Appendix 31

Desk Study for Potential Historic Unexploded Ordnance Contamination

Prepared by RPS Explosives Engineering Services

RATCH Australia Corporation Limited

Mt Emerald Wind Farm, Arriga, Queensland

Desk Study for Potential Historic Unexploded Ordnance Contamination

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RATCH Australia Corporation Limited

Mt Emerald Wind Farm, Arriga, Queensland

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Glossary

ADF	Australian Defence Force
Allied Forces	The Allies of World War II were the countries officially opposed to the Axis powers during the Second World War
bgl	Below Ground Level
EOC	Explosive Ordnance Clearance
EOD	Explosive Ordnance Disposal
HE	High Explosive
Kg	Kilogram
mbgl	Metres Below Ground Level
RPS	RPS Group
SI	Site Investigation
Sqm	Square Metres
UXO	Unexploded Ordnance
WWII	Second World War (1939 – 1945)

Terminology

Explosive Ordnance Disposal (EOD) - The detection, identification, evaluation, rendering safe, recovery and disposal of UXO.

Fuze- A designed and manufactured mechanism to activate munitions. It can be designed for use by electrical, chemical or mechanical systems, by push, pull, pressure, release and time activation, singly or in combination. Usually consists of an ignite and detonator.

High Explosive (HE) - An explosive that normally detonates rather than burns; that is, the rate of detonation exceeds the velocity of sound.

Initiation - A physical process that sets in motion a cascade of chemical reactions of ever increasing energy (the explosive chain) that will eventually generate sufficient energy (the velocity of detonation) to allow the main charge to detonate in a violent, explosive chemical reaction, releasing energy in the form of heat and blast.

Unexploded Ordnance (UXO) - Explosive Ordnance that has been primed, fuzed, armed or otherwise prepared for action, and which has been fired, dropped, launched, projected or placed in such a manner as to constitute a threat to the safety and/or security of people, animals, property or material and remains unexploded either by malfunction or design or for any other reason.

UXO Contamination - UXO that is present, within any given physical context that is considered to be an impediment to the safe on-going or intended use of a facility, including geological features. Safety in this instance is measured against an acceptable level of exposure to the potential risks that UXO present.

Executive Summary

SITE DESCRIPTION

The proposed works consist of the construction of the Mt Emerald Wind Farm, comprising 75 individual wind turbines at Arriga, Far North Queensland. Once constructed, the facility will span the Herberton Range on the Atherton Tablelands, west of the Kennedy Highway between Atherton and Walkamin, approximately 50km southwest of Cairns, Queensland.

The proposed works will take place in a rural zoned area with adjoining regional landscape territory occupied by access roads, water infrastructure and power transmission lines. Active farmland borders the northern and eastern boundaries of the site with the nearest residential building in excess of 1000m from the proposed works.

POTENTIAL SOURCES OF CONTAMINATION

RPS has assessed that there may be the following potential types of Unexploded Ordnance (UXO) contamination on site, which are detailed below:

- ***Allied Mortars and Grenades* –** It has been identified that the proposed site was formally utilised for live firing purposes by Allied forces during training and deployment phases of World War II. As such, there is the potential for High Explosive (HE) Mortars (primarily 2, 3 and 4.2 inch) and hand grenades to have landed within the boundaries of the project site.

RISK ASSESSMENT

Based on the identified and available information, it has been determined that there is a risk from UXO during the potential future works being undertaken at the site, with the highest identified risk being **High** from Allied projected ordnance.

RPS has identified that a high level of Allied firing practices occurred in and around the project area, with one dedicated HE impact area within the boundaries of the site. State and Federal records confirm the presence of numerous firing points, areas where mortars would be fired *from*, in conjunction with recoded discoveries of UXO in close proximity to the site.

Due to the nature of the site, being predominantly rural regional landscape, it is considered unlikely for any UXO landing / penetrating the ground in such areas to have been readily identified, and as such may have remained until the present day.

RECOMMENDATIONS FOR FUTURE INTRUSIVE WORKS

Based on the risk assessment carried out for the site, RPS recommended that the following mitigation strategies be implemented in support of works taking place on site:

- ***Explosives Safety & Awareness Briefings / Explosives Site Safety Guidelines*** - It is recommended that all personnel conducting intrusive works should attend an ***Explosives Safety & Awareness Briefing***.

- ***Explosives Engineer Supervision*** - It is recommended that an Explosives Engineer should be present during any excavations/trial pits taking place at the site.

- ***Intrusive Magnetometer Survey -*** it would be prudent to conduct an intrusive Magnetometer survey ahead of proposed piling and borehole locations across the site to reduce the risk of encountering deep buried UXO. The type of survey methodology required would be dependent upon ground conditions and the works taking place.

- ***Non-Intrusive Magnetometer Survey -*** As an alternative to *Explosives Safety Engineer Supervision*, and considering the specific conditions on site, it may be feasible to carry out a Non-Intrusive Magnetometer survey ahead of shallow excavations/works in certain areas.

- ***Final Works Programme -*** RPS EES would recommend that, once the full extent of the works has been confirmed / finalised, we are contacted to discuss the most suitable mitigation approach. RPS would take into account further details regarding the specific locations, site conditions and methodologies of the proposed works to determine the most practical and pragmatic approach available to deliver the required mitigation.

1 Introduction

1.1 Instruction

RPS Explosives Engineering Services (RPS EES), part of RPS Energy Ltd, has been commissioned by RATCH Australia Corporation to conduct a desktop study for potential historic Unexploded Ordnance (UXO) contamination for the proposed Mt Emerald Wind Farm, Arriga, Far North Queensland.

1.2 Scope of Work

This study comprises a desk-based collation and review of available documentation and records relating to historic ordnance and live firing activities. Certain information obtained by RPS EES is either classified or restricted material or considered to be confidential to RPS EES. Therefore summaries of such information have been provided.

The purpose of this study is to assess the likelihood of buried historic air delivered ordnance and/or unexploded ordnance (UXO) related items to be present within the footprint of the site. Moreover, to then evaluate the implications of potential items during any future land use.

The site is considered to offer a potential explosives risk based on the following:

- ***Allied Live-Fire Practices*** **–** Sections of this site were regularly utilised by Allied forces as live fire ranges during pre-deployment training throughout World War II.

1.3 Definitions

The term ’site’ refers to the area encompassing the extent of the works associated with the proposed Mt Emerald Wind Farm site in Arriga. This report will generally focus on activities that occurred on site and its immediate surroundings. A location map is presented at *Appendix 001*, which details the extent of the site.

1.4 Reporting Conditions

It must be emphasised that a desk study can only indicate the potential for UXO related items to be present on site; a geophysical survey and subsequent intrusive investigation may be necessary to provide confirmation of any potential UXO contamination, and may be advisable prior to any future redevelopment. This desk study did not involve any non-intrusive survey or intrusive site investigation works.

Please note that our appraisal relies on the accuracy of the information contained in the documents consulted and that RPS EES will in no circumstances be held responsible for the accuracy of such information or data supplied.

1.5 Objectives

The primary objective of this document is to ensure the safety of personnel and civilians in the vicinity of the site, with regard to any impacts from potential UXO contamination and to identify the potential risk of uncovering either buried unexploded ordnance or explosive devices.

1.6 Legislation

Whilst undertaking this desk study the requirements of the following articles of legislation were considered:

- Environmental Protection Act (Queensland) 1994
- Explosives Act (Queensland) 1999
- Work Health and Safety Act 2011

In accordance with the definitions of the Environmental Protection Act (Queensland) 1994, UXO is considered a contaminant under the scope of the legislation, but not a hazardous contaminant according to the regulations, and requires that the contaminant be handled as such.

The Explosives Act (Queensland) 1999 does not specifically relate to Commonwealth (Military) explosives and UXO, but rather to the safety procedures and requirements associated with the storage and transport of items containing explosive compounds. Even though this legislation is not directly applicable to site works where UXO may be encountered, there are several pertinent points which may

be borne in mind when undertaking works on sites which pose a risk from encountering UXO, for example:

- Before an employer employs someone to do something allowing the employee to have access to explosives, the employer must ensure, as far as practicable, the person is an appropriate person.
- A person must not store or hold an explosive at a place other than on licenced premises by a licenced person.
- A person who is doing an act involving explosives must take reasonable precautions and use reasonable care to avoid endangering any person's safety, health or property

Work Health and Safety Act 2011 highlights the requirement to ensure that;

- Any person conducting a business or undertaking must ensure, so far as is reasonably practicable, the health and safety of its workers.
- In addition any dangerous incident, such as an uncontrolled explosion as described in the Act is a reportable incident that must be reported to Workplace Health and Safety authorities.

Although the Work Health and Safety Act 2011 and the Explosives Act (Queensland) 1999 do not specifically require a search for unexploded ordnance, there is an obligation on those responsible for intrusive works to ensure that comprehensive assessment and risk mitigation measures are enforced with regard to all underground hazards on site.

These points reinforce that when significant risks from UXO are identified on a site, it is essential for proper procedures to be put in place. In higher risk scenarios it is essential for trained Explosives Safety Personnel to be present on site to mitigate the risks, and be on hand to handle the situation in the event of a suspicious item/UXO discovery.

2 Research

2.1 Research Objectives

Research into the history of the site and its immediate surroundings, has been undertaken to establish the following:

- Review of military activity in the area.
- Records of Explosive Ordnance Clearance tasks or bomb disposal activities during and after WWII.
- The potential for UXO to remain on site.

2.2 Sources of Information

The main sources of information consulted included:

- RPS related site records.
- RPS Company records.
- State and Local Government records.
- National Archives.
- Historic maps, photographs and records.
- Internet Research.

2.2.1 Supplemental Sources of Historical Information Consulted

The following additional sources were consulted for general background information.

Wilson, P (1988) North Queensland – WWII 1942-1945. Department of Geographic Information: Brisbane

Plunkett, G (2007) Chemical Warfare in Australia. Australian Military History Publications: Loftus

3 Site Details and Description

3.1 Site Location & Description

The proposed works consist of the construction of the Mt Emerald Wind Farm, comprising 75 individual wind turbines in Far North Queensland. Once constructed, the facility will span the Herberton Range on the Atherton Tablelands, west of the Kennedy Highway between Atherton and Walkamin, approximately 50km southwest of Cairns, Queensland.

The proposed works will take place in a rural zoned area with adjoining regional landscape territory occupied by access roads, water infrastructure and state power transmission lines. Active farmland borders the northern and eastern boundaries of the site with the nearest residential building in excess of 1000m from the proposed works.

RPS has identified the Powerlink Chalumbin to Woree 275kV transmission line that traverses the Herberton Range within the boundaries of the project site. In the event that an uncontrolled high order detonation occurs this infrastructure may be subject to damage from flying debris. Whilst the chances of this event occurring remain low, it would be prudent to maintain awareness of this local infrastructure whilst conducting invasive works.

Due to the remote nature of the site and the limited intrusive works that have thus far been conducted since the introduction of UXO, educated assumptions have been made with regards to surface and sub-surface conditions in the region. Commissioning of intrusive site investigations and associated survey works would permit the establishment of baseline data, improving the accuracy of the depth penetration assessments contained within this document as well as establishing real time data as to the condition and volatility of any identified UXO improving risk assessment outcomes.

3.2 Geology

One of the most important factors in assessing the maximum ordnance penetration depth is to establish the site geology. The ground conditions will predominately determine the path of ordnance. Furthermore, the consistency and thickness of any pre WWII made ground should be considered, as this would have the potential to

significantly limit the penetration. The ordnance penetration assessment will be discussed later in this report.

RPS understands at the time of writing that no detailed geotechnical study has been conducted of the Mt Emerald site, limiting the ability to estimate ordnance penetration depths. Once a data set of geotechnical information has been established RPS should be contacted to refine ordnance penetration predictions.

3.3 Historical Mapping

RPS EES has reviewed a series of historical maps, excerpts presented at *Appendix 002 and 003*, which cover the immediate area of the site. These have been reviewed to identify historic site conditions and usage (where possible), in light of the potential for UXO contamination. Information gleaned is as follows:

3.3.1 1943 (1:63,360)

This map shows the site to be bush land removed from local infrastructure. Roads to the north of Granite Creek depict access to framing structures and the gravel pit can be seen to the east. The vintage of this document correlates with the 1943 build-up of Allied forces in the region.

3.3.2 1982 (1:10,000)

No notable infrastructure developments within the project area. This excerpt does not show the Chalumbin to Woree transmission lines due to the projects 1998 completion date.

3.4 Summary

The maps reviewed show that there have been few changes to the general vicinity of the site since its employment by Allied forces as a live firing range. In support of Powerlink's Chalumbin to Woree transmission lines a number of support towers were erected onsite, however no additional alterations or invasive works have been made. Due to the rural nature of the site, minimal development has taken place within the project footprint resulting in a largely unaltered state of the site.

4 Military Positions

4.1 General

The Atherton Tablelands was a strategically significant staging area for Allied forces during the second half of World War II. In excess of 100,000 troops passed through the area between 1942-1945 for pre-deployment or repatriation purposes where the region experienced significant exposure to live firing practices and subsequent potential UXO contamination.

Reports indicate that given the scale of operations in the vicinity of the project site the north western sector experienced heavy bombardment by Allied mortar forces resulting in significant UXO contamination. Despite Japanese attacks on the Australian mainland during WWII no direct bombing of the project site or surrounding lands took place. The nearest enemy bombing took place 75km North at Mossman, well outside the boundaries of the project.

4.2 Allied Camp Proximity

Tolga, 7km ESE of the southern end of the project boundary, was home to the 13th Army Advanced Ordnance Depot as well as the Rocky Creek Military Hospital, the largest military hospital in the country during the Allied services occupation of the Atherton Tablelands. As a result the Australian Defence Force (ADF) has categorised the eastern face and adjacent lowlands of Mt Emerald as both ‘Substantial’ and ‘Slight’ for the possibility of containing UXO contamination. Records show that areas subject to camp conditions of WWII era are prone to UXO discovery outside of those areas designated as firing ranges as ground forces were often prone to casual contamination of their surrounds.

4.2.1 Mortar Firing Positions

Mortar firing positions were located within the vicinity of the project site for the purpose of troop training and firing practice and were the primary source of site related UXO contamination. 2, 3 and 4.2 inch mortars were the primary choice of mortar weapon of Allied troops during WWII with a variety of ordnance options for these armaments.

The closest recorded mortar firing positions are detailed approximately as follows:

Mortar Firing Positions in the Local Area			
Location	**Approximate Distance from Site**	**Approximate Grid Reference Lat , Long**	**MGRS**
Firing Point #1	0.3km E	17°09'50"S, 145°24'54"E	55K CB 3141601626
Firing Point #2	0.3km E	17°09'54"S, 145°24'49"E	55K CB 3127001502
Firing Point #3	1.5km E	17°12'13"S, 145°25'52"E	55K CA 3316697244

Table 4.2.1 - Locations of Nearby Mortar Positions

The table presented above is not exhaustive of all mortar sites found within a 5km radius of the site however, it does represent the known and recorded locations and highlights the active nature of the impact areas situated around Mt Emerald. 2in and 3in mortars had an approximate maximum range of 500yds and 1,600yds respectively which corresponds with the recorded 'substantial' contamination of selected areas of the site.

In addition, artillery weapons were in frequent use on the Atherton tableland during the 1943-1945 period. With an approximate range of 16.5km for British 5.5inch Guns, it is conceivable that artillery ammunition could be found within the site boundaries, however no specific evidence has been uncovered to suggest their presence in the direct vicinity.

4.3 Training Ranges / Areas

Live firing or training ranges can include permanent facilities such as Rifle or Small Arms Ranges, Artillery Ranges or Close Assault Training / Battlefield Training Areas. RPS have reviewed military administrative maps, dated 1945, which depicts locations that were used for military training exercises in the region. Supporting these maps are ADF findings highlighting the existence of a mortar/grenade range within the project boundaries as presented in *Appendix 004*. Nine confirmed UXO contamination sites have been identified in vicinity of Tinaroo_Tolga with the Walkamin Mortar/Grenade range situated in the north-eastern quadrant of the project site as the closest source of 'substantial' contamination.

4.4 Document Limitations

Records of firing ranges, ordnance stores and the locations of UXO were rarely released into public domain in the interest of security and public safety. Furthermore, details relating to these records are often difficult to locate. Types of munitions fired within the boundaries of the site was not accurately recorded during the period the live firing range was active and as such accurate ratios of ordnance types likely to be found remains unknown. A lack of population density and associated invasive works in the immediate vicinity also lends the accuracy of information towards partial at best.

Requests for information submitted to the National Archives and the Australian War Memorial remain extant however due to 30-90 day wait times for some information requests are still pending. In some instances the information request has yet to vetted for public release compounding already lengthy delays. In light of these delays eye witness reports have been considered alongside compelling available data in support of these findings compiled and were only as detailed and accurate as the availability of time, personnel and the ease of access to information would allow..

4.4.1 WWII Records & Statistics

RPS records indicate that Allied forces fired an extensive variety of High Explosive (HE) filled mortars ranging in size from the relatively small 2lb man-portable mortar through to the 4.2lb vehicle mounted variety. The 4.2inch mortar was equipped with a chemical weapon capable munitions', however as discussed below no evidence was discovered to suggest that chemical weapons were fired and/or landed within the boundaries of the site.

Available records suggest that the majority of projectiles fired were HE or incendiary in nature. It remains widely accepted that a small percentage of approximately 10% of ammunition fired failed to function as designed resulting in the current situation of UXO contamination.

4.4.2 Chemical Weapon Storage and Use

Historical records confirm the use of chemical weapons, in particular mustard gas, in vicinity of the Atherton Tablelands throughout the 1940's. Weapons trials conducted in Innisfail, 120km SE of the project site, remained isolated to the township and surrounding bush lands for trials and training purposes. Once commercially manufactured these chemical weapons were stored within armament storage depots

throughout the region and no evidence was located to suggest that chemical ordnance were fired within the vicinity of the site. Since the cessation of hostilities chemical ordnance has been discovered and reported to authorities within close proximity to active ordnance depots, such as the depot located in Tolga, 6km east of the project.

4.4.3 WWII UXO Mapping

RPS has reviewed a selection of WWII UXO mapping data for the Walkamin area. This data, under the management of the Australian Defence Force, relates to the area of Walkamin and Tolga and remains sensitive in nature. Excerpts of this data have been reproduced at *Appendix 004* marking the suspected contaminated sections in the vicinity of the impact area. Note that this data represents UXO discoveries reported to authorities by the public and that no known UXO has been reported. Military units and affiliated organisations have compiled this data resulting in the 'substantial' contamination level for this area without reporting individual ordnance discoveries.

5 Ordnance Details

5.1 Projectiles (Mortars)

Mortars come in many shapes and sizes depending on the intention of the firing mission. Generally, all these munitions are constructed the same and consist of a metal container (iron construction), a fuze (often in the nose of the projectile), and a stabilizing device or fin. The metal container (called the bomb body) holds the high explosive content. Once fired the body may appear in one or in multiple pieces. Examples of Allied High Explosive Mortars are presented at *Appendix 005*.

The main components of a mortar are:

- ***Mortar Body –*** This is the main item referred to as Unexploded Ordnance (UXO). Mortars will have a typical projectile (large bullet) shape with parallel sides in the front with a metal 'tail' section. Given the age and environmental conditions most mortars are found corroded and difficult to recognise. It is possible to mistake them for agricultural or water pipe.

- ***Tail Unit (Spigot) –*** As the UXO impacts with the ground this section often breaks off. The presence of a tail unit may indicate that UXO is buried at depth in the region.

- ***Fuze –*** Allied mortars commonly contained a mechanical or powder train fuse in the nose of the projectile. This fuse is considered the most dangerous component of the ordnance, however due to exposure to the elements over extended periods fuses can often appear considerable different to their original design and remain unpredictable.

5.1.1 High Explosive Munitions

This variety of munitions consisted primary of a HE payload for the purpose of producing blast and fragmentation effects upon it target. HE munitions present the largest explosive threat likely to be encountered within the project boundaries.

- ***2, 3 and 4.2 inch HE Mortar -*** The diameter ranges from 2–4.2 inches, and overall length not greater than 22 inches. The primary ewxplosive fill is Amatol/TNT.

5.1.2 Incendiary / Smoke / Illumination Munitions

This category of munitions usually consisted of a small component HE but a primary payload of phosphorous like compound for the purpose of producing intense flame or smoke. Similarly, illumination rounds were designed to illuminate the battlefield in a 'floating star' arrangement suspended below a parachute. These munitions have similar characteristics to HE mortars with their own unique hazards.

- ***2, 3 and 4.2 inch HE Mortar -*** The diameter ranges from 2–4.2 inches, and overall length not greater than 20.4 inches. The primary explosive fill is phosphorous compound.

5.1.3 Chemical Munitions

As discussed previously RPS is not aware of any chemical weapons being fired or identified within the boundaries of the site. Having dimensions and characteristics similar to smoke / illumination 4.2 inch projectiles, the 4.2 inch armament was the only mortar weapon in use in vicinity of the project site capable of firing chemical munitions.

- ***4.2 inch Chemical Mortar -*** The diameter is 2 inches, and over-all length 20.4 inches. The fill is an unspecified quantity of chemical irritant.

5.1.4 Grenades

Grenades likely to be discovered in the region consist of relative simple construction and firing mechanisms. Designed to be thrown by infantry soldiers grenades are considerably smaller than mortars and contain greatly reduced HE payloads. In use by Allied forces at the time and having been recovered by authorities throughout the region since 1945 were the British No. 69 and 36M grenades and the US Mk. II. Unlike mortars, grenades are smaller by design and subsequently will be difficult to identify on site.

- ***HE Grenades –*** Average diameter is 60mm, and average over-all length 60mm. The average fill is 0.90kg of Baratol or TNT high explosive.

6 Ordnance Ground Penetration

6.1 Background on Ordnance Penetration Depths

There are a number of factors applicable to predicting ordnance penetration depths, which can lead to variations in the penetration depths for projected ordnance, as follows:

- ***Shape & Weight of Ordnance*** **–** variations in the design of the delivered ordnance has a large impact on the depths to which it is able to penetrate. Generally speaking, the heavier the ordnance, the deeper the penetration, and when constructed in a streamlined shape this can also lead to an increased penetration depth.

- ***Geological Strata*** **–** variations in the composition, thickness and homogeneity of the geological strata can lead to significant variations in penetration depths.

- ***Height of delivery*** **–** the altitude at which the ordnance was released can lead to variations in the final penetration depth. A factor often considered for air delivered weapons, however is less prevalent for ordnance fired/delivered from ground level.

- ***Deflection*** **–** should an item of ordnance impacted onto an obstruction / structure prior to penetration into the ground, it may have deflected and as such behaved anomalously upon penetration, and thus the final resting position may potentially be atypical to what is normally expected.

The following table provides a guide on probable penetration depths of bombs in geological conditions that are likely to be expected in the region:

TYPICAL PROJECTILE PENETRATION DEPTHS				
GROUND TYPE		*Limestone*	*Sand*	*Clay*
PROJECTILE WEIGHT	2.2lb	0.03m	0.12m	0.24m
	10lb	0.21m	1.5m	3m
	20lb	0.33m	2.3m	4.7m

Table 7.1 Projectile Penetration Depths

The above information assumes:

a) That the projectile is stable in flight and on penetration.

b) That the soil type is homogenous.

6.1.1 UXO 'Offset'

Unlike the majority of air delivered weapons, mortars commonly impact the ground with a near vertical aspect reducing the offset associated with aerial delivery. The distance between the centre of the entry hole and the centre of the projectile at rest is known as the 'offset'. A marked lateral movement from the original line of entry is not uncommon. The average offset is one third of the penetration depth. Hard standing on the impact zone can result in an offset increasing by some four times.

6.2 Background on Ordnance Penetration Depths

6.2.1 General

When assessing the potential for ordnance ground penetration it is essential not to rely solely on either an empirical, statistical and arithmetical formula. Experience has shown that a realistic depth is gained by considering the above approaches supplemented by accounts of Bomb Disposal Tasks in the area.

6.2.2 High Explosive Bombs

For this assessment RPS has used a British 20lb HE Mortar Projectile as the benchmark for the maximum ordnance penetration, as this was the largest of the common munitions used on this range.

In the absence of geotechnical data for this site it should be considered that the maximum projectile penetration depth for the site is likely to be approximately up to **4.7m below ground level (bgl)**, dependant on the specific geological conditions encountered on a location by location basis. In addition, it should be noted that any penetrating UXO may have come to rest anywhere between ground surface and their maximum penetration depth.

Should mitigation be required on site, where applicable and possible, the bomb penetration depth may be able to be assessed by UXO personnel in attendance, on a location by location basis, when the sub surface strata become exposed.

Penetration depths detailed in the table and above are generic in nature. If levels have changed significantly since the creation of this data, this could have an effect on the likely depths that unexploded ordnance could be present relative to current ground levels in the area of the site.

7 Unexploded Bombs

Since the end of WWII, there have been a limited number of recorded incidents in the Australia where ordnance have detonated during engineering works, though a significant number of bombs have been discovered.

The major effects of partial or full detonation of a device are shock, blast, heat and shrapnel damage. It should be noted that the detonation of a 50kg buried bomb would damage brick or concrete structures up to 16m away and unprotected personnel on the surface up to 70m away. Larger ordnance is obviously more destructive, with an accepted safety distance for a 500kg HE device being 1km.

Once initiated, the effects of the detonation of explosive ordnance such as shells or bombs are usually extremely fast, often catastrophic and invariably traumatic to the personnel involved. The degradation of a shell or bomb may also offer a source of explosive contamination into the underlying soils. Although this contamination may still present an explosion hazard, it is not generally recognised that explosives offer a significant toxicological risk at concentrations well below that at which a detonation risk exists.

Unexploded bombs do not typically explode without outside disturbance under the environmental conditions experienced in Australia. UXO has lain un-disturbed for some 60 years and should not detonate unless they are significantly disturbed. All HE requires significant energy to create the conditions for detonation to occur. Intense impacts in intrusive engineering such as drilling/piling and mechanical excavations could initiate a detonation. There are a number of scenarios that may occur on sites which may potentially lead to the detonation of an encountered item of UXO, as follows:

- ***Direct impact upon the main body of the UXO*** – needs to be significant impact e.g. In the case of piling or large scale excavations.
- ***Restarting clock timer in a fuze*** – contact or vibration applied to a clock timer, in certain situations, may cause it to reinitiate. However, in the case of WWII (and pre-WWII) ordnance it is likely that such devices would be corroded and no longer able to function.
- ***Initiating Fuze Explosive*** – environmental factors, such as introduction of temperature fluctuations and water, can lead to degradation of explosives within

items of UXO, which may then exude from the main body of the device and crystallise. Certain resultant compounds from such processes can be very sensitive and volatile, and through application of a small amount of movement/energy through either vibration or impact may result in detonation of the main charge.

Apart from the explosives risk, the main concerns of UXO are threefold, these are:

- Heavy metal (Copper, Zinc etc) contamination from the bomb's casing.
- Organic aromatics (Toluene, Nitrosamines, daughter products etc) contamination from the degradation of the explosive charge.
- Heavy metal (Lead, Mercury) contamination from the degradation of the detonator charge.

8 Regulatory Authority Data

8.1 State and Local Authorities

State and Local authorities were consulted for supporting evidence of UXO contamination and land use for the project site. Mapping provided by the Queensland State Archive confirms that due to the nature of the site, being predominantly rural regional landscape, it is considered unlikely for any UXO landing / penetrating the ground in such areas to have been readily identified, and as such may have remained until the present day.

8.2 MoD Explosive Ordnance Disposal (EOD) Archives

Request for information from Defence EOD archives have yet to yield a response confirming precise locations of historical UXO discoveries. Local government records do confirm discovered UXO contamination confirming the presence of hazardous munitions. Local EOD technicians contest the accuracy of local government information.

9 Explosive Ordnance Contamination Risk Assessment

9.1 General

Risk assessment is a formalised process for assessing the level of risk associated with a particular situation or action. It involves identifying the hazards and the potential receptor that could be affected by this hazard. The degree of risk is associated with the potential for a pathway to be present linking the hazard to the receptor. This relationship is usually summarised as the Source – Pathway – Receptor.

9.2 Sources / Hazards

Previous sections of this report have highlighted a number of activities that are known to have occurred on / around the site. The following sections will assess if they have the potential to cause significant explosive ordnance contamination.

Source of Contamination	Contaminate
Allied Live Firing Practices	High Explosive Mortars
	Incendiary Mortars
	Smoke Mortars
	Illumination Mortars
	Grenades No's. 36, 69 and Mk II

Table 10.2 Sources of Contamination

9.3 Pathway

The pathway is described as the route by which the hazard reaches the site personnel. Given the nature of the site the only pathways would be during:

- Enabling Works.
- Intrusive Site Investigations (Trial holes/trenches, boreholes, window samples).
- Excavations and Piling Works

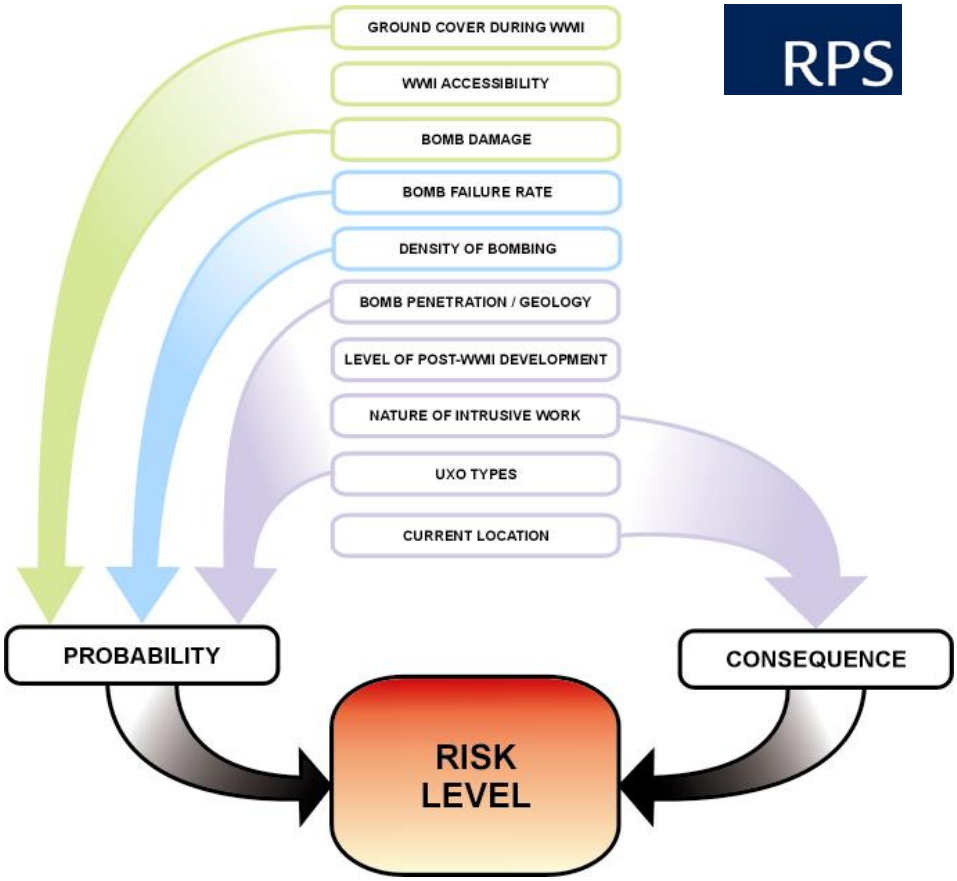
9.4 Receptors

Sensitive receptors applicable to this site would be:

- People (Site Personnel, Construction Works & General Public).
- Plant and Equipment.
- Infrastructure.
- Structures (Including existing school buildings and nearby properties).
- Environment.

9.5 Risk Assessment

The following sections contain the risk assessment for the site, prior to the implementation of any risk mitigation measures. For the risk to be properly defined, several factors have to be taken into account, including the consequences of initiation and the probability of encountering UXO on site. The technique used to assess level of risk is detailed in the diagram below:



9.5.1 Risk Assessment Matrices

In order to identify an appropriate risk mitigation strategy for the works it is now necessary to complete a semi-quantitative assessment of the identified risks.

Once the factors detailed above have been assessed for the site, the consequence level is obtained from the table presented in *Appendix 007 A*, which provides a consequence rating from 1 to 10, depending upon the severity. The probability is also deduced and given a rating between 'improbable' and 'frequent'. These two ratings are then combined to determine the final risk levels to the proposed site works from the various threat items, using the risk matrix in *Appendix 007 B*, taking into account the potential UXO threat items as detailed earlier.

Following are the risk assessment matrices for potential future site works, prior to the implementation of the any risk mitigation measures:

Risk Assessment Matrix								
Contaminate		**Hazard**	**Potential Pathway**		**Potential Sensitive Receptors**	**Likelihood of Encounter***	**Consequence of Initiation***	**Final Risk Level**
Allied Munitions	**High Explosive Mortars**	Blast, Fragmentation	Surface Activities	Enabling Works	Site Personnel, General Public, Engineering Equipment, Existing Buildings & Infrastructure, Environment.	D	8	**H**
			Intrusive Activities	Excavations / Trial Pits		D	8	**H**
				Boreholes / Piling		D	8	**H**
	Phosphorous Mortars	Heat	Surface Activities	Enabling Works	Site Personnel, General Public, Engineering Equipment, Existing Buildings & Infrastructure, Environment.	D	5	**L**
			Intrusive Activities	Excavations / Trial Pits		D	5	**L**
				Boreholes / Piling		D	4	**L**
	Grenades	Blast, Fragmentation	Surface Activities	Enabling Works	Site Personnel, General Public, Engineering Equipment, Existing Buildings & Infrastructure, Environment.	C	7	**M**
			Intrusive Activities	Excavations / Trial Pits		C	7	**M**
				Boreholes / Piling		C	7	**M**

KEY: **N: Negligible** **L: Low** **M: Moderate** **H: High**

*Table 9.5.1 - Risk Assessment Matrix (*See Appendix 007 B for assessment scheme)*

9.5.2 Risk Assessment Analysis

Based on the identified and available information, it has been determined that there is a risk from UXO during the potential future works being undertaken at the site, with the highest identified risk being **High** from Allied Live Firing Practices.

Due to the nature of the site, being predominantly mountainous uninhabited terrain, it is considered likely that fired UXO during live fire practices may have landed/penetrated the ground, remaining undiscovered until the present day.

10 Recommendations

10.1 The 'ALARP' Principle

On sites where a risk from UXO has been identified, an aim must be mitigate the UXO risk to as low as is reasonably practicable (ALARP); considering safety and cost vs. benefit.

ALARP has particular connotations in Health and Safety practices and the core concept of what is "*reasonably practicable*". This involves weighing a risk against the effort, time and costs needed to control it. For a risk to be reduced in line with ALARP it must be possible to demonstrate that the cost involved in reducing the risk further would be "*grossly disproportionate*" to the benefit gained. The ALARP principle arises from the fact that it would be possible to spend infinite time, effort and money attempting to reduce a risk to zero. Importantly, it is not simply a quantitative measure of benefit against detriment but a common practice of "*judgment*" of the balance of risk and social benefit.

Diagrammatic representations of the ALARP principles are presented at *Appendix 008*.

Based on the assessed risk the following mitigation is recommended to be implemented in support of works taking place across the site:

10.2 Field Verification

RPS recommends that prior to commencing invasive works a field verification assessment take place to validate this historical assessment of UXO contamination and justify any mitigation practices that may be required. Following field verification the potential exists to adjust and/or customise the risk assessment of this site into individual 'zones', dependent upon the results of the verification, particularly for turbines located within the 'substantial' contamination areas.

10.3 RPS Explosives Safety & Awareness Briefings / Site Safety Guidelines

It is recommended that all personnel conducting intrusive works, in any part of the site, should attend an ***RPS Explosives Safety & Awareness Briefing***. This should comprise part of the standard site induction briefing and would form a component of the Health and Safety Plan for the site adhering to the requirements of previously cited legislation. All personnel working on site would be briefed on UXO recognition and made aware of the possible risks. They would be informed of the actions to take to alert the site manager and to keep people and equipment away from the hazard.

RPS feels it may be cost effective and prudent to produce a set of ***RPS Explosives Site Safety Guidelines (ESSG)***, which would be provided to the client along with training. The guidelines are designed to aid the Project Team to plan the proposed works and potentially deal with the event of a suspicious item / UXO discovery incident. The guidelines would also enable the client to incorporate the Explosives Safety & Awareness Briefings into their standard site inductions.

The guidelines would address the risk to all of the specific proposed works and will inform all personnel how to undertake the works safely, and will refer to the specific risk items/hazards that have been identified for the site.

The guidelines would typically be provided to the client in the form of a ‘Guidelines Document’ along with a supporting PowerPoint slideshow.

However, it should be noted that if a significant / elevated risk is subsequently identified then a fully qualified Explosives Engineer should manage the situation on behalf of the client.

10.4 Explosives Engineer Supervision

It is recommended that an ***Explosives Engineer*** should be present during any excavations/trial pits taking place at the site.

The Engineer will confirm whether any suspicious item identified is ordnance related. If the item is ordnance related then the Engineer will aid with the incident management, until the appropriate authorities have control of the site.

The role of the Explosives Engineer would include:

- Visual reconnaissance across moderate risk areas to identify if any surface UXO is present prior to further mitigating or other works taking place.
- Using a magnetometer/locator to investigate in advance of the proposed works to ensure no ordnance is encountered.
- Managing the excavations/investigation of any anomalies identified by using magnetometers/locators.
- The monitoring of engineering works using visual recognition and instrumentation, where practical and advising staff of the need to modify working practices to take into account the ordnance risk.
- Providing an immediate response to reports of suspicious objects or suspected items of ordnance that have been recovered by the ground workers on site.
- Aid in incident management, including liaison with the Local Authorities and Police, should ordnance be identified and present an explosive hazard.

10.5 Intrusive Magnetometer Survey

RPS consider it prudent to conduct an intrusive Magnetometer survey or Down-Hole magnetometer ahead of/in conjunction with any proposed piling or boreholes being undertaken across the site to reduce the risk of encountering deep buried UXOs. The type of survey methodology required would be dependent upon ground conditions and the details of the works taking place.

10.6 Non-Intrusive Magnetometer Survey

As an alternative to *Explosives Safety Engineer Supervision*, and considering the specific conditions on site, it may be feasible to carry out a Non-Intrusive Magnetometer survey ahead of shallow excavations/works in certain areas.

Non intrusive magnetometer surveys have the capability to detect shallow buried items of UXO. The actual performance of the equipment is dependent on ground conditions and the sizes of potential ordnance present. It should be appreciated that

the success of the proposed methods will be dependent upon the geophysical contrast between the target and the background material.

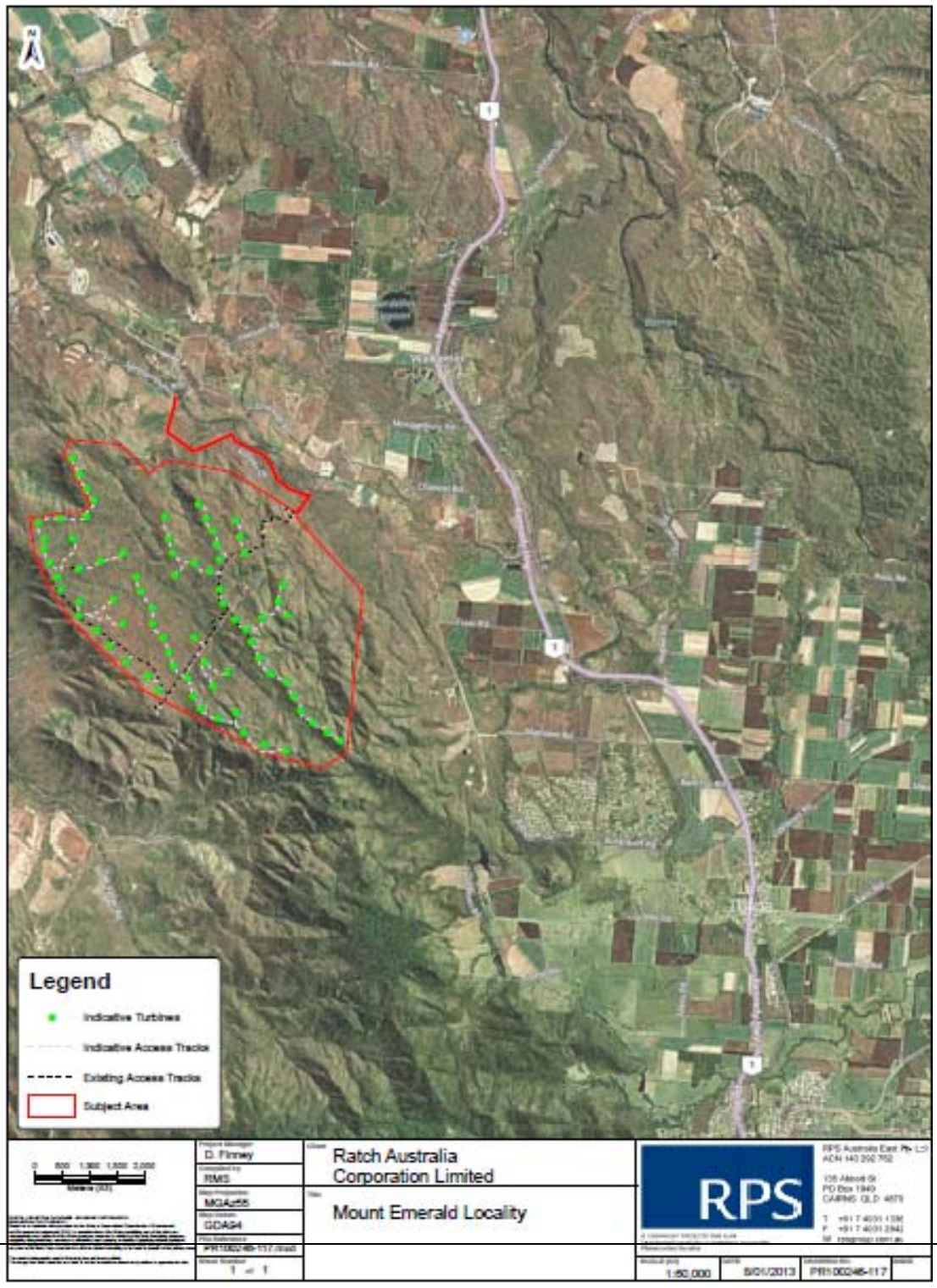
10.7 Final Works Programme

RPS EES would recommend that, once the full extent of the works has been confirmed / finalised, we are contacted to discuss the most suitable mitigation approach. RPS would take into account further details regarding the specific locations, site conditions and methodologies of the proposed works to determine the most practical and pragmatic approach available to deliver the required mitigation.

Appendices

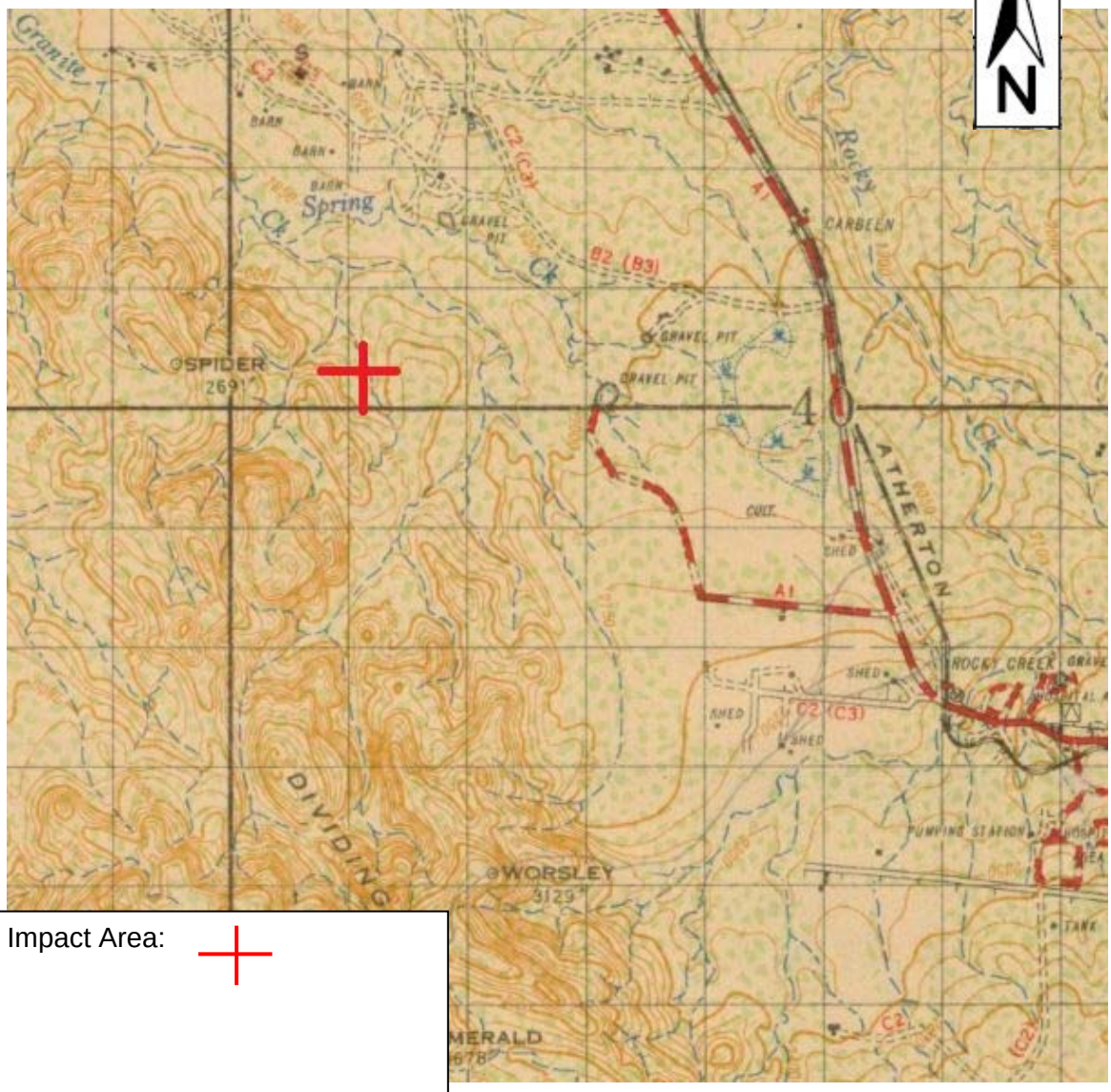
Appendix 001

Site Location



Appendix 002

Historical Mapping - 1943 (1:63,360)



Impact Area:

Project: Mt Emerald Wind Farm, Arriga, Far North Queensland

Project Ref: EES0394-R-01-00

Appendix 002: 1943 Site Mapping

Scale: Not to Scale

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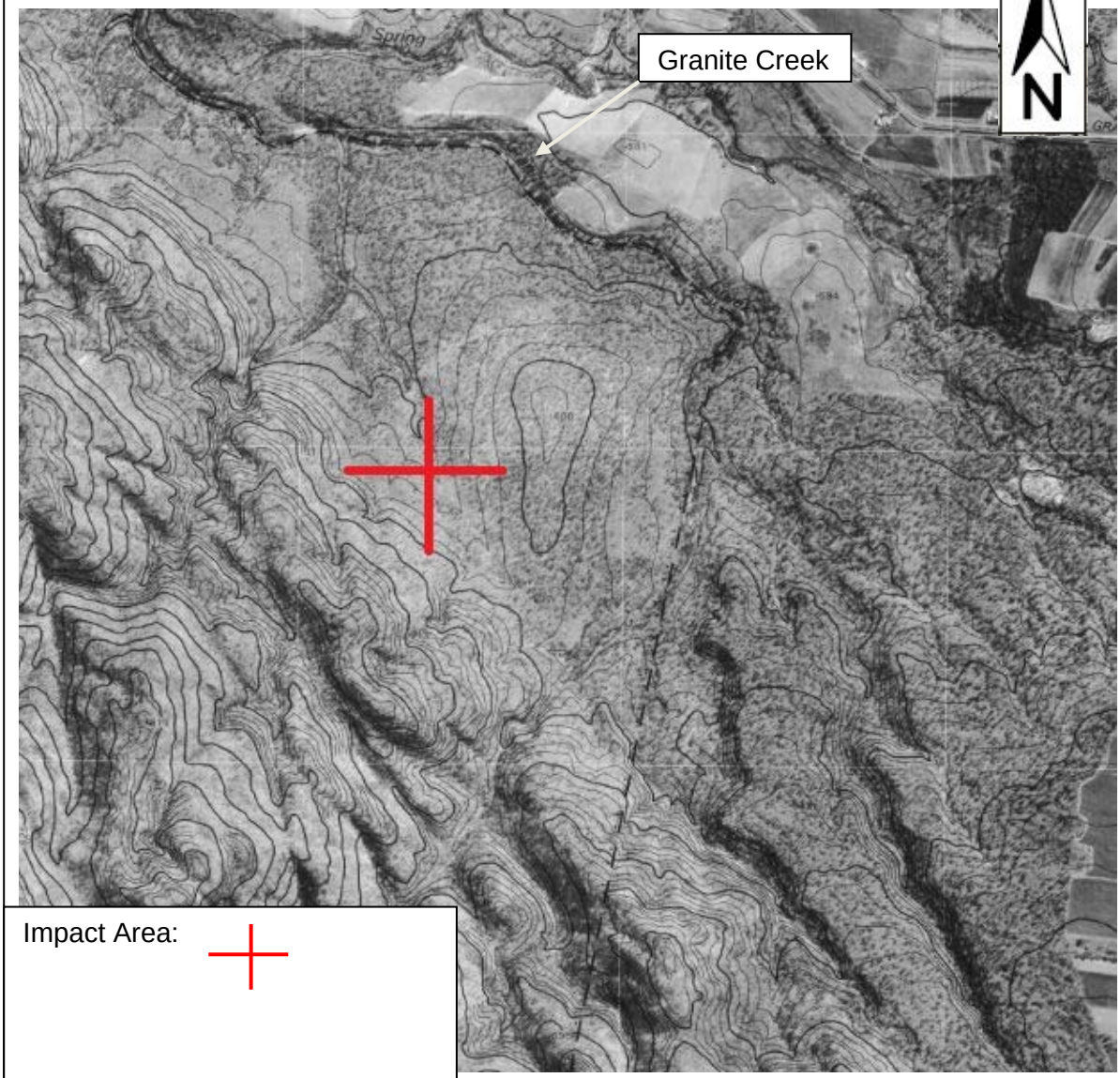
Appendix 003

Historical Mapping - 1982 (1:10,000)



Impact Area:

Project: Mt Emerald Wind Farm, Arriga, Far North Queensland

Project Ref: EES0394-R-01-00

Appendix 003: 1982 Site Mapping

Scale: Not to Scale

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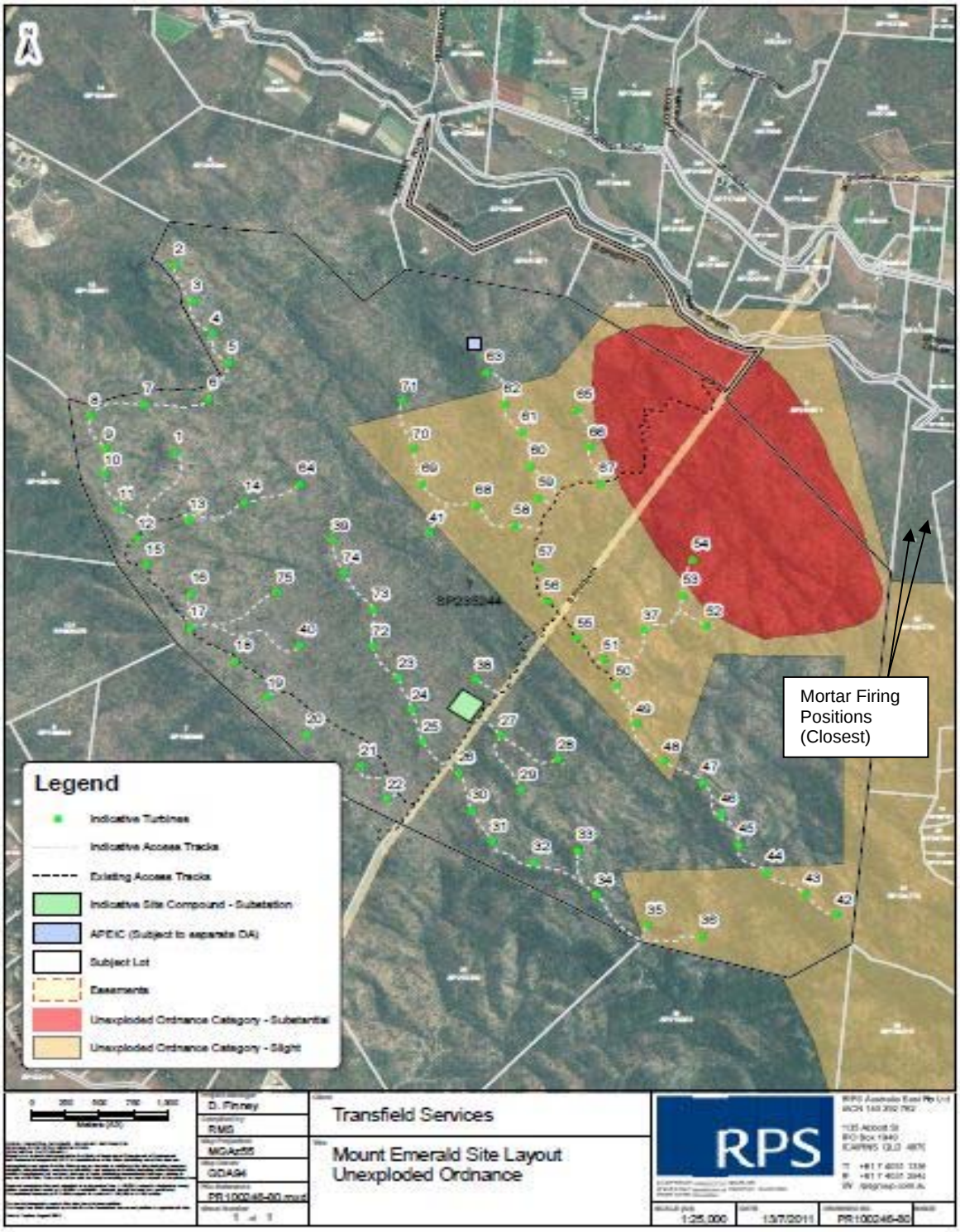
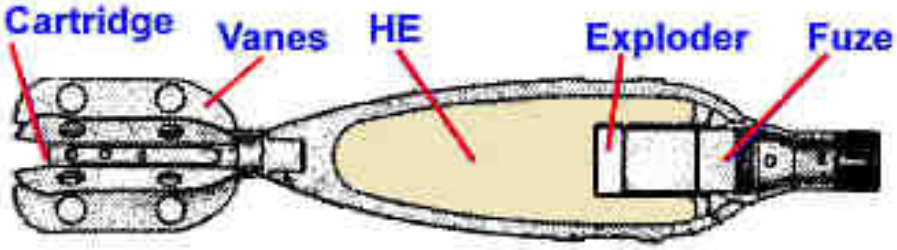
Appendix 004

Identified UXO Contamination Area Map



Appendix 005

Examples of Allied High Explosive Mortars



BRITISH 3 INCH MORTAR DATA

Mortar Weight: 13 lb (5.8 kg)

Length: 16.6 in (42.2 cm)

Diamiter: 3 in (7.6 cm)

Explosive: Amatol/TNT

NEQ: Various (Not greater than 10lb).

Fuse: Point Detonating (Impact)

Project: Mt Emerald Wind Farm, Arriga, Far North Queensland

Project Ref: EES0394-R-01-00

Appendix 005: Allied High Explosive Mortars

Scale: Not to Scale

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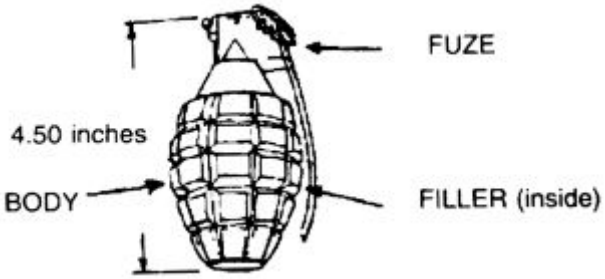
Appendix 006

Examples of Allied High Explosive Grenades



BRITISH 36M GRENADE DATA

Grenade Weight: 0.7 kg

Length: 4.5 in (11.4 cm)

Diamiter: 2.4 in (6 cm)

Explosive: Baratol or TNT

NEQ: 50g

Fuse:Time Delay

Project: Mt Emerald Wind Farm, Arriga, Far North Queensland

Project Ref: EES0394-R-01-00

Appendix 006: Allied High Explosive Grenades

Scale: Not to Scale

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Appendix 007 A

Risk Assessment Matrices - A

CONSEQUENCE LEVEL	EXPECTED CONSEQUENCES			
	Human Health	Plant and Equipment	Structures	Environment
1	No noticeable effect	No noticeable effect	No noticeable effect	No noticeable effect
2	First aid injury	No noticeable effect	No noticeable effect	No noticeable effect
3	Injury requiring medical treatment	No noticeable effect	No noticeable effect	Minor disturbance
4	Lost time injury < 3 days	Slight superficial damage	Slight superficial damage	Significant disturbance
5	Lost time injury ≥ 3 days	Moderate superficial damage	Moderate superficial damage	Slight damage to habitats.
6	Serious debilitating injury	Minor component replacement repair	Repairs - non-structural	Moderate damage to habitats.
7	Localised fatalities	Significant component replacement repair	Repairs - structural	Moderate damage to habitats. Some long term effects.
8	Multiple fatalities over extended area	Unit loss, un-repairable damage	Severe un-repairable damage	Severe damage to habitats. Some long term effects.
9	Multiple fatalities over extended area	Unit destruction	Localised structural failure and collapse	Localised destruction of habitats. Moderate long-term effects.
10	Multiple fatalities over extended area	Multiple unit destruction	Widespread structural failure and collapse	Destruction of habitats over extended area. Significant long-term effects.

Project: Mt Emerald Wind Farm, Arriga, Far North Queensland

Project Ref: EES0394-R-01-00

Appendix 007 A: Risk Assessment Matrices - A

Scale: Not to Scale

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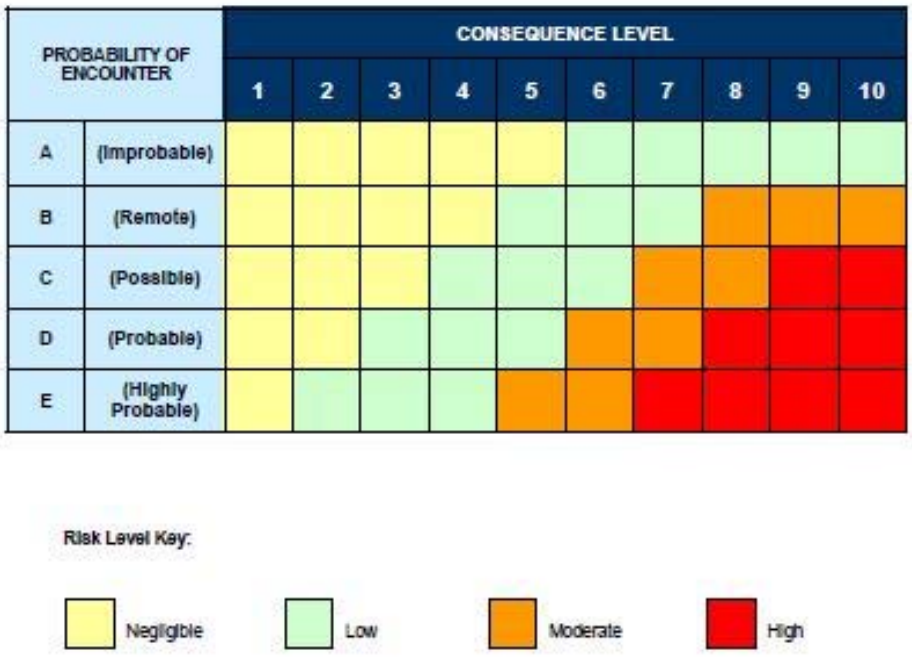
Appendix 007 B

Risk Assessment Matrices - B



Project: Mt Emerald Wind Farm, Arriga, Far North Queensland

Project Ref: EES0394-R-01-00

Appendix 007 B: Risk Assessment Matrices - B

Scale: Not to Scale

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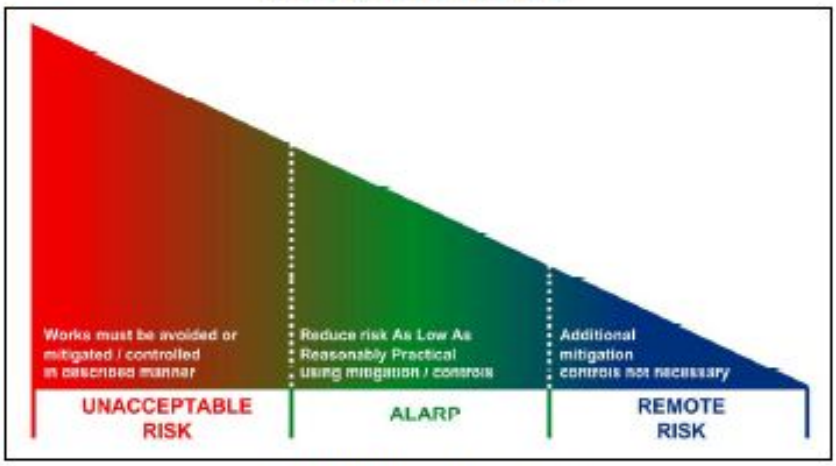
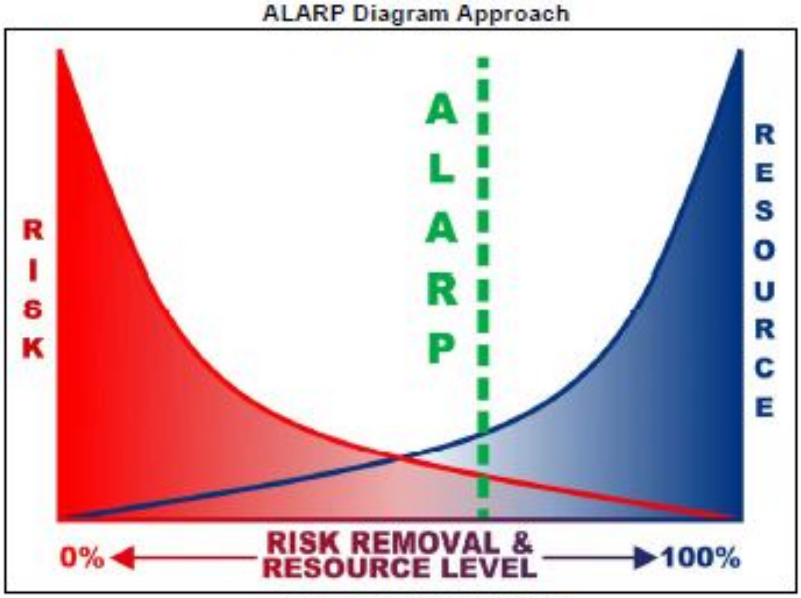
Appendix 008

'ALARP' Principle



ALARP Diagram Approach



ALARP Resource Graph

Project: Mt Emerald Wind Farm, Arriga, Far North Queensland

Project Ref: EES0394-R-01-00

Appendix 008: 'ALARP' Principle

Scale: Not to Scale

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