 USING HYDRO-CUTTING TO AID IN REMEDIATION OF A FIRING RANGE CONTAMINATED WITH DEPLETED URANIUM

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ABSTRACT

This paper describes the challenges encountered in decommissioning a firing range that had been used to test fire depleted uranium rounds in the late 1950’s and early 1960’s. The paper details the operational challenges and innovative solutions involved in remediating and decommissioning a firing range bullet catcher once unexploded ordnance was discovered. It also discusses how the Army dealt with an intertwining web of regulatory and permit issues that arose in treating and disposing of multiple waste streams. The paper will show how the use of a Resource Conservation and Recovery Act (RCRA) Temporary Authorization allowed the Army to deal with the treatment of a variety of waste streams and how hydro-cutting process was used to demilitarize the potentially unexploded rounds.

BACKGROUND

The Lake City Army Ammunition Plant (LCAAP) is located at the intersection of Missouri Highways 7 and 78 in Independence, Missouri. The LCAAP is a Government-Owned Contractor-Operated (GOCO) military industrial installation that manufactures small arms ammunition. In the late 1950’s and early 1960’s the installation manufactured, tested and later demilitarized a 20mm spotter round that contained depleted uranium (DU).

LCAAP had a small-scale DU operation during the 1960's and 1970's. Developmental planning of the XM-101 DU spotting projectile started in 1959 and by 1961, LCAAP was producing approximately 8,000 rounds per month. The XM-101 (later M-101) round consisted of a fused, 20mm projectile with a body constructed from DU. LCAAP also produced an XM-106 round identical to the XM-101, but without the explosive components. The installation designed, manufactured, and tested, and in later years demilitarized, some 75,000 20mm DU spotter rounds. The spotter rounds were approximately 6 inches long, 20mm in diameter and weighed approximately 1 pound each. The machined DU body made up 95% of the round’s 1-pound weight and contained a fused red phosphorous charge that would ignite after impact.
These munitions were designed as a high trajectory, low velocity lob round with primary ranges of 2,188 yards and 1,750 yards. One particular design specified the XM-101 accuracy as “50% probability inside a 50-yard diameter circle at 1,750 yards.” Various documents have interchanged yards and meters. Initially, DU activities consisted of test firing of approximately 2,000 XM-101 rounds to target areas at 1,600 and 2,000 meters. Radiation surveys conducted in 1993 confirmed impact areas at 1,750 yards and 2,188 yards.

For production purposes, the plant stored bar stock of depleted uranium in crates outside Building 3A. They protected them from the weather by covering the materials with plastic sheeting. Procedures stated that packages of DU would be brought just inside the building to support machining operations. They stored scrap from machining operations in water filled containers. Remington Arms Company, (then the LCAAP operating contractor) stored these filled cans in a metal storage shed behind Building 3A. When preparing materials for shipment off site, Remington replaced the water with oil. They would then over-pack the containers into 55-gallon drums before shipment, (reference U.S. Army Environmental Health Agency, 1961).

LCAAP confined the manufacturing activities for the Davy Crockett spotter round to Building 3A and Building 12. Chem Nuclear Systems, Incorporated (CNSI) was contracted in 1987 to decommission Buildings 3A and 12. Radioactive waste from this activity was disposed at the Barnwell, SC, low-level radioactive waste burial site. After the decommissioning, the NRC Region III authorized (reference NRC letter March 17, 1988) release of the buildings for unrestricted use.

LCAAP produced approximately 75,000 rounds of XM-101 ammunition from January 1961 to December 1963. By 1968, the Army terminated the Davy Crockett program and LCAAP was left with an estimated 44,000 spotter rounds to dispose. In 1971, Remington proposed procedures for the disposal of the remaining XM-101 rounds. Since the rounds were fused, the safest demilitarization methodology involved shooting the rounds into a sand filled catch box, identified as the “600 Yard Bullet Catcher.” Remington demilitarized the rounds by firing them into this sand-filled bullet catcher, the sand was used as an impact material.

All DU operations (manufacture, testing and demilitarization) from 1960 through 1985 were performed under Remington’s Nuclear Regulatory Commission (NRC) license. In 1985 Olin Ordnance Corporation became the LCAAP operating contractor. The DU operations were then added to the U.S. Army (then HQ, AMCCOM) Headquarters, Operations Support Command (HQ, OSC) NRC license for storage and possession of source material, SUC-1380.

In 2000, the Army contracted with Cabrera Services to perform NRC decommissioning activities on the 600-yard bullet catcher. The effort entailed removing and transporting an estimated 40,000 cubic feet of sand/soil contaminated with DU and hazardous levels of lead, per Resource Conservation and Recovery Act (RCRA). The DU levels averaged 198.6 pCi/g. Based on an isotopic make-up of 83.1 % U238, 15.0 % U234 and 1.9 % U235, the material was determined to be less than 0.05% source material by weight and therefore an unimportant quantity of source material in accordance with 10 CFR 40.13. The average concentration was estimated using on several dozen analytical (gamma spectroscopy) samples and verified with a mass balance calculation. The RCRA leachable lead levels from a limited analytical data set (Toxicity
Characteristic Leaching Procedure (TCLP)) was estimated to be in the 7-12 parts per million range. The NRC approved the Cabrera prepared decommissioning plan in April 2001 by amending the Army’s license to permit decommissioning activities.

Cabrera began field activities at LCAAP in May 2001. During the early stages of the remediation, Cabrera discovered unexploded ordnance (UXO) and, with the Army, revised the remediation process to ensure we generated the UXO and soil wastes separately. In accordance with RCRA, once the soil is excavated, it becomes a “waste.” Removal of the UXO from the resultant waste would be considered “treatment” under RCRA. RCRA treatment requires a special permit that is expensive and difficult to obtain, often taking months or years for approval. To complete the decommissioning in a timely and cost effective manner, we determined we could identify and remove UXO and potential UXO fragments from the top 6 inches of surface soil. Once we cleared the top six inches for UXO we excavated that soil and created a new “surface” that we subjected to the UXO screening process. In this manner, we were able to remove the UXO from the soil before it became a RCRA waste.

A trained crew of UXO technicians removed potential UXO fragments in the soil by hand and stored the material on-site before soil excavation. Cabrera and the Army worked with the Missouri Department of Natural Resources (MDNR) to ensure this process did not require RCRA permitting. Before discovering the UXO problem, Cabrera generated approximately 40 cubic yards of soil containing DU, RCRA lead, fragments of exploded munitions, and UXO that they stored in intermodal containers in a RCRA-permitted storage facility. The RCRA Building is designated for storage of hazardous wastes and has 4,020 square feet of floor space. The building is completely exposed and is constructed of corrugated metal with a dirt floor.

In addition to the 40 yd³ of contaminated soil, several recovered 20mm projectiles were surveyed for radioactive contaminants and a portion contained surficial DU contamination. Cabrera shipped the clean projectiles to SafetyKleen in Colfax, Louisiana for treatment and disposal. UXO removed by hand, including 20mm conventional rounds, 20mm XM101 DU rounds and DU fragments were stored in a separate RCRA storage building. This area was designed for ammunition and ammunition component storage and has approximately 1,040 square feet of floor space. The building is constructed of reinforced concrete and is completely enclosed. The building is equipped with an 18-inch diameter neck size, gravity-type ventilator that discharges adjacent to the door and surrounded by earthen bunkers.

As stated above, Cabrera then moved the waste into Building 13F, a permitted RCRA long-term storage building at LCAAP, giving us one year to find a solution. Efforts to find a waste processing facility willing to take radioactive material, RCRA waste and UXO proved futile. Our only option was to work with MDNR and develop a RCRA Temporary Authorization (TA). The TA is essentially a one-time mini-RCRA Part B permit. MDNR indicated the Army would need a TA or Part B permit to manage each waste stream because the processes required to manage them the waste stream was not covered under existing LCAAP permits.

**TEMPORARY AUTHORIZATION PERMIT**

As previously stated, proposed on-site management of these wastes is considered treatment under RCRA (i.e., screening and hydro-cutting) by the MDNR. They indicated that a Temporary
Authorization or Part B permit was required to manage each of the waste streams because the required processes were not covered under current LCAAP permits. LCAAP requested authorization to complete the corrective actions to ensure compliance with RCRA hazardous waste storage requirements. In addition, our selected treatment operation required the approval of the US Army Explosives Safety community. Because of the potential for detonations, we were forced to perform all hydro-cutting operations at night and on weekends when the adjoining buildings were vacant.

The Temporary Authorization detailed proposed procedures to sift and sort for potential UXO. Cabrera proposed to hydro-cut projectiles that had the potential to be UXO. By eliminating the UXO hazard from the 40-yd$^3$ waste stream, we could manage the resultant radiological and RCRA hazardous waste streams. All operations were performed in accordance with Cabrera’s NRC Decommissioning License and 40 CFR 270.42.

Once the TA was approved, the screening operation was performed inside Building 13F where the 40 yd$^3$ of soil had been stored in DOT-approved intermodal roll-off boxes. Each filled intermodal was situated adjacent to an empty roll-off container. Soil in each filled intermodal was removed using a mini-excavator and spread evenly over the screen. The removal operation required screening the waste material to expose items according to size to identify potentially explosive ordnance that had been shot into the bullet catcher. Two UXO technicians used plastic hand rakes to pass the soil through the screen. Unexploded ordnance is a safety hazard and constitutes an imminent and substantial endangerment to the local populace and site personnel. For this reason, manual screening methods were selected because they provided for positive control with the least amount of disruptive conditions. Projectiles were removed manually and placed into containers for temporary storage.

The overall process (both the field activities and the TA) generated three 20mm projectile waste streams:
1. 20mm conventional HE rounds without surficial DU (341 projectiles), these were recovered during the field activities and were sent off site for thermal destruction;
2. 20mm conventional HE rounds with surficial DU contamination (619 projectiles); and
3. 20mm XM101 DU spotter round projectiles, intact (140 projectiles).

The methods and procedures described for the screening of the soil and handling of the suspect 20mm ammunition are standard Explosive Ordnance Disposal (EOD) procedures that have been field proven over the years. The process was extremely labor intensive and relied primarily on the training and expertise of the contractor performing the work, the equipment capability and reliability, and the use of qualified EOD personnel.

**HYDRO-CUTTING OPERATION**

The 140 each 20mm XM101 DU rounds and 619 each 20mm conventional rounds were addressed as part of the TA. The majority of these projectiles were sliced longitudinally starting at the base and traversing through the point-detonating (PD) fuse at the front. An abrasive slurry jet with the water and abrasives pressurized and accelerated together to 10,000 psi was used for the operation. The cutting nozzle was constructed of tungsten carbide/molybdenum carbide...
formed under high pressure. The cutting process generated DU scrap, metal scrap, and cutting related wastes.

All hydro-cutting operations were performed inside a ¾ inch thick steel plate structure capable of retaining all fragments from a detonation of an HE round. The structure had natural ventilation allowing excess water vapor from cutting operations to vent to Building 13F (Figure 1). No DU particulates were released from the hydro-cutting chamber due to particle size, mass, and downward trajectory of the water cutting jet.

**Fig. 1. Layout of hydro-cutting area within Building 13F.**

During hydro-cutting operations, the 20mm M101 DU rounds and 20mm conventional rounds were sliced longitudinally starting at the base and traversing through the point detonating fuze at the front. A high velocity stream of water was mixed with an abrasive agent (in this case garnet) to cut the UXO. The velocity of the water is a function of high pressure and the diameter of the orifice (a ruby orifice with a .014 cm diameter hole was used). As the high-pressure water passed through the orifice it created a high velocity stream that was mixed with the abrasive and together they exit the carbide cutting nozzle with a great deal of energy in a small space. This stream of particles and water are used to cut through solid steel, and can cut most any material, except diamond and some super alloys.
Cutting of HE rounds was performed at night when LCAAP personnel were not working in nearby buildings. Cutting operations were controlled from a remote control panel located outside Building 13F. Television cameras provided a direct view of the hydro-cutting process. Process cutting water continuously drained by gravity feed from the hydro-cutting chamber into a large storage tank. Water volume in the 55-gallon tank beneath the hydro-cutting apparatus was maintained at a constant level of 24 inches assuring that removed contents of the HE and DU rounds was captured and maintained in a safe, non-explosive, fully wetted state. The process following hydro-cutting did not rely on or use valving, pumps, or level controllers.

The particle stream is very small and the energy quite concentrated, resulting in some heat build up during the UXO cutting process. Cutting through the base first and the primer last minimized the chance of detonation. Once the case that encloses the explosive was split into two pieces, the UXO was rendered much less dangerous. Cutting UXO contaminated with DU with the water stream prevented most of the radioactive material from becoming airborne, the larger particles captured with in a 55-gallon drum.

The cutting rate was two to three linear inches per minute. Total wastewater production was approximately 1,000 gallons and was initially captured in a 55-gallon steel drum as part of the hydro-cutting system. The 55-gallon wastewater drum emptied (via gravity feed) into a large polyvinyl holding tank. High explosive 20mm conventional rounds and 20mm M101 DU rounds were cut separately to permit separate sorting of metal scrap and generated wastewater solids. The metal scrap and DU scrap generated in the process were caught by a screen under the cutting operation.

**Hydro-cutting Process Water**

The wastewater consisted of water with abrasive material (garnet-based sand), metal/filler (DU/red phosphorus/barium nitrate/RDX) from the UXO, fuze material, and small amounts of DU. These materials were initially contained in the 55-gallon hydro-cutting process drum at the hydro-cutting station.

The small size of the 55-gallon process drum resulted in greater than anticipated turbulence within the drum during cutting operations. A field change to piping was made to limit the amount of process wastewater that could directly enter the large 1,550-gallon receiver tank during hydro-cutting of the DU rounds. These rounds, unlike the HE rounds that had minor amounts of surficial DU contamination, consisted of a munition body comprised solely of DU. The field change consisted of disconnection of piping between the 55-gallon process drum and the 1,550-gallon tank and insertion of a pipe plug into the 55-gallon drum during cutting operations on the DU rounds. The 55-gallon drums provided in-tank settling of DU and cutting solids and were periodically changed out as the abrasive material, process wastewater, and cutting solids filled the drum.

This change eliminated the DU that could be directly carried over from the 55-gallon tank to the large 1,550-gallon receiver tank outside the hydro-cutting chamber during DU round cutting operations.
The smaller solids generated during the cutting operations remained in the 55-gallon hydro-cutting process drum. Wastewater contained in the polyethylene storage tank and the 55-gallon hydro-cutting process drum was sprayed over the screened sand/soil in the intermodals. In addition, a water binding polymer, SP400™, was mixed in with the water and soil with rubber paddles to absorb and bind excess water.

The hydro-cutting pump required two to five gallons per minute of cooling water during operations. Once-through cooling that was planned could not be used due to concerns that the discharge point in Building 11 (Lead Shop) would not accommodate this flow due the age and condition of the floor drain system in this World War II era building. Since direct discharge of the cooling water to the ground was not an option, a closed cooling system consisting of a new 300-gallon steel storage tank was devised. The tank was filled with fresh potable water from Building 11 and connected via flexible hose to the hydro-cutting pump in a closed-loop system. The hydro-cutting pump had a temperature sensor and shut down system to ensure cooling water inlet temperatures were within temperature specifications. Additional fresh potable water was periodically added as make-up. The tank was located with other hydro-cutting equipment outside the cutting chamber and within a secondary containment berm. Water from this tank was sampled for radioactivity before discharge to the LCAAP water treatment system and was never in contact with water used for cutting UXO.

Cabrera safety personnel’s calculations showed that the concentration of barium nitrate and DU in the wastewater was low and the spraying process would not cause a hazardous airborne condition. One hand auger boring was completed for each intermodal for waste characterization purposes and analyzed for characteristic TCLP, TCLP metals, and DU. Once the waste profiles for the process waste water were complete, Cabrera combined it (along with an appropriate absorbent) with the UXO-free sand and soil that was then shipped to a RCRA permitted disposal facility.

**FINAL DISPOSAL STATISTICS**

Soil sifting operations during the 2002 the Temporary Authorization work effort generated 137 conventional rounds and 22 DU rounds. These rounds were added to the existing 482 conventional rounds and 118 DU rounds previously generated during 2001 work at LCAAP, for a total of 619 conventional rounds and 140 DU rounds handled and disposed during this work project. 409 conventional 20 mm rounds and 82 DU 20 mm rounds were hydro-cut before ultimate disposal. The remaining 210 conventional and 58 DU rounds were examined by qualified UXO personnel and found to be void of energetics (inert) and required no additional treatment prior to packaging, shipment, and disposal.

All waste contained within Building 13F intermodals or generated during hydro-cutting operations were disposed in accordance with the Temporary Authorization permit. Four intermodal containers containing UXO-free soil with lead were shipped to Waste Control Specialists in Andrews, Texas for lead (D008) treatment and disposal. Five drums containing DU were shipped to Duratek Consolidation & Services Facility (Duratek) in Barnwell, South
Carolina. Volumes of waste shipped from LCAAP were four intermodal containers with approximately 40-yd³ total of lead contaminated waste and unimportant quantities of uranium were shipped to WCS. In addition, four 55-gallon drums (29 ft³) of solidified hydro-cutting generated sludge containing DU and one 55-gallon drum containing DU scrap metal, sand, and 200 lbs of soil were shipped to Duratek.

CONCLUSION

Decommissioning an artillery firing range can present unique challenges. As with most large-scale remediation projects not all the challenges are apparent prior to project mobilization and many times do not become apparent until remediation activities actually begin. In spite of the presence of a variety of waste streams and a challenging regulatory environment, the decommissioning of the 600-yard bullet catcher area of the firing range at Lake City Army Ammunition Plant was carried out safely and efficiently and in compliance with applicable regulatory requirements. With no other technically viable options and no offsite facilities capable of handling the three hazards (radiological, RCRA hazardous and explosive), finding a timely solution was critical. The use of the RCRA Temporary Authorization and hydro-cutting technology allowed the project to be completed in a timely manner and created cost effective disposal options for each waste stream.