

2. Clearance and decontamination

Explosive technologies in decontamination areas polluted by military activity

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ABSTRACT: As overall enemy focus has changed from a cold war perspective to the present global stabilisation and fight against terrorism, a large number of former military training facilities around the world were abandoned. The areas are scattered in both rural, close urban, and remote areas. Some areas are very attractive with respect to urban development and public use. Other areas were left with no real plan for the future; and in many cases thought to stay abandoned, forgotten and locked away.

The present national and international environmental awareness in terms of risk of explosive hazards, chemical and explosive pollution, combined with the actual attractiveness of both the rural and urban areas have changed the fate of the areas. In Europe a number of former military training fields have been cleared. However, the major part of the areas needs to be cleared. A huge task lies ahead to implement the plans of both international and national public and private organisations and companies. Also areas contaminated by ammunition and mine fields from World War II still remain in many European countries.

Based on more than 30 years of experience this paper elaborates on the challenges on reclamation of land contaminated by munition-related activity, including the explosion risk management and environmental protection.

International standards and guidelines for demilitarisation and explosive ordnance disposal (EOD) of unexploded ordnance (UXO), focussing on detection of UXO, render safe procedures, and destruction of UXO by detonation will be introduced. Also project planning, implementation and management will be presented.

Issues related to assessment of the UXO sensitivity and risk based approach, will be discussed. Experiences from Danish projects will be demonstrated:

- Clearance of 60 ha former military area for urban development of a new city, Oerestaden, close to Copenhagen Airport.
- Surface clearance of 1500 ha nature reserve for public access and commercial use.
- Clearance of an old test shooting facility used for calibres up to 3 inch rockets.

The presentation will focus on explosive technologies and blasting issues, including the problems related to getting permits from the authorities to purchase explosives, transport and storage of explosives on site, and the use of explosives for destruction of the UXOs.

1 INTRODUCTION

Pollution and risk related issues on former military areas have been a big part of the work of NIRAS

DEMEX over the past 30 years, only increasing with the change in both the national and international focus on military threats due to the end of the cold war and the increased focus on terrorist

threats.

The challenge has been heightened by the public awareness of explosive hazards, and chemical and explosive pollution of the former military areas. These areas have become attractive, due to their position, for use either as extensions of urban or suburban settlements or, in the case of the rural areas, the possibility of converting them into new nature areas and reserves, for public use.

NIRAS DEMEX has been the lead on the

European Union backed research project EUCLID RTP 14.12 developing tools to improve the efficiency and systematisation of identification and quantification of polluted sites. The research resulted in a focus on tools which have been used in ammunition and mine clearance projects both inside Denmark and internationally. This paper focuses on the use of a common database to track land contaminated by munition-related activities, and the reintroduction of these into civil society.



Figure 1. Small map in upper left corner: (A) The Urban Amager, (B) Sub-urban Værloese and the rural (C) Skallingen. The main map is an overview of Amager part of Copenhagen. (1) Oerestaden, new district of Copenhagen. (2) Kalvebod Miljø Center (KMC), expansion of Denmark's largest soil remediation centre. (3) Royal Golf Center. (4) Kalvebod Fælled, nature area for public access.

Reclamation projects and clearance procedures involve challenges with regard to:

- Standards and guidelines for demilitarisation and explosive ordnance disposal (EOD) of unexploded ordnance (UXO) focussing on the search for UXO, including the International Mine Action Standard (IMAS).
- Procedures to search for and clear the found items.
- Procedures and challenge of on-site destruction or transporting UXO to an external explosion site.
- Authority permission for purchasing and transporting explosives.
- Communication with authorities for regulatory approval and release documents approving the clearance.
- Risk management, quality assurance and control.
- Environmental protection from explosives.

To illustrate the reclamation for urbanisation of a former military area, projects of ammunition and mine clearance on Kalvebod Fælled in the vicinity of Copenhagen, used since the 17th century for artillery practise and other explosive tests, is introduced to illustrate the challenges and how the area becomes:

- a new city and district in Copenhagen, Ørestaden, close to Copenhagen Airport,
- a golf course,
- an enlargement of a soil remediation centre, and
- a large nature area for the public.

Reclamation of a nature preservation area contaminated by mines is illustrated by the project, Skallingen, where the last remnants of a World War II minefield in Denmark were cleared to make way for a nature reserve.

Likewise, the removal of ammunition in the shooting range of the former suburban Værloese air base, which became obsolete after the cold war, illustrates how a military area is cleared into an attractive housing and business area in part of suburban Copenhagen.

Also discussed is EU directive 2008/43/EC of 4 April 2008 setting up, pursuant to Council Directive 93/15/EEC, a system for the identification and traceability of explosives for civil use. Which, when implemented, will require unique identifying and tracking of even the smallest amounts of explosives, detonators, cords and other components. In this case used for

destruction of found ammunition and mines. The implementation of EU directive 2008/43/EC has been postponed by European interest organisations such as EFEE and FEMM communicating with EU, postponing the implementation date for user (both new and old stock) to the 5th of April 2015. The subject of introduction of trace and tractability is combined with the already existing restrictions of civil transport of the UXOs to a proper destruction site inflicted by the ADR 2011 rules on transport of dangerous goods (European Agreement concerning the International Carriage of Dangerous Goods by Road).

2 RECLAMATION OF LAND CONTAMINATED BY MUNITIONS- RELATED ACTIVITIES

The project 'Reclamation of Land Contaminated by Munitions-related Activity' has been conducted under Contract no. 02/EF 14.12/001, within the framework of the Western European Armaments Organisation, EUCLID Programme and more specifically the CEPA no. 14 on energetic materials.

The primary objective of the project was the development of guidelines, management tools and analytical measuring techniques for the investigation, clearance and reclamation of land that has been contaminated by munitions-related activities in Western European countries. The ever increasing pressures against the use of 'green field sites' for future developments means that land formerly used for munitions-related activities is becoming increasingly attractive, both financially and environmentally. This land does in the main, however, need to be rigorously assessed and where necessary cleared and reclaimed before it can be deemed suitable for use for housing, industrial development, agriculture, or other non-military use. The risks to people and the environment, and the value of former military sites are strong driving forces for the clearance of land contaminated by munitions-related activity.

Fired but unexploded munitions as well as unused munitions can be a safety and environmental risk when left in the soil. Fired munitions originate from hostilities in the past (in Europe mainly originating from World War I and II), but also from training and exercises with live munitions as well as remnants at (former) production sites. This so

called UXO (unexploded ordnance) and munitions related contamination still represent a safety risk for the population and an environmental risk. Experts on remediation agree that the efficiency of remediation projects in a certain area would be improved considerably by centralised management of information gathered during remediation projects in the past. Also, quality assurance and quality control greatly depend on information management and can be improved significantly by enhancing the effectiveness of the information management. In order to facilitate remediation, it is of utmost importance that the authorities have a reliable database they can access that contains information on the (potential) presence of UXO of munitions related contamination.

3 MINE CLEARANCE OF 60 HA FOR URBAN DEVELOPMENT OF A NEW CITY

From April 2000 to December 2001 NIRAS-DEMEX joined the consortium EOD Gruppen in a contract on clearing approximately 60 hectares of former military area, see figure 1, number 1. The area was reclaimed for an entire new district,

called Oerestaden, including dwelling areas, infrastructure, a national media city for the joint Danish broadcasting unit DR, shopping centres, offices buildings, metro and other infrastructure. See figure 2.

The clearance work was performed according to requirements set by the Danish Ministry of Defence and the quality assurance was provided by the Royal Engineers Regiment, which was the authority responsible for clearance of the area. The maximum depth of clearance was 800 mm which caused some problems with the magnetometer search. The normal depth of reliable search is approximately 50 mm. Therefore active magnetometer search was also used. The found explosive items were detonated on site or detonated in a shielded blast pit. The clearance work was completed successfully without any incidents.

4 SURFACE CLEARANCE OF MORE THAN 1500 HA FORMER BATTLE AREAS CREATING A NATURE RESERVE FOR PUBLIC ACCESS

4.1 Kalvebod Miljø Center (KMC)



Figure 2a. UXO clearance of 60 ha former military area for a new district in Copenhagen.



Figure 2b. The new district of Oerestaden, Copenhagen.

In connection with the expansion of the storage facilities of Denmark's largest soil remediation centre, ammunition clearance was performed on approximately 17ha of reclaimed land, see Figure 1, number 2, where a layer of 1 meter of top soil had to be removed. The depth of the UXO search was determined by the depth needed to be dug to reach the semi impermeable layer of clay which could ensure that there was no leakage from the contaminated soil to the surroundings. From January 2007 till June 2008, NIRAS DEMEX was hired in on the project as a consultant on QA and QC in regards to explosion risk and environmental protection of the ammunition clearance which had to be made due to the areas former status as a part of a former artillery shooting range.

During the initial planning of the project the explosion risk and environmental risk, were evaluated based on:

- The historical use of the area determining both the possible finds and chances of items polluting.
- The methods used for the clearance, determining the risk during removal.

As the area was in the perimeter of the original artillery training area, and therefore was considered a low risk zone, the clearance challenge was met by using a man towed magnetometer system, see figure 3, for the initial survey. The used system logged the detected level of ferrous materials in the ground together with a GPS position, and was used on the whole area. By analyzing the collected data, the ammunition contamination of the area was mapped, indicating the detected single anomalies and areas of anomalies of ferrous materials. Hereafter the areas found to contain contamination by anomalies where controlled by an ammunition clearance contractor, with the use of handheld metal detectors.

NIRAS DEMEX performed QC on the:

- Procedures of the overall mapping and the data analysis of the collected data.
- Procedures and documentation of the ammunition clearance of the found anomalies.

When the clearance was completed a final QC was made on the area according to IMAS 9.20 Guidelines for post clearance sampling. This was done by performing a spot-check of 36 random points of 25 m², on the full area. The number of



Figure 3. Kalvebod Fealled magnetometer search of Unexploded Ordnance (UXO).

spots was found by computing a formula given in IMAS 9.20 which includes former and future use of the area, size of area, probability of finding explosives in the area and the skill of the personnel performing the ammunition clearance.

The few findings (two) were safely removed by the ammunition clearance contractors EOD trained personnel. Under the rules and regulations the findings were destroyed on-site by splitting the grenade using plastic explosives, and thereby defusing the ammunition, using primary blast protection with regards to fragments, and a safety distance between 275 and 1000 meters with regards to the size of the item being destroyed. Both destructions were documented accordingly to the accepted procedure on destruction. Even though the amount of ammunition was small, this part of the project would have meant additional cost with the future EU directive 2008/43/EC, as explosives and other blasting components, for the destruction of old ammunition would require tracking with unique identification of each item.

4.2 Royal golf centre

In 2008 25 ha of the former artillery shooting area Kalvebod Fealled, see Figure 1, number 3, was surface cleaned by visual surface clearance. The

purpose of the surface clearance was to make way for a golf centre, which at the present is the most central golf centre in Copenhagen. The clearance involved areas which had bushes and trees during the former military clearance of the area, and therefore had not been cleaned. NIRAS DEMEX was assigned as a consultant, taking part:

- In the initial planning and QA-plan, based on risk evaluation through knowledge the future use of the area and the historical use of the area.
- Communication with authorities, including regulatory approval.
- QC of the clearance procedures during operations.
- Final QC by spot check of 10 % of the area
- Communicating with the authorities and making of release documents to be approved by the authorities.

The number of points where found according to IMAS 9.20. Positions where randomly placed on the areas and found and documented by the use of GPS.

The visual clearance, see Figure 4, resulted in 27 UXOs whereof 12 were found to be harmless while 15 were driven off to a shielded blast pit, appropriate for the semi urban area with close-by traffic, lowering the safety distance needed for the



Figure 4. Visually clearing of future golf center.

destruction. The transport to the bunker and the destruction were performed according to the approved procedures by educated EOD personnel. The findings were both of high and low order. Some were split for neutralizing (low) while others were totally destroyed (high order) by the use of plastic explosives. All destructions were documented according to the accepted procedure on destruction. Similar procedures would in the future give additional costs, considering the future EU directive 2008/43/EC, as explosives and other blasting components for in the destruction of old ammunition would require tracking with unique identification of each item.

4.3 Kalvebod Fealled

During the last quarter of 2009 and the first half of 2010 approximately more than 1500 ha of the former impact area for artillery practice, Kalvebod Fælled, see Figure 1, number 4, was visually surface cleared. Upon release it opened a much needed nature area, containing light forest and tidal meadow, accessible to the public in the capital area of Copenhagen. Prior to the release the public had only been allowed to move along the roads and paths of the area.

The surface, clearance performed by the German

company Heinrich Hirdes, contained clearance of ammunition, mainly artillery ammunition in a vast range of calibres, including both exploded and unexploded remnants of the shooting practise. The visual clearance was performed by educated ammunition clearance personnel; who walked in a single row, at arms length distance between them, systematically scanning the field in front of them, see Figure 5a.

NIRAS DEMEX was hired as a consultant for the Danish ministry of Environment. The project contained QC and QA of the visual clearance, controlling the work of the ammunition clearance contractor. The QA and QC was implemented by visually controlling 5% of the cleared areas, accordingly to IMAS 9.20, and ISO 2859-10. Sampling procedures for inspection by attributes, see Figure 5b.

The randomly picked areas each had an area of 100 m² which meant that the QC involved more than 8,000 single points. Each point was picked by the use of specially designed software, which created GPS points and the fastest route for the single controller. By using a handheld GPS the controller could follow a planned route and on arrival at a single point the controller would either verify or, if ammunition was found, fail the single point directly on the handheld GPS.



Figure 5a Kalvebod Fealled - visual clearance.

The collected data from the inspection, on the handheld GPS, was finally used for documentation and QA of the inspected areas. In the case of failed control points, the ammunition clearance entrepreneur would have to redo a specific area respective to the failed control point, where after the QC would be remade on 5% of the areas that had been re-cleared by the ammunition clearance entrepreneur. Each control point was inspected visually and when needed, during periods of snow, guided by the use of metal detectors.

Upon completion of the project, the ammunition clearance contractor had found and collected more than 3.5 tons of ammunition, which included both unexploded, empty cartridges and pieces of ammunition. The collected items were manually removed from site by the Danish military EOD.

In this project, working with the military removed the complication of getting permission for public transportation of dangerous goods.

Similarly, handing over the destruction of the found items to the military authorities; would have solved the future challenge of identifying and tracing even the smallest amounts and components with unique identification of each item, EU directive 2008/43/EC.

5 CLEARANCE OF WORLD WAR II MINEFIELD, SKALLINGEN

When the German minefields in Denmark were cleared in the first years after World War II, an area at the peninsula of Skallingen, see Figure 1, position C, was never completed due to the difficult and technically demanding nature of the clearance. Over the years the coast line has changed and large mined areas have now become seabed. Because of political issues with respect to the 'Ottawa Convention' the Danish Government decided in 2005 to have the remaining minefield cleared. The



Figure 5b. Kalvebod Fealled - QC of the cleared areas.

approximately 18 ha of Phase 1 area was completed in 2006. The clearance of the approximately 47 ha Phase 2 area was conducted by the Danish consortium 'Minegruppen' in 2007 and 2008, which included NIRAS DEMEX as a consultant.

NIRAS DEMEX involvement in the project was:

- Documentation and reporting, and establishing a large scale database system for the project and a Quality Management System.
- Management of procedures for quality, environment, safety and health is followed according to procedures, also referred to as the Quality, Environment, Risk & Safety management (Q-E-R-S-H) function.
- Development on a database based on the Information Management System for Mine Action (IMSMA) and the EUCLID CEPA 14.12 Project 'Reclamation of Land Contaminated by Munition-Related Activity'.
- Risk evaluation of critical processes (risks to

the staff working on site, evaluation of the excavators and other machinery involved in the work, and if needed reinforcing them to be able to protect the personal from risk.)

- Approving the special operation procedures (SOP) and rewriting the SOP that were not accepted.

After mapping the 47 ha large area and analysing the collected data, by the use of the established database, all possible UXOs were removed. Apart from a lot of scrap metal found during phase 2, the project managed to locate 26 AP-mines, 27 AT-mines and 150 parts of mines and other non-explosive remains. The found items were destroyed by the use of plastic explosives according to the approved SOP. The items were destroyed or neutralized by splitting, according to the specific item, high or low order. Specific precautionary measures and safety distances were easy to meet due to the remoteness of the location. All destructions were documented accordingly.



Figure 6a. Skallingen, phase 2 removing remaining mines from World War II to fulfill the Ottawa treaty.

Destruction of all the found items on site, by the ammunition clearance contractor, was an obvious solution due to the remote location, also solving the challenges of the ADR regulations on transportation of dangerous goods. On the other hand destruction of the items on site would in the future demand an additional task, in respect to the EU directive 2008/43/EC, and thereby an increased price. The destruction of the found items would require an extra effort to be able to fulfil the directive instructions on identification and tracing of all components used for civil explosives.

The major challenge was the state of the found explosive items. Several of the mines found in the dunes were dry and potentially hazardous. The explosive main charge, typically TNT, AMATOL, RDX and various mixtures of high explosives are indestructible, while the fuse train containing primary explosives and black powder friction igniters are sensitive to humidity. The Dutch research institute TNO made a project, examining the detonator sensitivity of a representative selection

of the found items, for the Danish Coastal Authority, and concluded that detonators in the mines, placed in the sand below the water table and exposed to water, were not functioning. All AP-mines under the water table were considered as not functional while some AT-mines might be potentially hazardous. This made the clearance of the sub-sea area work much easier and safer. Besides the issue of the explosives sensitivity, the rough environment working along the coastline during all seasons of the year was rather tough and found to be quite a challenge.

In 2011 the last phase (3) will be finished, clearing more than 120 ha of coastal and beach areas, and opening a vast nature reserve to the public.

6 CLEARANCE OF OLD TEST SHOOTING FACILITY

In 2005 Vaerloese airbase, see Figure 1 position b, ended 90 years as a military area, first as a military camp and for the last 60 years as an airbase for the Royal Danish Air force. The beginning of the



Figure 6b. Skallingen, phase 2 removing remaining mines from World War II, to fulfill the Ottawa treaty.

end of the base came, as for many others, with the end of the cold war. The phasing out of the airbase started in 2004 by the Danish Defence Estates & Infrastructure Organisation. As the base is situated in a popular suburb of the Danish capitol Copenhagen, and as the area represents a vast amount of possibilities both for housing and business combined with a large nature area the municipalities choose to sell or rent out the facilities of the former airbase.

This involved several environmental and infrastructural initiatives and projects cleaning the area mostly in environmental concerns, but also in regards to clearance of old ammunition.

In this context NIRAS DEMEX was involved as a consultant for the Danish Defence Estates & Infrastructure Organisation. The consulting service was made on the removal of old ammunition from a former test shooting facility used for calibres up to 3 inch rockets and other light and heavy flight ammunition.

The project involved several hazardous risks and events in regards to detonation of ammunition in the facility during removal. The facility had been used since WORLD WAR II without any systematic documentation of the different types of test ammunition that was fired. Therefore the initial project planning involved risk evaluation, including:

- Collection of data on historical used ammunition based on information from the Danish Air Force, in estimation of the possible types of ammunition fired.
- Ballistic calculations of possible fragments and projectiles from detonation on the site.
- Assessment of pollution from the ammunition in the sand inside the shooting range.
- Workers health and safety, risk minimizing of the involved workers with respect to UXO work.

At the same time the project involved challenges such as:



Figure 7a. Ammunition clearance of old test shooting range - protecting the surroundings from possible detonation during

- Destruction of found ammunition.
- Control and reduction of environmental impact and inconveniences to nearby tenants.

Risk estimates were also made for protection of the surrounding individuals and buildings, both due to possible detonations during excavation and protection from planned destruction of cleared ammunition.

The initial analysis resulted in demands to the ammunition clearance contractor:

- Shielding of the working area, to prevent fragments and projectiles from leaving the shooting range in case of an unwanted detonation of ammunition during excavation.
- Protection of the workers on the ammunition clearance site, by the use of remote controlled diggers.
- Restrictions on destruction of the found ammunition, to prevent fragments inflicting damage on people or buildings in the surroundings.

The work was performed by the use of a remote

controlled, armoured excavator, which loaded the polluted soil with the ammunition items in a rotating sorter. The sorted items were manually controlled and all suspicious items were separated for destruction.

The project was implemented according to these requirements and resulted in the collection of approximately 7500 UXOs, which were suspected of containing explosive materials and had to be destroyed. Most of the found items were transported to a government approved military test range for explosives where they were destroyed by detonation by the ammunition clearance contractor, while a single 51 mm rocket was destroyed on site by EOD personnel of the Danish military.

In future perspective of the EU directive 2008/43/EC, destruction of the found items would not have been a problem, as use of the military for removal of the found explosives would have removed the task of track and tractability.

Apart from the found UXOs, more than 10 tons of non explosive pieces of metal were found



Figure 7b. Ammunition clearance of old test shooting range - EOD personnel and medic during examination of the found items.

by the entrepreneur, which was declared as metal scrap and handled as such.

7 CONCLUSION

Reclamation of land contaminated by munitions-related activities is an important source of ‘new’ land in urban, rural and remote areas. The reclamation of such land has a long list of challenges which require skills on clearance of the area and also on these projects, as explained, demand either close cooperation with the military authorities and/or an extra working load to comply with regulations such as the EU directive 2008/43/EC on traceability of explosive components in civil use, and the ADR regulations on transportation of dangerous goods.

With a special view on explosives technologies and the interest of the EFEE members, some of the important lessons learnt of the Danish UXO

clearance are as follows:

- Clearance of mines and UXO require a basic understanding of explosives behaviour comprising the sensitivity of primary explosives, and secondary (high) explosives, and the function of fusing systems etc.
- Destruction of ammunition by add-on explosive charges must be performed as a traditional blasting job with special regard to the sensitivity of the old ammunition, and the protection of the environment against throw, vibration, noise and chemical pollution.
- For the destruction of ammunition performed by civilian companies, national civil regulations for blasting must be followed strictly like all other blasting works.
- Finally, procurement, transport, storage and handling of explosives must follow EU directives on explosives placed on the market,



Figure 7c. Ammunition clearance of old test shooting range - found UXO.



Figure 7d. The command centre of the remote controlled excavator.

mentioned in this paper.

To be able to overview the many possible land reclamations contaminated by munition related activities a common European database, such as the Information Management System Mine Action (IMSMA), would be recommendable considering the vast amount of 'new' land that only awaits its reintroduction into urban, rural and remote parts of civil society.

A huge task lies ahead to implement the plans of both international and national, public and private organisations and companies.

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