rapidly than unexcavated areas. Increased erosion will contribute soil to the local streams, two of which run through the impact area. Residual DU in the eroded soil could provide significant input of DU to the environment. Erosion also would eventually expose the reclaimed excavation site and make additional residual DU subject to transport through the environment. The potential effects of remediation activities include dispersing more DU into the environment than would have been present had no remediation been conducted.

Stream sediments must be surveyed and DU fragments in sediments collected during the various surveys. Remediation of sediments, should this be necessary, would result in at least short-term water quality degradation. The aquatic environment would be disturbed during the remediation, but would be expected to return to its pre-remediation state after the clean up. Remediation of sediments, however, is complicated by the possible release of DU that is sequestered in the sediments. Recent research (Shaw *et al,* 1994) indicates that natural perturbations in Chesapeake Bay oxidize and mobilize U entrained in sediments. Perturbations of sediments due to remediation in the streams would result in similar mobilization of DU that is not removed with the sediments. The result would be dispersion of DU that would most likely have remained sequestered (immobile) in the stream sediments.

Remediation and reclamation activities could effectively remove the residual radioactivity to levels that are not of concern to the health of site users or those downstream from JPG. However, the potential impacts of cleaning the soils and sediments could result in an ecological resource that is unusable for many purposes, and may have little value even though it is available for unrestricted use.

4.1.2 Possible Economic Impacts of Remediation

The expense of remediating DU for even small areas of JPG can be staggering, and estimates range from about $4.1K per acre to almost $79K per acre (see Table 1, p. 19 of this report). Estimated survey and excavation costs coupled with the costs of reclaiming affected areas and disposal of the excavated soil and/or sediments range from $1 billion to $1.6 billion for UXO remediation at JPG (Mason and Hanger, 1992). The remediation of UXO will result in removal of most of the soil from surface to bedrock (approx. 20 feet in some cases) and replacing the soil with either clean fill or the original soil free of ordnance. The remediation efforts would significantly alter the present habitat for many years, and the unconsolidated nature of the fill material could erode and damage water quality in streams of JPG and the Ohio River Valley west of Madison. DU fragment clean-up is expected to cost significantly less than remediation of the UXO. The damage to the ecosystem during a DU clean-up could be minimized if excavation and subsequent reclamation were minimized.

A human health and ecological risk assessment (Ebinger and Hansen, 1994) suggest that the risk of adverse health effects to humans and deer at JPG are small under most conditions. Expected occurrence of health detriments (fatal and non-fatal cancers) due to exposure to DU during periodic hunting at JPG averaged about 4.5×10^{-7} detriments/year, where a detriment is cancer death or cancer incidence. For farming scenarios, the expected detriment rates increase to 1.4×10^{-5} to 21×10^{-5} per year when drinking water is supplied by the city of Madison, Indiana. The detriment rate increases to 37×10^{-5} to 185×10^{-5} per year when local JPG groundwater is used for drinking water. The two farming scenarios assume residents produce all food on-site and live on-site. The farming scenarios are also not realistic with regard to the U. S. Fish and Wildlife proposal to use JPG as a wildlife refuge. The hunting scenario, however, is a reasonable approximation of exposure to the general public if JPG is released for restricted use and opened as a preserve. Doses to humans did not change appreciably when data from the SEG surveys (SEG, 1995) were incorporated in the estimates. Risks of detriments were of the same order of magnitude as in the initial DU risk assessment (Ebinger and Hansen, 1996).

The risk assessment assumed that the DU on the site was the present inventory and that none of it had been removed. Removal of just the surface contamination, that is, the easily detected fragments and complete penetrators, would reduce the human and ecological hazards significantly. Extensive excavation of the site to remove dispersed DU does not seem reasonable when the potential damage to the natural resources at JPG is weighed against the slight reduction in human health risk and ecological risk.

4.2 Restricted Use Scenario

The alternative to release of JPG for unrestricted use is to impose institutional control on the use of the site by the public, that is, to release the site for restricted use. The combination of high cost of remediation and potential damage to the JPG environment due to remediation justifies consideration of release for restricted use. Current regulations do not support release for restricted use, however a proposed change specifies how restricted use can be effected.

The presence of large quantities of UXO, the extremely high cost of remediating the UXO areas, and the high risk of injury to workers also lend weight to the release of the JPG site for restricted use. JPG personnel are currently pursuing the possibility of turning over management of JPG grounds to the U. S. Fish and Wildlife Service. The plan is to use the area as a game refuge and/or controlled access area where wildlife can flourish. The area could be accessed by a trail system and/or paved or gravel roads so that the public could use the area.

Release for restricted use provides a means to minimize the time visitors spend in the affected area. One scenario in the JPG risk assessment considered the doses to hunters who use the site for about two weeks each year. The predicted doses were minimal as mentioned above. Doses to visitors of a refuge are expected to be similarly low, especially if access to the DU area was infrequent. Release for restricted use would also mean that extensive excavation of the soils and sediments need not occur, and the remediation of the site would not "result in significantly greater releases of radioactive material to the environment than those [releases] associated with operation" of JPG as a DU test facility (10 CFR 40).

4.2.1 Advantages and Disadvantages of Restricted Use

Advantages of release for restricted use center around the maintenance, protection, and stewardship of the indigenous environment at JPG. Extensive remediation as discussed above would alter the ecosystem for at least the near future and could be responsible for significant environmental impacts to the aquatic ecosystems at JPG and in the surrounding area. More limited remediation would leave most of the ecosystem of interest intact and would allow its preservation for future use with only minimal adverse impacts. Maintenance of the area as a refuge or habitat would ensure that the natural resources present in southern Indiana are protected from development such as housing or farming. While use of the land for housing, farming, or similar activities is not inherently a negative impact, the additional exposure of the user of the land to residual radioactive material under those scenarios should be considered.

Another advantage to release of the JPG site to restricted use is that the cost of remediation would be significantly less than for unrestricted use. A multiple-phase survey and remediation strategy will be discussed below. The important aspect of such a strategy is that a surface clean-up for DU followed by characterization of remaining hot spots would reduce the source term on site and provide locations of areas to which access should be limited. Eliminating extensive excavation reduces the cost of remediation significantly, maintains the present ecosystem, reduces the risk of injury to workers, and limits the amount of material that requires disposal as low-level radioactive waste.

An additional advantage to release of the site to restricted use, especially for use as a refuge or habitat as proposed by JPG, is that the local stakeholders endorse such a plan. Local meetings with JPG personnel and residents of the Madison, Indiana area indicate that potential users of the wildlife refuge support its creation and maintenance. The interest provided by the stakeholders shows the concern that the environment remain intact.

Disadvantages of release to restricted use include the fact that there will be significantly more residual radioactive material and UXO in the soils and possibly the stream sediments than if the site is released for unrestricted use. The higher concentration of residual radioactive material left on the site could affect the quality of the ecosystem, thus have deleterious effects overall.

However, the estimated doses to vegetation and animals is well below 100 mrad/d (Ebinger and Hansen, 1994), and no adverse ecosystem effects due to radioactivity would be expected (IAEA, 1992).

5.0 Completing the Decommissioning

5.1 Overview

Release of the JPG site for restricted use is the goal toward which this decommissioning plan is oriented. Risk assessment using available environmental monitoring data showed only incremental risk of cancer death or cancer incidence in humans and ecosystem components if JPG is released for restricted uses (Ebinger and Hansen, 1994). Based on the risk assessment, a large-scale remediation designed to remove all DU from JPG is not suggested. Instead, collection of DU fragments deposited in the soil surface would be a cost effective means to keep the exposure of humans and animals to residual radiation as low as reasonably achievable.

Interest in the fate of DU in the environment has been expressed by the citizens of the JPG area. Even though risks of DU-caused cancer incidence and cancer death are small, continued environmental monitoring of soil concentrations, groundwater, surface water, and possibly plants and animals will provide the data to show the potential doses delivered to site users, people who use the water downstream from the impact area, and animals living in the impact area. Since these doses are expected to cause little adverse health effect at present, i.e., without cleanup, decreasing the source term further will only decrease the already small risk of adverse health effects.

Decommissioning of JPG south of the firing line is completed. The scoping survey resulted in defining the affected and unaffected areas (Berger, 1992). The survey grid was also established and will be used for further surveys and sampling. Approximately 400 pounds of DU fragments were located during the scoping survey and removed after the survey was completed. The NRC completed confirmatory surveys in June, 1995. TECOM requested release of these areas for unrestricted use so the areas can be leased for use by the public.

The site characterization survey provided the detailed radiological survey of the affected area. The survey showed the spatial distribution of residual DU in the soils and sediments of the affected areas. Background radiation from naturally occurring U and other radionuclides was also measured from selected sections of the JPG site not used for DU testing. Data from site characterization shows the extent of contamination and the location of "hot spots" or areas of locally elevated concentrations. The site characterization data were also used to evaluate the possible exposure of different organisms to DU by means of pathway analysis. Results of the pathway analysis indicate that further remediation is not required at this time since the impact area will not be released for unrestricted use.

The last stage in the decommissioning is the final survey to demonstrate that cleanup criteria have been met for the residual radioactive material in the impact area after remediation. The pathway analysis will be repeated with the final survey data to estimate the exposure to ecosystem components if additional remediation is conducted.

Information gathered during each stage of the JPG decommissioning will be integrated as part of the final survey results. It is essential that data collection in each of the surveys be conducted in such a way that all data may be legitimately compared. For example, data from the scoping survey concerning the unaffected areas may be adequate to include as final survey data if the scoping survey data and the final survey data are collected with similar equipment and protocols. Data collection methods for all surveys shall be selected before the first survey begins in order to avoid ambiguity in the results at the end of the decommissioning. Field methods and laboratory analysis will be standardized, as will sample collection protocol, chain of custody, and sample handling.

5.2 Scoping Survey Results

The scoping survey conducted by Scientific Ecology Group (SEG, 1995) accomplished several objectives:

- identified the extent and location of DU contamination relative to guideline values;
- delineated the impact area into affected and unaffected areas
- located fragments and penetrators on the soil surface.

Approximately 400 pounds of DU fragments were collected and stored after the scoping survey. Collecting additional fragments during or after the site characterization survey would reduce the DU source term in the affected area at minimal cost. We suggest collecting or flagging the fragments if the site characterization survey is conducted when the soil surface is visible.

The scoping survey was conducted according to NRC guidelines (Berger, 1992). Grid lines were established at 50 m intervals from north to south, and radiation readings were taken every 10 m along an east to west (or west to east) traverse of each grid line (SEG, 1995). The 50 m north-south grid lines were used in place of 10 m grids because of the large area covered in the scoping survey. The 50 m grid resulted in over 25,000 readings; a 10 x 10 m grid would have generated at least 217,000 measurements and taken significantly longer to complete. The 50 x 10 m grids were sufficient to provide adequate data to delineate the affected and unaffected areas.

Figure 5-1 of the SEG report (SEG, 1995) shows the areas with dose rates greater than 13.3 µR/hr. The 13.3 µR/hr limit was the upper 95% confidence level calculated from the survey data. The affected area determined by the 13.3 µR/hr criterion covers approximately 2.9×10^6 m^2 or about 700 acres.

5.3 Site Characterization Survey

The affected and unaffected areas delineated during the scoping survey are the focus of the site characterization survey. Removal of surface fragments and fragments near the surface will reduce the DU source term significantly. However, residual DU concentrations will remain in the JPG soils and sediments. The purposes of the site characterization survey are to determine the spatial distribution of DU in the affected area and provide the data needed to assess the potential exposure of the ecosystem to the residual radioactive material.

5.3.1 Survey Grids

The survey began by establishing a 10 m x 50 m grid in the affected area. The important factors in determining the size of the survey grids were the number of samples required for an adequate survey and the total area that needed to be surveyed. The grid size for the affected areas was determined after analysis of the scoping survey data.

Survey of the unaffected areas was less exhaustive than in the affected areas (Berger, 1992). Data collected for each soil or sediment sample included DU concentration, the radiation exposure rate at the sampling point, and the location of the sample. Locations of samples were recorded on the impact area map for future reference.

5.3.2 Site Background Determination

Background measurements were made during the site characterization survey. Background areas were selected from the unaffected area determined in the scoping survey and from areas near the impact area that were not used for DU munitions testing. Ten samples were collected initially and analyzed for background radioactivity. Background radiation was adequately characterized for the site when the average of these samples was < 10% of the guideline level of

35 pCi/g (*i.e.*, 3.5 pCi/g). Adequate sampling was conducted to provide the background radiation of about 10 to 15 μrad/h.

5.3.3 "Hot Spots"

Areas of elevated concentration, also known as hot spots, were identified during the site characterization survey. However, these hot spots were incorporated into the risk assessment calculations and were not shown to cause significantly higher risks to humans or the ecosystem. Thus, the elevated areas were considered acceptable for decommissioning.

5.3.4 Estimation of Average DU Soil Concentration

One goal of the site characterization survey was to estimate the average soil concentration of residual DU in the affected areas. Data from the survey along the 10 or 50 m grids proposed for the site characterization survey provided the information to complete this goal. The data also showed the distribution of the DU concentrations on the site in addition to the average value. The average DU concentration was used to estimate the expected doses to humans and the ecosystem from residual DU, whereas the distribution of concentration values is essential in estimating the uncertainty in the expected doses. Average doses were from 1 to about 5 pCi/g of DU according to the SEG (1995) report.

Data collected along the grids was plotted and the necessary statistics to describe the sample population were calculated. Elevated areas were included in the averaging. Average concentrations were calculated using the procedures outlined by Berger (1992; Section 8) and shown in the risk assessment report (Ebinger and Hansen, 1996). Weighted and unweighted averages were calculated and compared to the guideline of 35 pCi/g. The 95% confidence interval was from about 1 to 5 pCi/g.

5.3.5 Map of Residual DU

The data collected in the site characterization survey were used to construct a detailed map of the residual concentration of the affected areas. From this map and from analysis of the data as discussed above, the need for further remediation of the affected areas was evaluated. Figure 4-2 of the SEG report (SEG, 1995) shows the importance of mapping the data to aid visual interpretation of the site. The map data was of great importance in evaluating the average soil concentration and in estimating the actual size of the affected area for the risk assessment.

5.3.6 Pathway Analysis and Risk Assessment

The site characterization data was used to estimate the exposure of humans and different ecosystem components to residual radioactivity from DU in the affected area. RESRAD (Yu *et al*, 1993) is one model that was used in the estimation of dose to humans and the ecosystem. The results indicate that little risk of detriment to humans or the ecosystem is expected unless intensive farming occurs in the impact area.

5.4 Site Remediation Decisions

5.4.1 Discussion on Remediation

There are several reasons arguing against remediation of the impact area beyond surface cleanup of DU fragments. First, the risk of adverse human health effects is low if the recreational land use scenario is used, that is, if the site were released for restricted use. The current hunting program and potential access by way of maintained or administratively controlled trails are in accord with release for restricted use. Risk of adverse health effects to ecosystem components, specifically deer, are also infinitesimal as long as extensive farming does not occur. Extensive farming of the impact are is not recommended, nor are there plans to return the site to farm land.

Also, data from groundwater monitoring wells show little contamination from DU, and no significant contamination is expected in the future because of the limited mobility of DU fragments. Thus, maintaining the impact area within a recreational scenario appears reasonable and within the scope of BRAC plans for JPG.

A second argument against remediation beyond surface cleanup is the cost to remove the DU from the JPG soils and sediments. The Mason and Hanger Report (Mason and Hanger, 1992) estimates UXO cleanup costs at JPG for FY 94 at about $19 million, with total costs ranging from $225 million to $7.8 billion (single reuse option) or $1 billion to $1.6 billion (multiple reuse option). The cost per acre is ranges from approximately $4.1K to over $140K. The estimate for clean up of the DU area is from $2.8 million to $98 million, with $12 million a best estimate using the multiple reuse option. The estimates for the DU area comes from the Mason and Hanger data and assumes that cleanup of UXO in the impact area would cost the same as UXO cleanup at other ranges at JPG. Additional cost estimates for UXO cleanup are discussed in Section 5 below.

A third argument against further remediation includes the impacts to the environment because of the remediation activities. Excavating portions of the impact area may result in removing DU fragments, but disturbance to the environment could also result in degraded surface water quality due to excess runoff from the excavated areas and disturbance of established habitat for several species of game and non-game animals. Small-scale excavation, on the order of tens to hundreds of square meters, would minimize environmental impacts, whereas excavation of the entire impact area would result in significant erosion of soils, disturbance to stream sediment, and habitat removal for many species of plants and animals.

Associated with excavation is the issue of worker safety. The presence of UXO in the impact area complicates the plans for remediation. To ensure worker safety, excavation would be done remotely, and the time to complete the task and the cost would increase. The issues of worker safety and impact to the environment must be factored into the decisions to remediate the impact area.

Remediation of the impact area because of the high UXO concentration on the site could be the deciding factor in a decision to remediate or if no further action is appropriate. If remediation occurs because of the high concentration of UXO, DU remediation should occur simultaneously with the UXO remediation. The costs of remediating UXO and DU would not be significantly higher than remediation for the UXO alone. Further, the safety issue mentioned above would already be addressed through UXO remediation. The effects of the remediation on the quality of the ecosystem, however, is still a concern. Whether the goal is to remove UXO or DU, there are still impacts to surface water quality as well as habitat disturbance and potential release of residual material due to the technologies applied during the remediation.

Data from SEG surveys (1995) indicate that the cost of remediation ranges from nothing if no remediation is conducted to over $12M if penetrators are removed and contaminated soil is remediated. Much of the cost in the last option is in disposal of the waste and in the remediation of the soils by washing or other technologies. The cost estimates assume that facilities for disposal are available for use and that remediation technologies are sufficiently proven so they provide the necessary level of cleanup. The results of the risk assessment calculations underscores the importance of examining the "no action option" in the case of DU remediation at JPG.

5.4.2 NEPA Documentation

Preparation of an environmental assessment (EA) in accordance with the National Environmental Policy Act (NEPA) shall be completed if the decision is to remediate and after the affected and unaffected areas are delineated. The EA shall state the impacts to the ecosystem, and shall address the ramifications of removing the contamination. As discussed above, excess impact to the environment due to the removal of the contamination is not a desired result. The removal of the contaminant must be weighed against the adverse effects on the environment caused by removing the contaminant and the added risk of injury to workers performing remediation activities. A finding of no significant impact (FONSI) in the EA means that the remediation can proceed. Significant impacts on the environment, however, will require an environmental impact statement (EIS) and will involve long delays and higher costs in completing the decommissioning.

5.4.3 Remediation Decisions

During the preparation of the EA, the need for deep excavation must be evaluated. Removing the buried DU means that the source term is decreased significantly. However, the risk of injury or death to workers handling UXO will decrease the benefit of DU removal and render deep excavation undesirable. Deep excavation may also lead to significant ecosystem effects such as destruction of habitats, alteration of biodiversity in the impact area, and/or decreased stream and groundwater quality due to increased erosion from the remediated areas. The costs of reclamation and the possible impacts that reclamation could have on large areas also become factors in planning for deep excavations.

An alternative to deep excavation is to excavate the elevated areas by hand or other means to only tens of centimeters in depth. Excavation would be easier to execute, much less destructive to the environment, and should effectively remove the most significant source of DU in the environment. Risk to workers from both DU and UXO would be minimized with the help of JPG EOD personnel and protocols designed to minimize risk of adverse effects due to UXO. Recovering the DU from hot spots and shallow burials aid in monitoring both personnel and the environment during the remediation process.

The appropriate remediation efforts will be determined at the time of the decision to remediate. Technologies not currently available will be considered at that. If further remediation is not required, the decommissioning will proceed to the final survey stage. However, at least surface clean up in elevated areas is expected before the final survey begins.

5.4.4 Radiation Survey and Monitoring

If remediation is required, radiological survey will be implemented during the remediation to ensure that the remedial actions are meeting the goal of removing residual radioactive material below the guideline level. At all times during the remediation, regardless of which method is used, the site and the workers will be monitored. Dosimeters will be carried by all personnel in the field in order to estimate the doses to workers and to keep the doses as low as reasonably achievable. The remediation survey will show if the workers are successful in removing the contamination from the soils and sediments at JPG. Areas sampled will be surveyed and recorded to show the progress of the remediation and to provide records of the reduction of DU in the field. Areas that are surveyed and are still not acceptably clean will be reworked until successful surveys are obtained. Areas that are surveyed during remediation will be compared to the map constructed during the site characterization survey to determine the effectiveness of the remediation.

5.5 Final Survey

The purposes of the final survey are 1) to demonstrate that the JPG site has been surveyed and cleaned to specified standards; 2) that the NRC license held by the U. S. Army at JPG can be transferred or terminated; and 3) the site is ready for release for restricted public use. The final survey will be conducted in the same manner as the site characterization survey for the affected area, and will incorporate data from the unaffected area gathered during the scoping survey and site characterization survey. The 10 m x 50 m grid from the site characterization survey was used along with the same soil and sediment sampling plan used during site characterization. Data collection included activity measurements, soil or sediment collection, and geographical location information.

The data from the final survey were recorded on the site map, and the map was used extensively to compare the results of the surveys and the distribution of residual DU. A detailed plan for the final survey will be written and approved by the NRC before the final survey begins.

Statistical comparison of data to guideline values were conducted as discussed above. Data from different surveys at JPG were used together and compared to guidelines. The methods used to obtain the data, that is, a combination of survey measurements in the field and submitting samples collected in the field for additional chemical analysis in a laboratory, were consistent from survey to survey. The results of all comparisons will be tabulated as appendices in a final report to document the progression of the decommissioning from scoping survey to final survey.

The site characterization data combined with the ERM data and the site survey indicate minimal risk to humans and the ecosystem. The estimated risks from the DU concentrations measured in the surveys and the ERM data were immeasurable. Risk estimates using the 35 pCi/g limit for soils and sediments resulted in higher risk, especially to humans if they farm the impact area. Occasional use by hunters, however, resulted in nearly immeasurable doses even at soil concentrations of 35 pCi/g. Risk assessment calculations based on the SEG final surveys provide confidence that the residual DU poses no significant risk if the area remains restricted use.

5.6 Health and Safety Considerations

Protection of workers during the surveys will be provided in accordance with JPG radioactive materials safety plan or in accordance with an approved radiation safety plan implemented by contractors performing remediation activities. Workers will also be subject to safety plans related to handling explosives and UXO in the field. Modifications to existing JPG safety plans may have to be made in order to work safely in the field. If such changes in the safety plans are required, they should be made as soon as possible to avoid delay in completing the work.

Protection of public health and safety is also an issue. No member of the general public will be near the area of interest during operations. Site access will be controlled, and all traffic into and out of the impact area will be monitored. Access to the DU area will be controlled even after remediation to ensure public exposure to residual DU is minimized.

Activities such as the surveys, recovery of spent penetrators and fragments, and general area operations will be designed and conducted in a manner that ensures all exposures to DU will be kept as low as reasonably achievable. The radiation protection officer for JPG and/or the remediation operations will determine whether specific jobs require protective measures (clothing, respirators) for safe completion. Also, JPG ordnance experts will determine the safety needs for all personnel in the impact area and near UXO. The goals are to ensure that no worker is unnecessarily exposed to DU during the surveys and clean up, and to ensure that all personnel are kept safe from UXO on the site.

All contractors responsible for remediation or any activity that requires site access must demonstrate that they have adequate training to handle radioactive material and samples that could contain radioactive material. Training includes familiarity with specific procedures concerning environmental sampling, data QA/QC, sample handling and preparation, personal radiation monitoring, selection and use of protective clothing, and emergency procedures. Contractors will also demonstrate familiarity and compliance with U. S. Army procedures pertinent to their activities at JPG.

The radiological hazards associated with activities at JPG are limited to DU. While the specific activity of DU is approximately half that of naturally-occurring U, the chemical toxicity is an important factor with regard to health effects (Diamond, 1989; Kocker, 1989; Leggett, 1989). Thus, working conditions must be maintained to minimize both radiological exposure and toxicological exposure in order to minimize adverse human health effects. The significant exposure pathways include inhalation of DU in dust and ingestion of DU through food or water. Inhalation exposure can be minimized by maintaining a damp work area especially when soils are being excavated. Wetting soil surfaces with water before excavation will minimize the dust that is raised during excavation.

Face masks or face shields that filter dust are also adequate as long as the masks conform to the OSHA standards of 29 CFR 1910. Personnel electing to use face masks must be certified to do so and provide verification of their ability to use this type of protection. Personnel choosing masks or respirators shall also consider the extra physical stress induced when such protection is used.

Special areas for consuming refreshments (water, liquids, snacks) during working shifts will be established within the impact area. Eating and drinking outside these areas will not be allowed in order to minimize the possibility of ingestion of DU. Because of the UXO on site, smoking in the impact area will not be allowed. A decontaminating facility will be established for all workers in the field. The facility will include a changing station to allow workers to change boots and overalls before leaving the affected area, cleaning station to wash hands of any remaining DU from the site, and storage of protective clothing for later use. Traffic through the station will be regulated so that DU from the affected area is not tracked through the decontamination facility. Personnel will be monitored as they enter and as they leave the facility to ensure that mobile DU is not transferred out of a given affected area.

5.7 Instrumentation

Exposure rate measurements will be made using sodium iodide or thin plastic scintillation detectors. Measurements of counts per second will be converted in to μR/h. Exposure rates above background will be attributed solely to DU. Concentrations of DU in soils and other media sampled during the surveys will be analyzed by α-spectroscopy or inductively-coupled plasma with mass spectrometry (ICP-MS). Data obtained by α-spectroscopy will be converted to exposure rate in μR/h, and data from ICP-MS will be converted to activity concentration, then to exposure rate.

The calibration of all instruments will be checked at the beginning and end of each day of use and at least twice during the day while in use. Results of calibration checks will be recorded at the time they are made in field notebooks. Entries concerning instrument performance in the field notebooks will be checked weekly for adequacy by designated supervisors. All calibration standards will be traceable to NIST.

Instruments will be scheduled for periodic maintenance, and a log of maintenance will be kept. No instrument will be used in the field if it is due for maintenance or if it fails the daily calibration checks.

5.8 Estimated Cost of DU Remediation

Estimates for DU area clean up are shown in the SEG report (Table 2-1, 1995). It is clear from the SEG analysis that risk-based decisions concerning remediation must be considered. In areas where risk is low of adverse effects to humans and the ecosystem, a corresponding emphasis should be placed on remediation of the area of interest.

6.0 Unexploded Ordnance Remediation

6.1 Overview

Unexploded ordnance poses a significant complication when considering the remediation of JPG for release as land for restricted or unrestricted use. By all accounts, there is considerably more UXO at JPG than DU, and the UXO is distributed over more of the site than the DU fragments. An estimated 1.5 million explosive munitions have been fired since World War II and presumably remain on site. The amount of UXO ranges from less than 1 per acre to 85 per acre, and a map of the potentially affected area suggests that most of the land area is contaminated by UXO in the high (4 UXO per acre) to very high (85 UXO per acre) category (Mason and Hanger, 1992). The DU area falls mainly in the very high category with some in the high category.

Considering the risks of injury or death due to UXO-related accidents is important in decisions about remediation of JPG. Release of the site for unrestricted use requires removal of all UXO at all depths. Since UXO has been found to a depth of 25 feet, extensive deep excavation is required to remove the UXO. Deep excavation generally means that the first 25 feet of JPG soils will be strip-mined for UXO. Since the depth from soil surface to limestone bedrock is often less than 25 feet (Abbott *et al*, 1983; Nickell, 1985), removal of the entire ecosystem now present at JPG is required in order to remove the UXO. Release for unrestricted use is not recommended from the standpoint of ecological damage alone. Economic considerations are important also. Estimated costs to remediate for unrestricted use range to about $8 billion and would not be completed until approximately 2021 (Mason and Hanger, 1992). Controlled access for recreational use or using the JPG area as an R&D testing center for UXO cleanup are variations of restricted use scenarios, as is the U. S. Fish and Wildlife scenario. Each has its cost, ranging from $225 million per year for the R&D test center alternative to over $2 billion per year for controlled recreational use, exclusive of the Fish and Wildlife preserve.

6.2 Location of UXO

UXO remediation involves finding the UXO, then removing or destroying it. The problem is similar to locating DU, except that remote sensing of UXO is more complicated than for DU. Once located, disposal or destruction in place tends to uncover more UXO because the concentration of UXO in soils is so large (Mason and Hanger, Chapter 5). Operations to maintain safe and useable impact locations for testing at JPG result in reported detonation of multiple ordnance during blading. Field detonation of individual ordnance often results in uncovering more ordnance that require destruction or removal.

Ground cover obscures UXO on the surface and causes significant difficulty for crews who search the impact areas. General practice at JPG includes burning the grass and leaf-litter cover yearly so that the ground surface can be seen clearly. Usually only 10,000 acres annually are cleared by burning, but larger areas will need to be burned for UXO remediation. While large-scale burning is not always desirable, the risk of injury from UXO detonation is significantly reduced when undergrowth is cleared and workers can see the surface and the UXO clearly. Clearing of impact areas is also done, but there tends to be a large number of UXO migrating to the surface due to frost heaving after clearing (Mason and Hanger, 1992).

Location of surface and subsurface UXO can be accomplished during the different surveys for DU. Additional personnel will be required to operate the magnetometers or other UXO detectors in addition to the DU survey equipment. With more people in the field, however, the probability increases that more UXO and DU will be found than with smaller survey crews. Surface and subsurface UXO locations shall be flagged and mapped for later collection or destruction during the scoping survey. Collection of surface UXO shall be done concurrently with the DU collection. Only those ordnance that are safe to handle and dispose of should be removed, the remainder should be destroyed in place. Those UXO that require destruction in place shall be left until after the DU collection is complete. The subsurface UXO should then be excavated, then removed if appropriate. The UXO deemed unsafe for handling will then be destroyed in place and the area searched for new UXO uncovered during the destruction operation.

Different technologies for detecting and removing UXO are discussed in previous reports (Mason and Hanger, 1992). New technologies presently under development and technologies not discussed in the Mason and Hanger report should be considered as the remediation of UXO is planned. Such technologies as robotic search vehicles may be on line at that time, could reduce risk of injury to workers, and could significantly increase UXO recovery.

6.3 Additional UXO Surveys

A site characterization survey shall be completed after the scoping survey, and can be piggy-backed with the DU site characterization survey. The site characterization survey will be similar in scope to the DU site characterization survey. The same grid system can be used for both site characterization surveys. Survey crews would include personnel capable of using the UXO detection equipment, EOD experts to identify UXO, and the DU survey personnel. The UXO sweep will be done at the same time as the DU survey, allowing UXO data and DU data to be used together. A map of the UXO in the DU impact area will be constructed and will be used to guide additional clean-up of UXO.

6.4 Procedures for UXO Handling

Procedures for UXO removal, handling, excavation with and without heavy equipment, and UXO identification in the field will be adopted from the procedures used presently at JPG. Changes in any of the procedures will require review and approval of EOD personnel to ensure the safety of the survey crews.

6.5 Cost Estimates for UXO Remediation

Costs have been estimated in the Mason and Hanger report and range from about $225 million into the billions (Table 1). These figures are for remediation of the entire JPG reservation. We recommend revision of these figures with regard to different technologies after the radiological survey results are complete. Factoring in technologies that have not been considered to date could result in significant cost savings and possibly increase the efficiency of the remediation.

Three promising technologies for UXO clean up are laser cutting, explosive identification using laser-induced fluorescence (LIF), and base hydrolysis of explosives. Cost estimates are not available for these technologies because they are currently in the demonstration phase of development (John Sanchez, DX-16, LANL, personal communication).

Laser cutting is a field portable application of a successful method for separating explosive materials from metals such as casings of munitions. This application reduces the risk of explosions and detonations from conventional cutting technologies, thereby increasing worker safety in the field. Laser cutting can be coupled with LIF and positive identification of the explosive can be made during the cutting operation.

Base hydrolysis is a chemical treatment for explosive materials. In the process, explosives are treated with a strong base to hydrolyze solid explosives. The liquid remaining after the hydrolysis, the hydrolysate, is significantly less energetic than the starting explosive material. The hydrolysate is then either decontaminated by way of biodegradation reactors or decomposed to non-hazardous components by way of supercritical water oxidation. Currently the demonstration phase for base hydrolysis is a laboratory-based operation, but there are plans for hydrolysis units for field use.

Although exact costs per acre are not available, demonstration of the technologies in the field and laboratory could be completed for a fraction of the costs estimated in the Mason and Hanger report (Mason and Hanger, 1992), or approximately $10 million.

7.0 References

10 CFR 40, Section 42, paragraph (c)(1)(v)(D), January 1, 1994.

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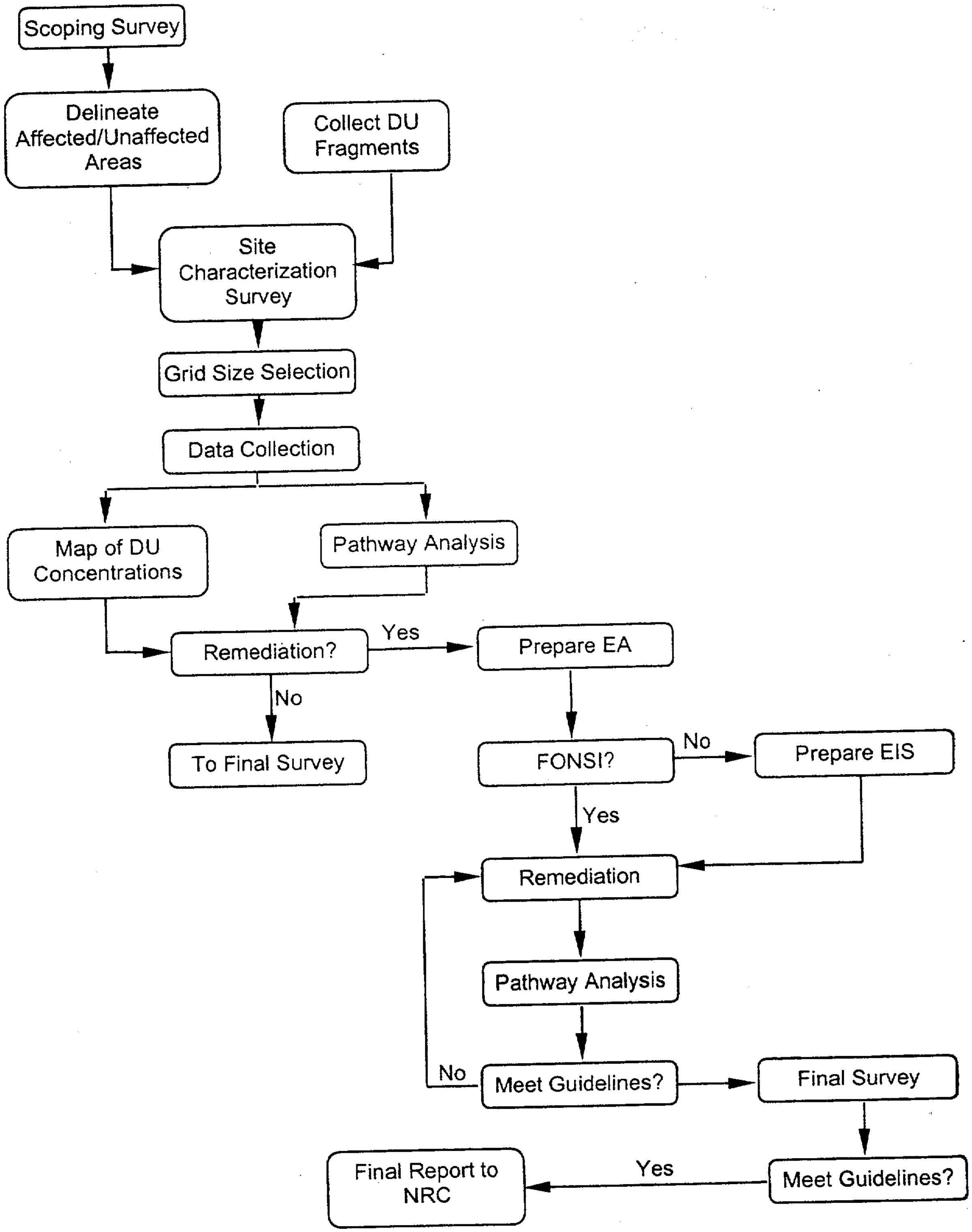
Figure 2. Remediation Flow chart for decommissioning at JPG.



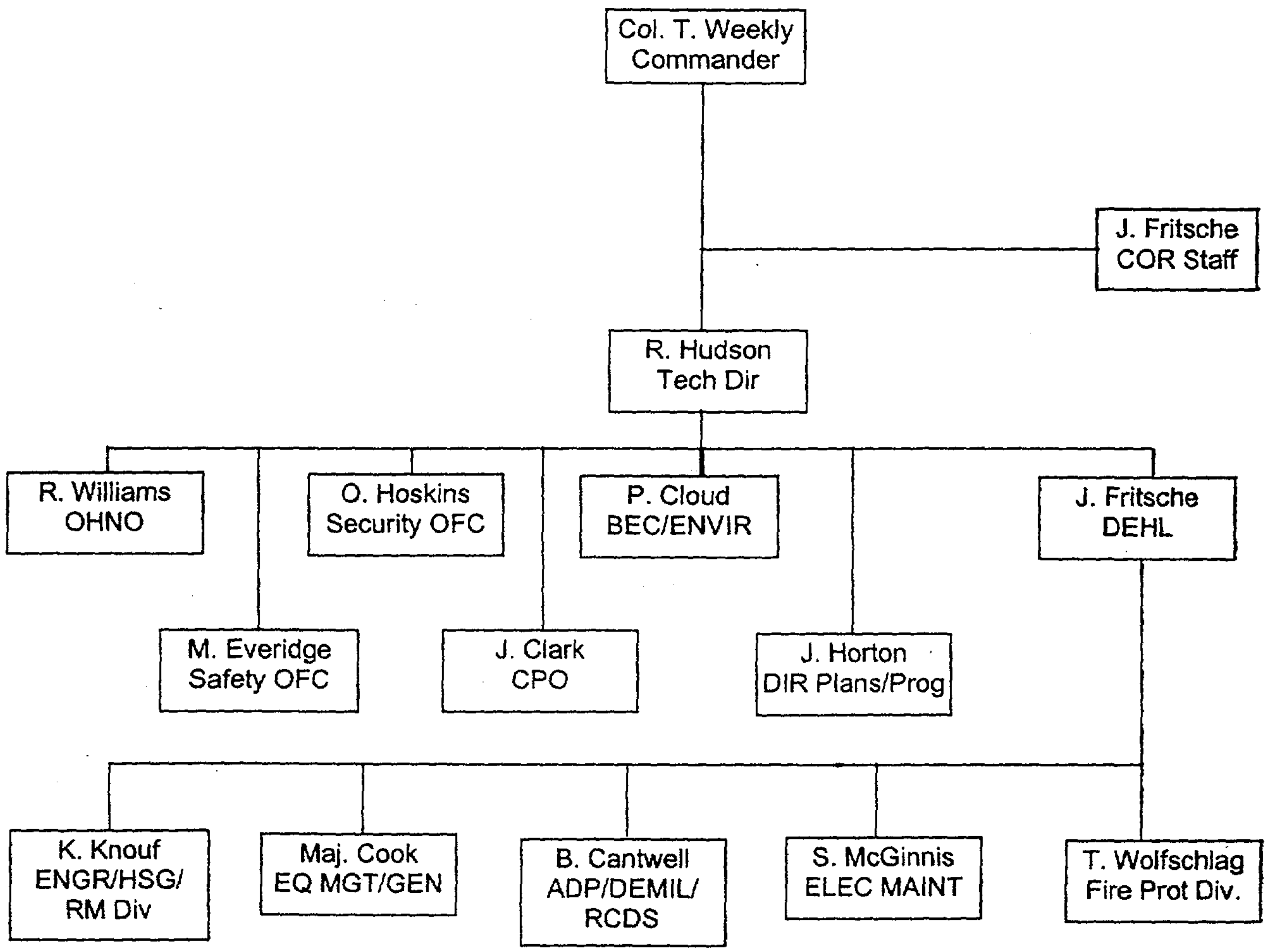
Appendix A

Schedule and Milestones

Milestone	Date
Contract Awarded for Risk Assessment	Jun 93
Contract Awarded for Decommissioning Plan	Oct 93
Contract Awarded for Scoping Survey	11 Apr 94
Termination of DU Testing	2 May 94
Draft Decommissioning Plan	15 Aug 94
License Renewal Application	30 Aug 94
Risk Assessment Completed	15 Sep 94
JPG Ceases Testing	30 Sep 94
Meeting with NRC, IDEM, TECOM, AEC, SEG, LANL	14 Oct 94
Begin Scoping Survey	15 Oct 94
Final Decommissioning Plan	15 Dec 94
Scoping Survey Completed	30 Dec 94
Scoping Survey Report	30 Jan 95
Meeting with NRC, IDEM, TECOM, AEC, SEG, LANL	15 Feb 95
Begin Monitoring Plan	30 Mar 95
JPG Closes	30 Sep 95
Confirmatory Survey	1 May 96
Request License Termination	Oct 96

APPENDIX B

JPG Organizational Chart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COR Staff
R. Hudson
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R. Williams
OHNO
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Safety OFC
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