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Evaluating application for Ammunition Depot on SA1 Waterfront

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1. Abstract

This report assesses BigBang Solutions' proposal for an ammunition depot at Swansea Harbour using standard explosive licensing and using an Explosion Consequence Analysis (ECA) aligned with IATG standards. The evaluation considers hazard identification, risk estimation, and ALARP principles to determine feasibility and safety compliance.

Three Net Explosive Quantity (NEQ) scenarios were analysed: 3000 kg (worst case), 1500 kg (best case), and 235 kg (maximum permissible under reduced Quantity Distances for earth-covered magazines). Key site constraints include proximity to public roads (80 m), inhabited buildings (130 m), and vulnerable structures (235 m). Blast overpressures modelling using Kingery-Bulmash and blast effects using Bowen curves indicate severe consequences for higher NEQs, including damage to buildings up to 1.3 km and ground shock effects extending 1.7 km, impacting thousands of buildings and tens of thousands of people. Financial losses could exceed £10's of millions for major incidents.

The ECA confirms that storing 3000 kg or 1500 kg per ESH is unacceptable under industry standards, while 235 kg may be permissible with National Authority approval. Recommendations include reducing NEQ, implementing engineering and process controls, conducting population and exposure surveys, and engaging stakeholders. While depot construction is feasible, significant design modifications and robust mitigation measures are essential to ensure public safety and regulatory compliance.

2. Introduction

3.1 Why is it important to safely site an ammunition depot?

The safe siting of an ammunition depot ensure that human lives are protected, minimize damage to local properties and prevent the likelihood and severity of a catastrophic incident while maintaining national security. The Stockpile within an ammunition depot is typically attractive to criminals and terrorists and sites should be strategically located to prevent diversion and theft. The International technical guidelines provide guidance on how siting an ammunition depot can be achieved.

3.2 What is the International Ammunition Technical Guidelines (IATG)?

The IATG are internationally recognized set of technical guidelines that support the effective overall management of ammunition stockpiles, Safety and Security. The guidelines are based on scientific explosive safety principles, risk-management and continuous improvement with emphasis on prevention. The guidelines are to be used by states to help form national guidelines and regulations like ER2014 in the UK. [1]

The IATG uses a modular structure with all being relevant to the planning application of a new ammunition depot. Modules of high importance include Introduction and Principles (Chapter 1), Risk Management (Chapter 2), Ammunition accounting (Chapter 3) and Explosive facilities (Chapters 5 and 6). [1]

The purpose of the IATG and more broadly ammunition and explosive safety is to provide sensible legislation and regulation; good infrastructure and management; fire safety precautions and appropriately trained personnel. The consequences of poor safety can result in mass explosion, fire, injuries to worker and civilians and damage to buildings. Ammunition and explosives are inherently dangerous and both a liability as well as an asset. An example of poor explosive safety and management resulting in a massive casualty incident was on the 27th of January 2002 in Lagos Nigeria when over 1000 people died and thousands more displaced. [2]

3.3 Key Technical terms:

Ammunition Depot:

"An installation devoted primarily to the receipt, storage, issue and maintenance of ammunition" [1]

Hazard Division (HD)

"A subdivision of explosive or ammunition according to the major hazard present."
" [1]

Compatibility groups (CG)

"A further subdivision of explosives and ammunition depending on their volatility. Certain compatibility groups cannot be mixed due to the increased risk of sympathetic reaction and initiation of the assets. " [1]

Exposed site (ES)

"A magazine, cell, stack, truck or trailer loaded with ammunition, explosive workshop, inhabited building, assembly place or public traffic route which is exposed to the effects of an explosion at the potential explosion site." [1]

Potential explosive site (PES)

"The location of a quantity of explosives that will create a blast, fragment, thermal or debris hazard in the event of an explosion of its content." [1]

Quantity distance (QD)

"Which is the minimum permissible distance between a PES and an ES." [1]

Net Explosive Quantity (NEQ)

"The total explosive content present in a container, ammunition, building etc. Unless it has been determined that the effective quantity is significantly different from the actual quantity. " [1]

Explosive License Limit (ELL)

"The permitted amount of explosives at a potential explosion site." [1]

3.4 Risk Analysis

To achieve the overall principals of the IATG the risk analysis process including risk management needs to be implemented. This is critical when siting an ammunition depot because it ensures that explosive hazards are controlled to protect people, infrastructure, and the environment to an as low as reasonably practicable (ALARP) Level. The IATG chapter 2 uses QDs, PES and ES to identify where the hazards will originate from and who/what will be affected. These distances vary based on a variety of factors. Understanding these distances is essential for preventing catastrophic blast effects and fragmentation risks. Formulae and technical support data supports the creation of QDs. [1]

Risk management accounts for site-specific conditions. For example, port environments introduce additional hazards due to water amplification of ground shock effects due to the incompressibility of water and operational activities like ship fuelling which introduce flammable substances. These complexities require tailored controls, such as using reduced QDs to accommodate the required infrastructure within the port while increasing other QDs to other ES which are more susceptible to the hazards. This is critical to avoid incidences such as the Halifax explosion in 1917 where a French cargo ship containing explosives caught fire and detonated. A wave of water caused by the displacement of water resulted in further damage to the surrounding area. [3]

Further support from geologists and hydrologists among many other supporting SQEP will be able to provide more expert understanding on factors like the ground type, condition and the likelihood of flooding within the PES. More support is required when the severity of the potential incident increases. This is captured as part of the Risk analysis process.

Furthermore, the quantity, nature, and condition of explosives significantly influence incident severity. A dispersed stock of small items will likely pose less initial risk than a single large explosive article because of insufficient energy to initiate all the stores through sympathetic propagation resulting in a significantly smaller primary blast hazard. Secondary hazards presented during clear up of such an event will likely be much greater, however. This is highlighted during the clean-up of unexploded ordnance after conflict in particular resulting in the convention of cluster munitions ban in 2010. [4]

Poorly maintained or aged explosives increase the likelihood of accidental initiation. Historical incidents, such as the Evangelos Florakis Naval Base explosion on July the 11th 2011, highlight the consequences of neglecting these factors. Continuous monitoring, segregation, and mitigation strategies are therefore essential to reduce risks to ALARP levels before granting planning approval. Further information regarding the surveillance and in service proofing of munitions is found in IATG Chapter 07.20. [1] [5]

3.5 Formulae

To be able to complete a successful risk analysis of the Ammunition Depot the technical formulae used to justify the suitable quantity distances must be applied. In the case of an explosive consequence analysis the formulae found in Chapter 1 of the IATG can also be used to justify reduced quantity distances because of the effects of the specific ammunition stock. The following parameters require consideration: Air Blast, Debris, Ground shock and the Thermal effects; The consequences of the effects including damage to buildings and vulnerability of people; The likelihood of the consequences such as the probability of Damage, Injury and fatalities.

➤ Air Blast

Level 1: uses widely accepted formulae such as the Kingery and Bulmash air blast calculator and Hopkinson scaling law. [6]

Level 2: The Bowen curves capture historic testing on the effects of air blast resulting in probability of injury and fatality. While the Scilly Model is used for the probability of damage to buildings. [7] [1]

➤ Debris

Level 1:

Using Trajectory calculators and Gurney's equation for initial velocity. The fragment velocity of the specific explosive article can be identified. These require the coefficient of drag of the fragment, Mach number, initial fragment velocity and Fragment shape.

Mott Distribution principal considers the length of the debris created from concrete structures. This is used to calculate the debris velocities from the ESH. Tools such as the US SAFER tool is simpler empirical tool to predict the fragment velocities. [8]

Level 2:

Empirical correlations in DDESB TP-14 can be used to assess the probability of fatal hits and injury. [1]

➤ **Ground Shock**

Level 1:

The effects are normally much less than those caused by Air blast and Debris however using the approach in Ammunition Storage and Transport Publication – 1 which includes the use Peak Particle Velocity equations ground shock can still be calculated which can be used to assess if Building structures would fail. Ground shock effects are much greater in the harbour environment due to the incompressibility of water. [1]

Level 2: Tables found in AASTP-1 relate the degree of damage to a building due to the oscillating velocity of a ground shock. [1]

➤ **Thermal effects**

Level 1:

The greatest hazard present from initiation might be the thermal effects especially for HD 1.3. Using the Baker Fireball characterisations and the thermal flux point effects can be calculated.

Level 2:

Criteria taken from the HSE correlate thermal dose to the severity of the injury. [1]

3.6 Siting and planning of an Explosives facility

As well as understanding the blast effects produced from the unintended initiation of any of the explosive stockpile further considerations are required when siting an ammunition depot. These considerations include security measure to prevent the loss of explosives. A prolific example of when an ammunition depot stock has been stolen was in 2004 from the Al-Qa'qaa weapons depot where around 342 tonnes of HMX, RDX and PETN HE was stolen by Iraqi insurgency. [9]

Further Key considerations when siting ammunition depots:

- Ensure that they can be operated safely, economically and efficiently
- Ensure there is an acceptable level of protection to the public and individuals not connected to the facility
- All risks are kept ALARP
- Minimise loss of stocks
- Ensure the stocks can be safely maintained
- Ensure the ELL are not compromised

To determine the maximum NEQ limits for an explosive limit license the building construction of both the PES and the ES need to be considered.

Location

The location of PES requires a combination of Isolation, Accessibility, Communication and suitable terrain with predictable climate. Orientation of the ESH also is critical. Frangible walls must be facing away from the most vulnerable ES. [1]

Types of facility within depot

An Ammunition Depot will have the following activities taking place with explosives as per Chapter 5 of the IATG:

- Transportation of Explosives to site, amongst site and leaving site
 1. Infrastructure like roads and parking locations will need to be sufficient
 2. Requirements to transport by Sea using a Port is different to On Road transport
- Handling of Explosives
 1. Sufficient space is required for handling of explosives depending on the size of the assets
 2. Competent staff will be required to handle explosives both packaged and unpackaged.
- Storage of Explosives on site
 1. Facilities with temperature and humidity control are required especially if items will be stored for long period of time

- Receipt and goods out inspections
 1. Specific facilities to complete inspections will be required
 2. Process license required for that facility
- Processing to maintain stocks on site and complete unpackaged activities of the item
 1. Throughout the storage period further inspections might be required to ensure degradation of the items has not occurred
- Potential disposal of unsafe explosive items
 1. If at any point an unsafe item is found the disposal of the asset needs be able to be accommodated. [1]

Underground storage

For Smaller sites underground storage is an effective space saving design. With damage being mostly contained within the facility and preventing initiation of explosives in surrounding ESH. The climatic conditions of the outside are easily avoided. The benefits of Underground storage also are countered by some disadvantages like cost, unstable terrain and flooding as found within a harbour area. An incident at RAF Fauld on the 27th of November 1944 clearly shows the devastating effects explosives stored underground and near a large body of water can have devastating consequences and need to be mitigated against. [10]

Security and access control

To prevent unauthorised access and potential diversion of the Explosive items effective security plans, access control, perimeter security like fences, detection and deterrence like CCTV should be implemented.

Risk assessments – evaluate the attractiveness of the stockpile to diversion and how vulnerable they are to espionage. Specific control measures should then be identified to mitigate that risk. Munitions might not be fully assembled, and their constituent parts should be stored separately.

Access control – ensure that only those with permission can access the stockpile and those individuals are suitably vetted. This is controlled by keys and suitable locks managed by authorised personnel

Perimeter security – the use of suitably classed security fencing should be used around the perimeter of the ammunition depot. Additional challenges are presented in harbour areas where the perimeter might be surrounded by water. These sites will need additional controls to maintain a suitable level of security.

Detection and deterrence – intrusion detection systems and patrols with dogs are another tool to prevent diversion of the stockpile.

3. Evaluation of proposal by BigBang Solutions

3.1 Construction of the ESH

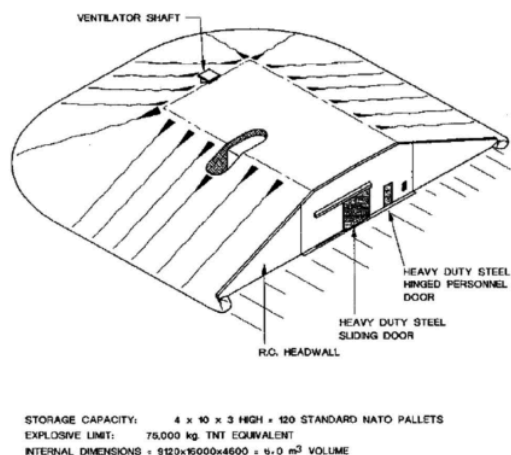


Figure 1 – ECM construction [1]

BigBang solutions propose 5 separate earths covered mound ESH with directional effects side of magazine perpendicular to the direction of the ES. There are a variety of different Earth covered mound ESH designs. Big Bang solutions will need to identify what design they have chosen however for this report the simplest standardised design has been selected as shown in figure 1.

An Earth covered magazine has earth covering the roof and against 3 walls. The side walls are perpendicular to the direction of the ES. This is shown in figure 2 below where the doors of the ECM are all facing the same direction and parallel with each other. [1]

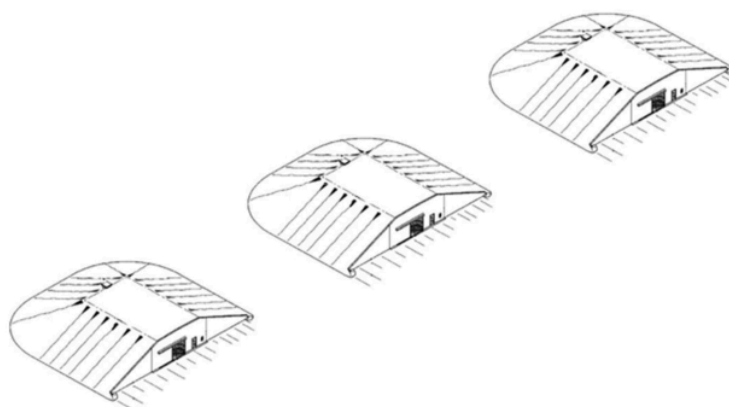


Figure 2 – orientation of ESH [1]

The directional effects for HD 1.1 and 1.3 are shown in Figure 3 and for HD 1.2 shown in figure 3.

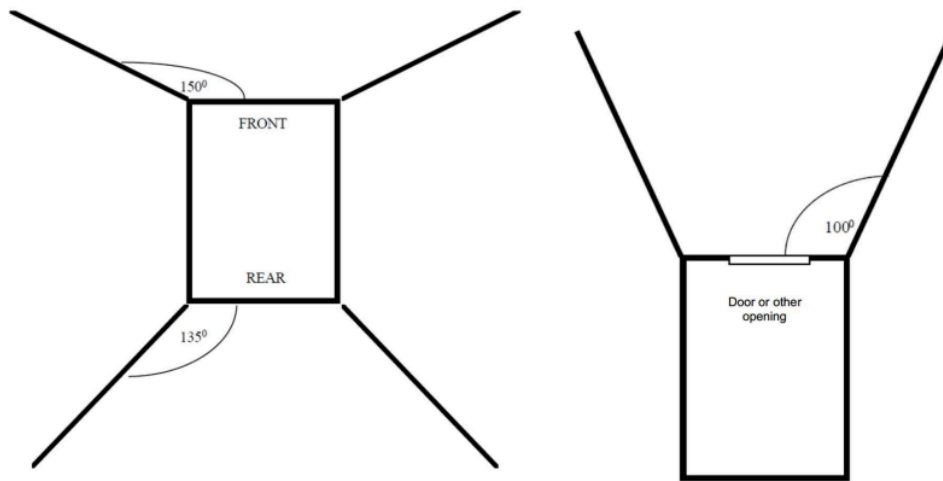


Figure 3 – directional effects from HD1.1, 1.2 and 1.3 [1]

4.2 What will the maximum ELL be for each ESH?

Within the 5 ESH the Big Bang proposal states “there will be no more than 5 ESH which will contain a total of 5000kg of HD 1.1, 500kg of HD 1.2, 1000kg of HD 1.3 and 1000kg of HD 1.4. BigBang solutions has also stated the compatibility groups of all stores.

To achieve the BigBang solutions proposal the HDs must be mixed in each ESH. Aggregation rules need to be applied when HDs are mixed with the greatest HD being applied and the NEQs combined excluding HD 1.4.

BigBang solutions other statement “each ESH will be able to hold up 1000 kg of each type of hazard division (pallets stacked 3 high), thereby requiring no more than 5 x ESH built east to west along the waste land.” The lowest reasonable permissible quantity of explosives in each ESH while still meeting the first requirement is shown in table 1 below. [1]

HD	CG	ESH 1(KG)	ESH 2(KG)	ESH 3(KG)	ESH 4(KG)	ESH 5(KG)
1.1	B					50
	D	1000	1000	1000	200	
	E				800	450
	F					500
1.2	C	87.5	87.5	87.5	87.5	
	D	25	25	25	25	
	F					50
1.3	C	250	250	250	250	
1.4	S	137.5	137.5	137.5	137.5	450
Total NEQ	Excl HD 1.4	1362.5	1362.5	1362.5	1362.5	1050
	Inc HD 1.4	1500	1500	1500	1500	1500

Table 1 – NEQ limits for requirement 1

HD		ESH 1(KG)	ESH 2(KG)	ESH 3(KG)	ESH 4(KG)	ESH 5(KG)
1.1		1000	1000	1000	1000	1000
1.2		1000	1000	1000	1000	1000
1.3		1000	1000	1000	1000	1000
1.4		1000	1000	1000	1000	1000
Total NEQ	Excl HD 1.4	3000	3000	3000	3000	3000
	Inc HD 1.4	4000	4000	4000	4000	4000

Table 2 – NEQ limits for requirement 2

Table 2 meets the latter requirement and will be used to assess the feasibility of the proposal throughout this report as it is worse case however Big Bang solutions need to clarify their proposal. They will also need to clarify the expected type of munitions they expect to store. Recommended clarification questions will be noted in Annex B.

As part of Table 1 two presumption have been made. The first being that suitable segregation can be implemented within the ESH. Additionally, that the CG B Fuzes form part of the munitions that are CG E which in turn aggregates the CG to all CG F within ESH 5.

Using Table 2 and aggregation rules each ESH will need to have a maximum ELL of 3000kg of HD 1.1. using the IATG UN Safeguard tool for QD the Vulnerable building distances, Inhabited building distances and public traffic route distance for an earth covered explosive store house with directional effects perpendicular to the direction of the ES is shown in Table 3 as well as other ES found in table in IATG chapter 2.20. [1]

4.2.1 Outside Quantity distances

ES description	Earth covered PES containing 3000kg of HD 1.1 QDs
Earth covered ESH	D3 = 8m
IBD	D15 = 400m
PTR	Low = $0.5 \times D15 = 200m$ Medium = $D17 = 270m$ High = $D15 = 400m$
VBD	$2 \times D12 = 650m$
Office within Ammunition Depot <20 people	$D17 = 270m$
Overhead powerlines	Super Network = $D13 = 305m$ Normal Network = $D11 = 205m$ Minor Network = $D10 = 120m$
Petroleum, Oil and Lubricants	Protected Underground = $0.5 \times D7 = 17.5m$ Protected above ground = $D13 = 305m$

Table 3 – QDs for each ES type

The above distances can be plotted onto a map to identify any ES than falls within the QDs and will lead to refusal/restrictions of the proposal.



Figure 4- IBD and high density PTRD

Figure 4 shows the IBD and PTR distances of 400m around area within which 5 ESH can be built. The blue line shows the perimeter of the whole ammunition depot.



Figure 5 - VBD distance of 650m around PES



Figure 6 - Closest exposed sites to the PES.

ES Number	Description of ES	Distance from PES (m)
1	Dock	130
2	Dock	160
3	Seras Energy	135
4	Driving Centre	265
5	Driving Centre	255
6	VW Garage	305
7	Marine Broker	350
8	60 residential flats (Multistorey)	235
9	100 residential flats (Multistorey)	305
10	Village Hotel (Multistorey)	420
11	Residential Flats	435
12	Church	385
13	Hospital	490
14	Residential Flats	325
15	Dock Building (Warehouse)	195
16	Dock Building (Warehouse)	230
17	Cemex Swansea Sand Wharf (Office)	340
18	UWTSD IQ and IM Building	265
19	Student Accommodation (Multistorey)	370
20	UWTSD Library (Glass)	405
21	Dock Building (Warehouse)	360
22	Dock Building (Warehouse)	360
23	Dock Building (Warehouse)	590
24	J D Marine and Sons (Office)	470
25	Health Centre	535
26	Premier Inn Hotel (Multistorey)	560
27	Variety of Offices	620
28	Appletree Nursery	715
29	Variety of Restaurants and	560
30	Driver Vehicle Standards Agency	535
31	Steel Recycling	305
32	Berth	160
33	Berth	205
34	Storage area	270
35	Berth	140
36	Dry Dock	395
Access road	PTR Low density	80
Footpath outside ES 8	PTR Medium density	230
	PTR High density	230

Table 4 - ES and the distance from the PES

The information collated in tables 1 to 4 confirm that the proposal is not feasible using standard siting and licensing procedures outlined by the IATG and should not proceed. The IBD of 125m, VBD of 300m and PTR of 270m provided by BigBang Solutions are all incorrect. Justifications for these distances from BigBang solutions

need to be provided and this is outlined in Annex B. The National Authority should also be included in these discussions to provide clarification.

The Maximum ELL using standard licensing permitted within the proposed ammunition depot is shown in Table 5 and Table 6 below. Only the nearest type of each ES has been used during this process.

Standard Explosives Limit Licence (ELL)										
IATG Form 02.30C										
PES Number / Designation:				PES 1,2,3,4 or 5						
Unit			Location				Authorised as			
BigBang Ammo Depot			Swansea Harbour				Explosive Store House			
Maximum Authorised NEQ										
HD 1.1		HD 1.2.1		HD 1.2.2		HD 1.3.1		HD 1.3.2		HD 1.4
0kg	and kg	for No Limit	and kg	for No Limit	and kg	for 8380kg	and kg	for 8380kg	kg	To physical capacity

Table 5 – Standard ELL [1]

Explosives Limit Licensing - Supplementary Matrix											
											IATG Form 02.30E
UNIT	BigBang Depot						LICENCE No				
SITE No / NAME	Swansea Harbour		FOR USE AS		Explosive Store House		ADEQUATE FIRE FIGHTING		YES / NO		
ELECTRICAL STANDARD		LIGHTNING PROTECTION			AREA PLAN No		SAFEGUARD MAP No				
CAT: A / B / C / D / OTHER		YES / NO									
CONSTRUCTION DETAILS											
HEADWALL & DOOR		TYPE OF FLOOR			TYPE OF HEATING		IAS		SITE DRAWING No		
7 BAR / 3 BAR / FFR / OTHER							YES / NO				
TRAVERSE DETAILS											
QUANTITY DISTANCES (METRES)											
ES →											
PES ↓											
	ESH 1,2,3,4	ES 1	ES 8	Access Road	Footpath ES 8						
	40	130	235	80	230						
NET EXPLOSIVE QUANTITY (IN UNITS OR DECIMAL FRACTIONS OF 1000 KILOGRAMS)											
HD 1.1	250.00	0.00	0.15	0.37	0.00						
HD 1.21	No Limit	No Limit	No Limit	No Limit	No Limit						
HD 1.22	No Limit	No Limit	No Limit	No Limit	No Limit						
HD 1.31	No Limit	8.38	49.51	15.63	46.41						
HD 1.32	No Limit	8.38	49.51	No Limit	46.41						
MAXIMUM NEQ PERMITTED BY QUANTITY DISTANCE									LICENSING AUTHORITY UNIT STAMP		
HD 1.1	0kg	or HD 1.21	No Limit	or HD 1.22	No Limit	or HD 1.31	8380kg	or HD 1.32	8380kg		

Table 6 – Supporting matrix for ELL [1]

The location of the ammunition depot falls within the Swansea Docks /port area (Annex E). Different Q factors are used within a port due to different levels of risk and too many variables to be able to provide a single matrix like the standard QD tables shown above. Further clarification is needed from BigBang solutions on the use of this ammunition depot and if it falls within the International maritime dangerous goods (IMDG) Code as referenced within the IATG.

Factor	QD	QD Function / Formula	Remarks
Process Buildings (Land)	PBD	As per Annexes E, G and L as appropriate	
Inhabited Buildings (Land)	IBD	$16.7Q^{1/3}$	If a high density population then $22.2Q^{1/3}$ should be applied.
Vulnerable Buildings (Land)	VBD	$33.3Q^{1/3}$	If a vulnerable building falls within this distance an ECA should be completed.
Public Traffic Route Low Density	PTRD	$16.7Q^{1/3}$	
Public Traffic Route Medium Density		$11.1Q^{1/3}$	
Public Traffic Route High Density		$8.0Q^{1/3}$	

Table 7 – Port area QD formulae

ES description	Earth covered PES containing 3000kg of HD 1.1 QDs
Earth covered ESH	D3 = 8m = No change
IBD	D15 = 400m = No change
PTR	Low = $(200/14.8 \times 16.7)225$ m Medium = $(270/14.8 \times 16.7) = 310$ m High = $(400/14.8 \times 16.7) = 450$ m
VBD	$650/44.4 \times 33.3 = 490$ m
Office within Ammunition Depot <20 people	D17 = 270m

Table 8 – Updated QDs for Port area

The QDs found in Table 8 do not support those proposed by BigBang solutions (Annex E) and there are still many ES that fall within the VBD, IBD and PTRD at the proposed location.

4.2.2 Inside Quantity distances

BigBang solutions have only proposed the construction of the 5 ESH. An Ammunition depot typically requires:

Ammunition Process buildings to ensure inspections and repair tasks can be completed to ensure that the stockpile remains safe throughout it's time at the depot.

Office buildings will be required for the workers of the site to facilitate the support activities required like ammunition accounting and the staff required to run the site.

A disposal area in case any munitions within the stockpile are deemed unsafe to move.

When siting an ammunition depot local environmental condition should also be considered. Storing munition in the near vicinity of the sea in a wet and humid environment like Swansea docks is not an ideal location for an ESH especially for items in long term storage. Further clarification is needed on the duration and turnover of the stockpile as per Annex A, B and C.

5. What is the maximum permissible ELL using Non-standard licensing and Explosive consequence analysis

If there is a suitable justification on why the chosen site has been selected and cannot be built elsewhere then a non-standard license with the use of an Explosive safety case justification can be used to increase the ELL specifically for the munitions being contained within each ESH.

An explosion consequence analysis (ECA) is required to determine the separation distances using the method shown below.

Risk Assessment Process Component	Serial	ECA Activity	Support Information
Risk Analysis (Hazard Identification and analysis)	1	Determine Hazard division	3000kg of HD 1.1 worst case maximum quantity per ESH.
	2	Determine NEQ	1500kg of HD 1.1 best case maximum per ESH.
	3	Aggregate to HD 1.1 if applicable	235kg of HD 1.1 maximum NEQ permitted using reduced QDs for earth covered ESH
	4	Determine Level of protection of ESH	Earth covered mound with directional effects perpendicular to ES
	5	Range to nearest public road	80m
	6	Range to nearest IBD	130m
	7	Nearest VBD	235m
	8	Secondary hazards (docked Boat)	140m
	9	Determine condition of ammunition	Likely condition A1 or A2 from UK manufacturing facilities. Big Bang solutions to confirm. Spontaneous combustion improbable.
Risk Analysis (risk estimation)	10	Reduced QDs with Earth covered mounds with	Exact Blast pressures can be calculated using Kingery Bulmash Blast parameter Calculator and the DDESB TP-14. The latter is for the use of DoD.

		expected overpressure (JSP 482)	An alternative approach uses QDs from JSP 482 that considers the Earth cover mound shown below. 3.3 Earth-Covered Buildings 3.3.1 The earth cover of earth-covered buildings will generally attenuate the blast overpressure. The greatest reduction will be obtained from the rear of the building. The following QDs are considered for such buildings, containing up to 250 000 kg NEQ, defined as UK standard igloos: <table><thead><tr><th>Direction</th><th>QD (Q in kg, D in m)</th><th>Peak Incident (Side-on) Overpressure Expected (kPa)</th></tr></thead><tbody><tr><td>Side</td><td>19.0Q^{1/3}</td><td>5</td></tr><tr><td>Rear</td><td>15.5Q^{1/3}</td><td>5</td></tr><tr><td>Side</td><td>14.0Q^{1/3}</td><td>8</td></tr><tr><td>Rear</td><td>11.0Q^{1/3}</td><td>9</td></tr><tr><td>Rear</td><td>6.0Q^{1/3}</td><td>21</td></tr></tbody></table> Extract from JSP 482 <table><thead><tr><th>QD Type</th><th>Typical pressure</th><th>ECM QD</th><th>New QD 3000kg</th><th>New QD 1500kg</th><th>Maximum NEQ</th></tr></thead><tbody><tr><td>VBD (44.4Q^{1/3})</td><td>2.0 – 3.0 Kpa</td><td>Unknown (2 x IBD)</td><td>550m 450m</td><td>440m 360m</td><td>235kg 435kg</td></tr><tr><td>IBD and PTRD (22.2Q^{1/3})</td><td>5kpa</td><td>Side 19.0Q Rear 15.5Q</td><td>275m 225m</td><td>220m 180m</td><td>320kg 585kg</td></tr><tr><td>Medium PTRD (14.8Q^{1/3})</td><td>9kpa</td><td>Rear 9.0Q</td><td>130m</td><td>105m</td><td>700kg</td></tr><tr><td>PBD (8.0Q^{1/3})</td><td>21kpa</td><td>Rear 6.0Q</td><td>90m</td><td>70m</td><td>N/A</td></tr></tbody></table> Table showing the updated QDs for 3000kg HD1.1, 1500kg HD 1.1 and the maximum permissible NEQ using the VBD, IBD and PTRD identified in Table 4 and the explosive license.	Direction	QD (Q in kg, D in m)	Peak Incident (Side-on) Overpressure Expected (kPa)	Side	19.0Q ^{1/3}	5	Rear	15.5Q ^{1/3}	5	Side	14.0Q ^{1/3}	8	Rear	11.0Q ^{1/3}	9	Rear	6.0Q ^{1/3}	21	QD Type	Typical pressure	ECM QD	New QD 3000kg	New QD 1500kg	Maximum NEQ	VBD (44.4Q ^{1/3})	2.0 – 3.0 Kpa	Unknown (2 x IBD)	550m 450m	440m 360m	235kg 435kg	IBD and PTRD (22.2Q ^{1/3})	5kpa	Side 19.0Q Rear 15.5Q	275m 225m	220m 180m	320kg 585kg	Medium PTRD (14.8Q ^{1/3})	9kpa	Rear 9.0Q	130m	105m	700kg	PBD (8.0Q ^{1/3})	21kpa	Rear 6.0Q	90m	70m	N/A
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	11	Impact on humans due to Blast	Bowen Blast damage Curves show the Likelihood of fatality, lung damage and ear drum damage as shown in Annex D <table><thead><tr><th colspan="2">Injury/Fatality to Personnel Range (m)</th></tr></thead><tbody><tr><td>Fatal Distance</td><td>26.42</td></tr><tr><td>Lung Damage</td><td>41.87</td></tr><tr><td>Eardrum Rupture</td><td>107.67</td></tr></tbody></table> In a free field blast without the accounting for the effects of the ESH. <table><thead><tr><th colspan="2">Injury/Fatality to Personnel Range (m)</th></tr></thead><tbody><tr><td>Fatal Distance</td><td>14.24</td></tr><tr><td>Lung Damage</td><td>22.57</td></tr><tr><td>Eardrum Rupture</td><td>58.04</td></tr></tbody></table> Blast effects from a free field blast of 235kg HD1.1. These distances fall within the perimeter of the Ammunition depot and the waterways of the Docks.	Injury/Fatality to Personnel Range (m)		Fatal Distance	26.42	Lung Damage	41.87	Eardrum Rupture	107.67	Injury/Fatality to Personnel Range (m)		Fatal Distance	14.24	Lung Damage	22.57	Eardrum Rupture	58.04																																
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	12	Determine quantity of	A survey is required to understand the quantity of people that are located within																																																

		humans within range to experience injury	the area which they can experience injury. For 235kg of HD1.1 this distance is 58.04m in a free field. Eardrum Rupture 58.04 This does not mean an injury cannot occur beyond this distance due to the blast however it is much less likely. Bowen curves are based on healthy, "average" Humans. Elderly people for example, would be more susceptible to injury.
	13	For the maximum NEQ what damage is expected to buildings at certain ranges	3000kg HD1.1 House demolition at 61.08m Badly damaged at 90.35m Uninhabitable until repaired 157.79m House requires repair 542.07m Small windows break 374.98m Medium Window 605.74m Large window 1355.71m 1500kg of HD1.1 House demolition at 41.38m Badly damaged at 61.21m Uninhabitable until repaired 106.90m House requires repair 367.26m Small windows break 297.63m Medium Window 480.78m Large window 1076.03m 235kg HD1.1 House demolition at 12.43m Badly damaged at 18.38m Uninhabitable until repaired 55.14m House requires repair 110.28m Small windows break 160.45m Medium Window 259.18m Large window 580.07m
	14	Determine the number of buildings within each damage criteria	3000kg HD1.1 House demolition: 0 Badly damaged: 0 Uninhabitable until repaired: 2 Houses require repair: >500 Small windows break: >200 Medium Window: >500

			Large window: >10,000 1500kg of HD1.1 House demolition: 0 Badly damaged: 0 Uninhabitable until repaired 0 House requires repair >200 Small windows break: >50 Medium Window: >500 Large Window: >10,000 235kg of HD1.1 House demolition: 0 Badly damaged: 0 Uninhabitable until repaired 0 House requires repair 0 Small windows break: <10 Medium Window: <100 Large Window: >500																
	15	For the NEQ calculate the range ground shock is likely to cause damage	3000kg of HD 1.1 1752.71m 1500kg of HD 1.1 1239.35m 235kg of HD 1.1 490.55m																
	16	Determine the number of buildings within ground shock range	1752.71m contains 15,000 buildings 1239.35m contains 10,000 buildings 490.55m contains 500 buildings																
	17	Apply the probability of secondary blast injury to the series 14 result	<table border="1"> <thead> <tr> <th>Breakage</th><th>Minor injury</th><th>Major injury</th><th>Lethality</th></tr> </thead> <tbody> <tr> <td>100%</td><td>100%</td><td>10%</td><td>1%</td></tr> <tr> <td>50%</td><td>10</td><td>1%</td><td>0,1%</td></tr> <tr> <td>1%</td><td>0,1%</td><td>0,01%</td><td>0,001%</td></tr> </tbody> </table>	Breakage	Minor injury	Major injury	Lethality	100%	100%	10%	1%	50%	10	1%	0,1%	1%	0,1%	0,01%	0,001%
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	18	Estimate occupancy levels and	To be supplied by a survey however prediction of 30,000 people																

		exposure probabilities of serial 16	To be supplied by a survey however prediction of 20,000 people To be supplied by a survey however prediction of around 2000 people																																																																																													
	19	Estimate financial values	>£20 million >£10 million >£100,000																																																																																													
	20	Use Serial 19 in Expected Monetary Values model to estimate likely financial consequence	Using the EMV model and series 19 the financial consequence of a minor fire and Major fire. <table border="1"> <thead> <tr> <th rowspan="2">Financial Cost Area</th><th colspan="3">Costs of Event (\$x)</th></tr> <tr> <th>Minor Fire (No Explosion)</th><th>Major Fire (Minor Explosion)</th><th>Major Fire (Mass Explosion)¹¹</th></tr> </thead> <tbody> <tr> <td>Total Costs</td><td>8 x</td><td>18 x</td><td>35 x</td></tr> </tbody> </table> Table above showing total costs. Table below showing how the costs are calculated. <table border="1"> <thead> <tr> <th rowspan="2">Financial Cost Area</th><th colspan="3">Costs of Event (\$x)</th></tr> <tr> <th>Minor Fire (No Explosion)</th><th>Major Fire (Minor Explosion)</th><th>Major Fire (Mass Explosion)¹¹</th></tr> </thead> <tbody> <tr> <td>EOD Clearance Costs</td><td>x</td><td>xx</td><td>xxxxx</td></tr> <tr> <td>Repair Costs (Ammunition Depot)</td><td>xx</td><td>xxxx</td><td>xxxxx</td></tr> <tr> <td>Repair Costs (Civilian Buildings)</td><td></td><td>x</td><td>xxxx</td></tr> <tr> <td>Reconstruction Costs (Ammunition Depot)</td><td>xx</td><td>xxxx</td><td>xxxxx</td></tr> <tr> <td>Reconstruction Costs (Civilian Buildings)</td><td></td><td></td><td>xxx</td></tr> <tr> <td>Injury Compensation Costs</td><td></td><td>x</td><td>xxxx</td></tr> <tr> <td>Replacement Ammunition Costs</td><td>xxx</td><td>xxxx</td><td>xxxxx</td></tr> <tr> <td>Staff Training Costs (New Staff)</td><td></td><td>xx</td><td>xxxx</td></tr> </tbody> </table> Table below shows additional risk reduction measures which would reduce the severity of an event. Further risk reduction levels will be captured in Annex A <table border="1"> <thead> <tr> <th rowspan="2">Financial Cost Area</th><th colspan="3">Risk Reduction Costs against Event (\$y)</th></tr> <tr> <th>Minor Fire (No Explosion)</th><th>Major Fire (Minor Explosion)</th><th>Major Fire (Mass Explosion)¹²</th></tr> </thead> <tbody> <tr> <td>Robust Explosive Storehouse (ESH) Buildings¹³</td><td></td><td>yy</td><td>yyyyy</td></tr> <tr> <td>Barricades¹⁴</td><td></td><td>yy</td><td>yy</td></tr> <tr> <td>ESH and Barricades Annual Maintenance</td><td>y</td><td>y</td><td>y</td></tr> <tr> <td>Effective Fire Fighting Equipment</td><td>y</td><td>yy</td><td>yy</td></tr> <tr> <td>Vegetation Clearance Costs</td><td>y</td><td>y</td><td>y</td></tr> <tr> <td>Effective Staff Training</td><td>y</td><td>yy</td><td>yyy</td></tr> <tr> <td>Effective Ammunition Depot Procedures</td><td>y</td><td>y</td><td>y</td></tr> <tr> <td>Effective Contraband Measures</td><td>y</td><td>y</td><td>y</td></tr> <tr> <td>Total Costs</td><td>6 y</td><td>13 y</td><td>16 y</td></tr> </tbody> </table> Table 10: Indicative EMV orders of magnitude for risk reduction costs	Financial Cost Area	Costs of Event (\$x)			Minor Fire (No Explosion)	Major Fire (Minor Explosion)	Major Fire (Mass Explosion) ¹¹	Total Costs	8 x	18 x	35 x	Financial Cost Area	Costs of Event (\$x)			Minor Fire (No Explosion)	Major Fire (Minor Explosion)	Major Fire (Mass Explosion) ¹¹	EOD Clearance Costs	x	xx	xxxxx	Repair Costs (Ammunition Depot)	xx	xxxx	xxxxx	Repair Costs (Civilian Buildings)		x	xxxx	Reconstruction Costs (Ammunition Depot)	xx	xxxx	xxxxx	Reconstruction Costs (Civilian Buildings)			xxx	Injury Compensation Costs		x	xxxx	Replacement Ammunition Costs	xxx	xxxx	xxxxx	Staff Training Costs (New Staff)		xx	xxxx	Financial Cost Area	Risk Reduction Costs against Event (\$y)			Minor Fire (No Explosion)	Major Fire (Minor Explosion)	Major Fire (Mass Explosion) ¹²	Robust Explosive Storehouse (ESH) Buildings ¹³		yy	yyyyy	Barricades ¹⁴		yy	yy	ESH and Barricades Annual Maintenance	y	y	y	Effective Fire Fighting Equipment	y	yy	yy	Vegetation Clearance Costs	y	y	y	Effective Staff Training	y	yy	yyy	Effective Ammunition Depot Procedures	y	y	y	Effective Contraband Measures	y	y	y	Total Costs	6 y	13 y	16 y
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Risk and ALARP evaluation	21	Compare estimated predicted casualties at serial 12 and 18 to other industrial	The table below shows the suggested acceptable risk levels that the public can be exposed to according to the IATG. If the ESH stores the maximum NEQ irregularly this increases the acceptable risk level. Further questions to support this are capture in the Annex A,B and C																																																																																													

		levels are the predicted casualties tolerable.	<table><tr><td>General Public (Maximum Tolerable Limit)</td><td>1×10^{-4}</td><td> • The general public may be exposed to this risk level on an occasional basis and in exceptional circumstances. • A non-standard explosive limit licence should be issued at this risk level.¹⁴ • If the I_E is greater than 1×10^{-3} then a special case for licensing shall be submitted to the national technical authority, and political acceptance of the risk, in writing, shall be formally sought. </td></tr><tr><td>General Public (Warning Level)</td><td>1×10^{-5}</td><td> • This should be the maximum level of risk that the general public is exposed to on a regular basis. • A non-standard explosive limit licence should be issued at this risk level.¹⁵ </td></tr><tr><td>General Public (Acceptable Limit)</td><td>1×10^{-6}</td><td> • This should be the ideal level of risk for daily exposure. • A standard explosive limit licence should be issued at this risk level.¹⁶ </td></tr></table> Table 3: Suggested tolerable risk levels	General Public (Maximum Tolerable Limit)	1×10^{-4}	• The general public may be exposed to this risk level on an occasional basis and in exceptional circumstances. • A non-standard explosive limit licence should be issued at this risk level.¹⁴ • If the I_E is greater than 1×10^{-3} then a special case for licensing shall be submitted to the national technical authority, and political acceptance of the risk, in writing, shall be formally sought.	General Public (Warning Level)	1×10^{-5}	• This should be the maximum level of risk that the general public is exposed to on a regular basis. • A non-standard explosive limit licence should be issued at this risk level.¹⁵	General Public (Acceptable Limit)	1×10^{-6}	• This should be the ideal level of risk for daily exposure. • A standard explosive limit licence should be issued at this risk level.¹⁶											
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22	Are the financial consequence at serial 20 acceptable to the government?	The ECA has analysed 3 different maximum permissible NEQs for an individual ESH. The consequences of the highest, 3000kg and 1500kg would be unacceptable in line with under industry however the smaller 235kg might be permissible if the National Authority accepts. <table><tr><th>Generic Area / Activity</th><th>Specific Area / Activity</th><th>Remarks</th></tr><tr><td>Risk Management</td><td>Identify and nominate specific individual responsible for risk management policy in explosive facilities.</td><td>•</td></tr><tr><td>Risk Analysis</td><td>Identify 'Explosives Facilities'.</td><td>•</td></tr><tr><td>Risk Analysis</td><td>Identify 'At Risk' Groups.</td><td> • Workers in Explosive Area (Unqualified) • Workers in Explosive Area (Explosives Qualified). • General Public Residing in Proximity to Explosive Facility. • General Public Transiting in Proximity to Explosive Facility. </td></tr><tr><td>Risk Analysis</td><td>Decide on the appropriate level of Tolerable Risk in terms of I_E and S_{I_E}.</td><td>• Risk levels should be comparable with other industrial processes.</td></tr><tr><td>Risk Acceptance</td><td>Obtain written Approval¹⁸ for Tolerable Risk levels.</td><td>• This ensures that appropriate risk acceptance authority is aware of the risk, and of their responsibilities to allocate appropriate resources to manage the risk and maintain it within tolerable levels.</td></tr><tr><td>Risk Communication</td><td>Widely communicate the Tolerable Risk levels being applied to Explosive Facilities.</td><td> • Communities in close proximity should be made aware of the risks they are exposed to by their political class. • Means of communication should account for literacy and access differentials between men/women, as well as for the presence of linguistic minorities and transient populations to ensure maximum reach. </td></tr></table> Table 4: Tolerable risk protocol	Generic Area / Activity	Specific Area / Activity	Remarks	Risk Management	Identify and nominate specific individual responsible for risk management policy in explosive facilities.	•	Risk Analysis	Identify 'Explosives Facilities'.	•	Risk Analysis	Identify 'At Risk' Groups.	• Workers in Explosive Area (Unqualified) • Workers in Explosive Area (Explosives Qualified). • General Public Residing in Proximity to Explosive Facility. • General Public Transiting in Proximity to Explosive Facility.	Risk Analysis	Decide on the appropriate level of Tolerable Risk in terms of I_E and S_{I_E} .	• Risk levels should be comparable with other industrial processes.	Risk Acceptance	Obtain written Approval ¹⁸ for Tolerable Risk levels.	• This ensures that appropriate risk acceptance authority is aware of the risk, and of their responsibilities to allocate appropriate resources to manage the risk and maintain it within tolerable levels.	Risk Communication	Widely communicate the Tolerable Risk levels being applied to Explosive Facilities.	• Communities in close proximity should be made aware of the risks they are exposed to by their political class. • Means of communication should account for literacy and access differentials between men/women, as well as for the presence of linguistic minorities and transient populations to ensure maximum reach.
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Table 9 – Explosive Consequence Analysis [1]

6. Conclusion

After evaluating the proposal from BigBang solutions and completing a variety of non-standard explosive licensing tools above like the ECA this report recommends:

1. Further clarification from BigBang solutions is required. A recommended list of questions is captured in Annex B. A formal meeting/s to discuss siting of the Ammunition depot further with BigBang Solution, The National Authority (HSE) and the Council is critical to achieve a safe and pragmatic ammunition depot.
2. Clarification on the use of the exposed sites including the quantity of people located in each one and the ES usage will determine if any sites need greater or reduced levels of protection. This report uses what is available of google maps however the council more information will be available and for any unknown information can be measured using tools like surveys. The Council is best placed to support this, and relevant questions are found in Annex C
3. That BigBang implement a complete Risk Reduction Process of all 3 levels provided by the IATG. This includes the engineering controls like barricades and process controls to ensure the explosive stores remain secure and are not susceptible to diversion. Further evaluation of the RRPL is capture in Annex A
4. Users of the marina area must be communicated the risks of the site and any additional control measures that are in effect. These control measures include docking outside of the IBD distance of the ELL; refuelling, storage and handling of POL substances outside of the suitable distances agreed by the National Authority; additional security controls within the marina area.

7. Executive Summary

Initial findings of this report support the construction of an ammunition depot however using the design proposed by BigBang solutions (Annex E) is not permissible. Using the ECA, a smaller ELL of 235kg of HD 1.1 per ESH should be encouraged. This will only be permissible if the NEQ within the ESH is always kept to a minimum and that the aggregate of all explosives stores does not exceed that quantity. The remaining HD requirements provided by BigBang solutions are acceptable and do not exceed standard explosive licensing rules. To store the initial requested quantity an additional 17 ESH would be required. Physical space within the proposed ammunition depot would render this impossible. If BigBang solutions would like to proceed with a reduced ELL Ammunition depot potentially with a different design, then further technical support can be made available like that within this report. This would ensure the compliance of the Council towards the explosive safety standards of the IATG and those of the National Authority.

8. References

- [1] UNODA, “UN SaferGuard,” march 2021. [Online]. Available: <https://unsafeguard.org/>.
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9. Appendix

Annex A – Risk Reduction Process Level questionnaire

Annex B – Questions for Big Bang solutions

Annex C – Questions for Swansea City Council

Annex D – Blast Parameter calculator

Annex A – Risk Reduction Process Level Questionnaire (Simplified)

Ammunition Management Policy

Will there be a formal system in place to routinely determine surplus stocks of ammunition and explosives?

Will the ammunition facilities independently and formally inspected at least annually?

Health and Safety at Work

Have any formal Risk Assessments been completed and recorded?

Has the Risk Assessment estimated the Risk based on Probability?

Has the Risk Assessment estimated the Risk based on Explosion Consequence Analysis?

Has the Risk Assessment estimated the Individual Risk?

Will the Residual Risk be formally accepted in writing by a higher level of command?

Will the Residual Risk be formally communicated to the local civilian community?

Is there a formal system in place for use of land to extend current explosive facilities?

Is there a formal system in place for the identification and authorization of new land for explosive facilities?

Explosives Limit Licensing

Is there a formal and legal system to safeguard external danger areas?

Will Logbooks or Record Cards be formally kept for each explosive storehouse?

Will the Logbooks or Record Cards be signed on a regular basis?

Will copies of all appropriate publications (including IATG or equivalent) kept at each storage depot?

Inventory Management

Will the Ammunition Management Policy Statements (AMPS) (or equivalent) used to assist the through life management of each ammunition type?

Is there a formally established independent organization responsible for the technical inspection of ammunition stock holding units?

Will there be an effective ammunition accounting system that can account by type, quantity, lot number, batch number, technical condition and location of ammunition?

Will regular independent stocktakes and audits be carried out?

Lotting and Batching

Will a formal system for the effective LOGISTIC Lotting and Batching of ammunition exist?

Infrastructure - Design

Is there a formal system in place to ensure that all NEW PERMANENT explosive storehouses are constructed in compliance with the design principles in IATG 05.20 or to NATO Standards?

If constructed will the traverses and barricades for the explosive storehouses be built in compliance with the design principles in IATG 05.30 or to NATO Standards?

Is there a formal system in place to ensure that all NEW traverse and barricades for PERMANENT explosive storehouses are constructed in compliance with the design principles in IATG 05.30 or to NATO Standards?

Will the Lightning Protection Systems for the explosive storehouses be constructed in compliance with the design principles in IATG 05.40?

Infrastructure - Windows

Is the glass of acceptable standard?

Can sunlight shine directly onto explosive stores?

Are guard bars fitted and free of corrosion?

Infrastructure - Drains and Gutters

Are there suitable drains and gutters free of grass cuttings, leaves, wind-blown foliage, rubbish etc?

Infrastructure - Heating, Ventilation and Air Conditioning

Have ventilators been installed and are free from corrosion?

Do ventilators open and close properly?

Do ventilators require protective paint, oil or grease?

Are any thermal links or automatic opening device present? Serviceable?

Are hygrometers / thermometers present and serviceable?

Is there any heating / air conditioning present and serviceable?

Do radiators have sloped guards?

Security

Are security keys serviceable and rotated?

Is there a system in place to control the issue of keys to the Explosive Storage Area and Bunkers?

Are the locks in working condition?

Are staff working at ammunition storage facilities subject to routine security vetting?

Is access to ammunition storage location keys restricted to authorised personnel?

Is there a system in place to Control Entry to the Explosives Storage Area?

Is access to ammunition storage areas controlled and limited to authorised personnel only?

Are the doors and gates secured with padlocks?

Do padlocks should comply with European Standard EN 12320:2001, Building hardware - Padlocks and padlock fittings - Requirements and test methods?

Is the perimeter fitted with intrusion detection systems (IDS)?

Is there Class 4 security fencing present to provide maximum security?

Is perimeter illumination present to allow for detection of intruders?

Is there a guard response force deployed to check integrity of ammunition storage areas during non-working hours?

Safety - Explosive Contents

Is a system of Compatibility Groups for the safe mixing of ammunition during storage present?

Is the UN Hazard Division marking system used?

Is a National Hazard Division marking system used if the UN system is not?

Does the marking system shows HCC, HD, UN Serial Number, Ammunition Type, Lot/Batch Number and Quantity?

Are ESH stacking systems (Stack Tally Cards) in place?

Do Stack Tally Cards contain HD, Batch/Lot Number, and Quantity?

Are unsealed boxes clearly marked with remaining quantity?

Are the contents of unsealed boxes free of corrosion, damage or dampness?

Is there a formal system of ensuring that ammunition packaging or ammunition components is Certified as Free From Explosive (CFFE) by qualified personnel and that a 'CFFE Certificate' accompanies such items wherever they go?

Is there a formal system of ensuring that ammunition is Certified as Safe to Move (STM) by qualified personnel and that a 'STM Certificate' or equivalent accompanies the ammunition wherever it goes?

Is ammunition of Compatibility Group (CG) 'H' or equivalent stored separately to all other ammunition types?

Are tools and first aid available where CG 'H' equivalent (White Phosphorous) is being stored?

Are non-palletised stores on battens or racking or equivalent?

Are gangways between stacks in place and adequate?

Safety - Fire Fighting (Equipment)

Is an Emergency Water Supply (EWS) present?

Is the EWS full, clear and free of wind-blown debris?

Are fire hydrants present?

Are fire hydrants serviceable and at correct water pressure?

Is immediate firefighting equipment present in ESH (extinguishers, sand etc)?

Is immediate firefighting equipment regularly function checked and recorded?

Are fire appliances and equipment accessible, clearly marked and painted?

Are fire beaters serviceable and in sufficient quantity?

Safety - Fire Fighting (Response)

Is there a formal and written Fire Plan and Fire Orders?

Is a fire alarm system in place and operable?

Are fire alarm systems maintained, tested and recorded?

Is the vegetation around the Explosive Storage Area and the Explosive Storehouses regularly cut?

Are there fire breaks within the Explosive Storage Area?

Are regular fire practices held and recorded?

Are Fire Division Signs and Supplementary Fire Signs displayed, legible and serviceable?

Do Fire Division Signs and Supplementary Fire Signs correctly reflect the stocks?

Is there a Formal Liaison and Meetings with the Local Authority Fire Service?

Does the local authority fire service know what is stored in depot and what inherent risks are?

Is the local authority fire service informed of any major changes to storage conditions or types of ammunition being stored?

Are regular exercises held with the local fire authority?

Empty boxes are a potential fire hazard. Is there a designated area for them? Are they free of paints, oils, greases, solid waste, wood scraps etc?

Have all labels been removed from empty boxes?

Safety - Fire Fighting (Vegetation)

Is there a 1m sterile area around each ESH?

Is it clear of grass, foliage, shrubbery, gorse and heather?

Are grassed areas inside and outside the depot sufficiently mown and all grass cuttings removed?

Is the grass cut at least bi-monthly during spring/summer months?

Are there trees inside the depot for camouflage?

Safety - Operations

Are all Explosives Limits Licences (ELL) displayed?

Do the ELL reflect actual stock levels?

Are all tools, equipment and cleaning utensils allowable correctly listed and authorised?

Is there a system operable to ensure the Exclusion of Prohibited Articles from the Explosives Area?

Is there a contraband notice at entry to Explosives Area?

Is there a contraband box at entry to the Explosives Area?

Is it MANDATORY that ALL contraband is left in a contraband box upon entry to the Explosives Area with NO EXCEPTIONS whatsoever?

Is there a designated smoking area?

Is the designated smoking clearly signed and are ashtrays available?

Are 'actions on event of fire' posters or instructions posted around the depot?

Are there mechanisms for reporting accidents and incidents?

Are Man Limits clearly established, recorded and displayed for all buildings that store or process ammunition and explosives?

Are Accident Procedures clearly established, documented and displayed in all buildings that store or process ammunition and explosives?

Is the appropriate Personal Protective Equipment (PPE) available to all staff working in explosive facilities?

Is the 'Breakdown' of ammunition and explosives permitted?

Are comprehensive technical instructions covering the activity and safety for each 'Breakdown' operation?

Safety - Equipment (Lifting)

Are mechanical hoists present?

If yes, are chains and cables in good condition and lubricated?

Are electrical hoists present?

If yes, are chains and cables in good condition and lubricated?

If yes, is it to a Category C equivalent standard?

Have the hoists had a mechanical / electrical inspection within the last 12 months? Is it recorded?

Safety - Equipment (Electrical Installations)

Is there a formal national system of allocating different Electrical Safety Categories to buildings and equipment dependent on their purpose?

Is there a formal system of allocating different Electrical Safety Categories to buildings and equipment dependent on their purpose in full compliance with IATG 05.50?

Is the safety standard (e.g. Category C) shown next to the Master Switch?

Is the Master Switch serviceable?

Are all lights, alarms, telephones, switches and electrical switch boxes functional and free from corrosion and storm damage etc?

Are formal electrical tests regularly carried out and are they formally recorded? Can each component be easily identified from the record of tests?

Are Earth Leakage Circuit Breakers present?

Are Earth Leakage Circuit Breakers functional and tested?

Safety - Equipment (Lightning Protection)

Are lightning conductors present?

Are the current Lightning Protection Systems for PERMANENT explosive storehouses constructed in compliance with the design principles in IATG 05.40?

Is the integrity of bonding of lightning conductors correct? (Above and below each switch box to the air and ground terminals).

Is there any evidence of lightning strikes?

Is the internal bonding correctly connected to benches, terminals, structures, earth points and electrical hoists?

Are all lightning protection systems regularly tested and recorded?

Safety - Equipment (Conducting and Anti-Static Floors)

Is the anti-static flooring in compliance with the requirements of IATG 05.40?

Have all floors been electrically (resistance) checked and results recorded?

Are the floors free of cracks, large indentations, excessive wear, oil or grease?

Is there a cleaning plan in place and used?

Ammunition Faults and Performance Failures

Is there a formal system in place for the reporting of ammunition faults and performance failures as a routine task?

Is written guidance available for users to follow in the event of an ammunition fault or performance failure?

Does a formal Investigating Authority exist for the investigation of ammunition faults and performance failures?

Are there formal Cause and Closure Codes allocated to ammunition faults and performance failures?

Bans and Constraints

Is there a formal system in place for imposing bans and constraints at the national level as a routine task?

Is there a formal system in place to immediately inform user units of all bans and constraints?

Surveillance and Proof

Does a formal system exist for the physical inspection of all ammunition in storage on a routine basis?

Is there a formal proof schedule for the in-service proof firing of ammunition?

Is there a formal surveillance programme for the determination of propellant stability through chemical analysis by lot or batch number?

[1]

Annex B – Questions for BigBang Solutions

Why do you require the site in SA1 and why can it not be located elsewhere?

What are the expected NEQ and HD storage quantities during typical use?

What is the expected throughput of the ammunition depot? And how often will stocks be entering/leaving the site?

Can BigBang Solutions demonstrate any justification of their required ELL for the site?

Will the any of the stockpile be loaded/unloaded from boats within the harbour area?

What other buildings does BigBang solutions intend to build within the Ammunition Depot?

How many staff will work on the site?

How long will the site be required for and is there suitable resources to maintain the site for this period?

What state will stores arrive? Are they only A1 or A2 condition or will they be in a more unstable condition?

Can the Maximum NEQ limits of the site be reduced?

Is there suitable physical space within the magazines to store the assets?

What emergency considerations already been considered?

Who will manage the site once it is constructed and who will be the Head of Establishment?

What is the plan if an explosive item/s become unsafe? How will they be disposed of?

Will any processing be required on site? If so, has there been considerations where this will be sited and have the suitable separation distances been considered?

What involvement has the national authority (HSE) had throughout the process so far?

Have Barricades been considered to reduce separation distances and reduces the effects from debris and fragmentation?

What EMC surveys have been completed and are any munitions within the stockpile susceptible to initiation from EMC?

What are the expected contamination concerns and emergency response procedures after an explosive event happening? Are there any additional concerns for example stores containing phosphorous?

What security measures have been considered?

Annex C – Questions/considerations for the Council

Are there any underground gas mains, water mains and electrical installations within the ammunition depot and within the near by area?

Are there any new planning applications for potential other ES within the IBD and VBD?

Are there any large electromagnetic radiation emitters within the local area?

Is the site already contaminated?

Can restrictions on the port use be implemented? For example, the use of certain Berths.

What flood control measures are in place and what is the likelihood of a flooding event happening?

What critical infrastructure is nearby that has not been identified already?

Have structural surveys been completed on surrounding buildings?

Have surveys of the roads and building usage been completed to understand the population density of each ES?

Annex D

Explosive Type:

TNT

Charge Size (kg):

1500

Range from Munition to Structure (m):

80

Calculate

Damage to Windows of 4mm Thick Annealed Glass

Small Window 0.55m by 0.55m	High Hazard
Medium Window 1.25m by 0.55m	High Hazard
Large Window 1.25m by 1.55m	High Hazard

Minimum Range to No Break (m)

Small Window	297.63
Medium Window	480.78
Large Window	1076.03

Ground Vibration (m)

Maximum Effected Range	1239.35
------------------------	---------

Injury/Fatality to Personnel Range (m)

Fatal Distance	26.42
Lung Damage	41.87
Eardrum Rupture	107.67

Damage to Brick Structures (m)

Houses completely demolished	41.38
Houses badly damaged, beyond repair, require demolition	61.21
Houses rendered uninhabitable, can be repaired with extensive work	106.90
Houses rendered uninhabitable, can be repaired reasonably quickly	183.63
Houses require repairs, serious inconvenience but remain habitable	367.26

UN Safeguard tool combining Blast calculators with Bowen impact curves [1]

Explosive Type:

TNT

Charge Weight (kg):

1500

Range (m):

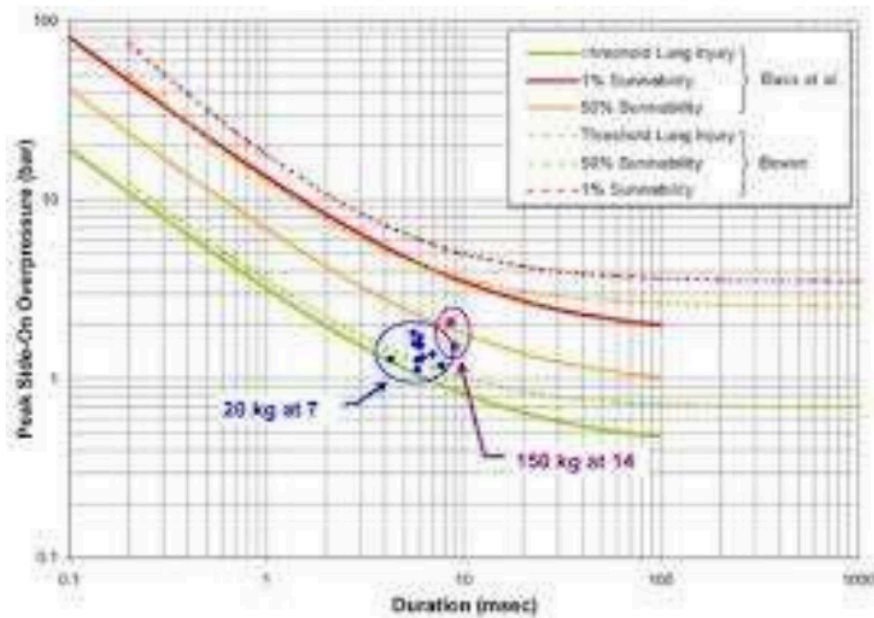
130

Enter a range between 0.78 and 467 meters.

Calculate Blast Parameters

TNT Weight for Pressure (kg):	1500.00	TNT Weight for Impulse (kg):	1500.00
Incident Pressure (kPa):	12.46	Incident Impulse (kPa-ms):	313.94
Reflected Pressure (kPa):	26.31	Reflected Impulse (kPa-ms):	593.67
Time of Arrival (ms):	290.50	Positive Phase Duration (ms):	57.10
Shock Front Velocity (m/s):	357.79		

Kinger Bulmash Blast Calculator



Example Bowen Curve [8]

Injury/Fatality to Personnel Range (m)

Fatal Distance	26.42
Lung Damage	41.87
Eardrum Rupture	107.67

Bowen impact of 1500kg HD1.1 Free field [1]

Damage to Brick Structures (m)

Houses completely demolished	41.38
Houses badly damaged, beyond repair, require demolition	61.21
Houses rendered uninhabitable, can be repaired with extensive work	106.90
Houses rendered uninhabitable, can be repaired reasonably quickly	183.63
Houses require repairs, serious inconvenience but remain habitable	367.26

Damage to buildings from 1500kg of HD1.1 [1]

Explosive Type: TNT

Charge Size (kg): 235

Range from Munition to Structure (m): 230

Calculate

Damage to Windows of 4mm Thick Annealed Glass

Small Window 0.55m by 0.55m	No Break
Medium Window 1.25m by 0.55m	No Break
Large Window 1.25m by 1.55m	Low Hazard

Minimum Range to No Break (m)

Small Window	160.45
Medium Window	259.18
Large Window	580.07

Ground Vibration (m)

Maximum Effected Range	490.55
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Injury/Fatality to Personnel Range (m)

Fatal Distance	14.24
Lung Damage	22.57
Eardrum Rupture	58.04

Damage to Brick Structures (m)

Houses completely demolished	12.43
Houses badly damaged, beyond repair, require demolition	18.38
Houses rendered uninhabitable, can be repaired with extensive work	32.10
Houses rendered uninhabitable, can be repaired reasonably quickly	55.14
Houses require repairs, serious inconvenience but remain habitable	110.28

UN Safeguard tool showing Blast effects of 235kg of HD1.1. [1]

QD Type	Typical pressure	ECM QD	New QD 3000kg	New QD 1500kg	Maximum NEQ
VBD ($44.4Q^{1/3}$)	2.0 – 3.0 Kpa	Unknown (2 x IBD)	550m 450m	440m 360m	235kg 435kg
IBD and PTRD ($22.2Q^{1/3}$)	5kpa	Side 19.0Q Rear 15.5Q	275m 225m	220m 180m	320kg 585kg
Medium PTRD ($14.8Q^{1/3}$)	9kpa	Rear 9.0Q	130m	105m	700kg
PBD ($8.0Q^{1/3}$)	21kpa	Rear 6.0Q	90m	70m	N/A

Calculated QDs with JSP 482 Earth Covered mound equivalence considered.

Annex E

TASK DESCRIPTION

The City and County of Swansea Council (the Council) has received an application for planning permission for an explosive facility to be erected at the following GPS location shown on the map below.

The proposal is to build 5 x ESH (without traverse) to store the ammunition. We have been told the ESH would be earth covered with directional effects for blast described as *Side of magazine perpendicular to the direction of the ES*. What does that mean?

The storage facility, as a whole, is required to hold the following quantities of ammunition by NEQ:

HD 1.1 – 5000 kg
HD 1.2 – 500 kg
HD 1.3 – 1000 kg
HD 1.4 – 1000 kg

Sadly, we have no OME experts on the council staff and believe this to be a significant hazard to the public. As such, we would wish to commission your services to determine that the following information is correct. Please also advise us if the distances that are being stated are correct and what additional public safety, storage or transportation issues we should be concerned with.

The following information has been provided by 'BigBang' Storage Solutions which has recently won the UK MOD tender:

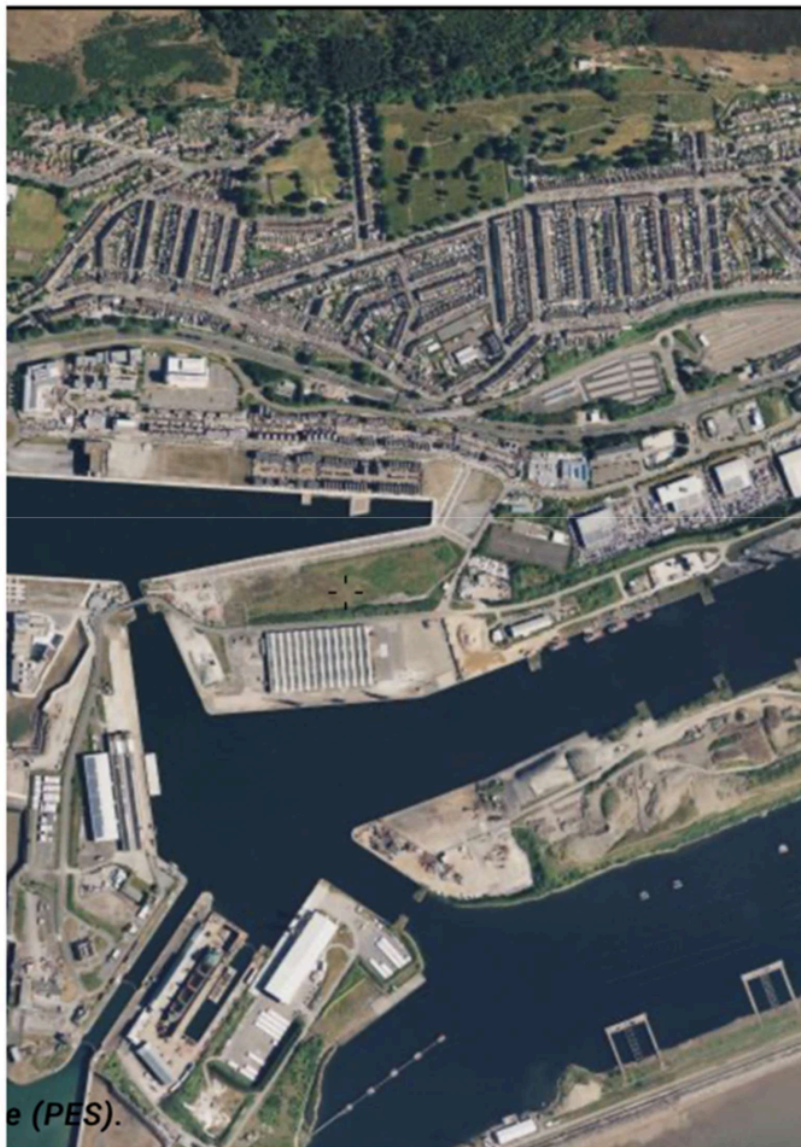
- Each ESH will be able to hold up 1000 kg of each type of hazard division (pallets stacked 3 high), thereby requiring no more than 5 x ESH built east to west along the waste land.
- The Vulnerable building distance is no more than 300 m for each ESH;
- The Inhabited building distance is no more than 125 m for each ESH
- The Public traffic route distance is 270 m for each ESH
- HD 1.1 is divided as follows:
 - HD 1.1B – 50 kg
 - HD 1.1D – 3200 kg
 - HD 1.1E – 1250 kg
 - HD 1.1F – 500 kg
- HD 1.2 is divided as:
 - HD 1.2C – 350 kg
 - HD 1.2D – 100 kg
 - HD 1.2F – 50 kg
- HD 1.3C – 1000 kg
- HD 1.4S – 1000 kg

If this plan is to be approved, what advice would you provide for maritime users of the area – they use the marina regularly.

Finally, can you provide us with a list of safety questions for risk reduction that we should go back the BigBang with? If this can be a stand-alone Appendix then that would be outstanding.

Latitude: 51.61818 51° 37' 5.45" ☐ 

Longitude: -3.91886 -3° 55' 7.90"



FINAL GRADE

The final grade is displayed as a large blue '78' followed by a smaller blue '/100'.

GENERAL COMMENTS

Engagement with Literature Skills 7/10

The student has demonstrated very good engagement with relevant literature. A wide range of sources have been used including guidelines, UNSaferGuard and wider academic literature. References are consistently formatted and used throughout the document. The references could be improved by adding page numbers/specific website pages to direct quotes or images where relevant and further expanding the list of references used with scholarly articles to support some arguments made. Additionally, in Section 3.5, the student introduces Level 1 and Level 2 but does not explain what these levels represent.

Throughout the paper, the student refers to a single citation of "[1] UNODA, "UN SaferGuard," march 2021. [Online]. Available: <https://unsafeguard.org/>." – It is assumed that they are referring to the IATG, which, as a combined volume, is about 1200pages in length – specific citations are vitally important when making critical points about specific regulations or safety matters.

Knowledge and Understanding Skills 23/30

The student has demonstrated excellent coherent and detailed knowledge and systematic understanding of explosives licencing and OME safety management through the content discussed in the document. The student has provided detailed information informed by several sources. The student has also discussed several safety considerations of storing OME. This could be improved by expanding the set of questions to include a wider scope of consideration for how the site would be managed, logistics considerations and more specific security questions. Further marks could be obtained by expanding upon critical analysis and the challenges to established views and the limitations of the information provided. In Section 4.2, the student mentions 'Aggregation rules' but does not explain what these are or how

they are applied. Neither do they explain why Tables 1 and 2 include totals 'Excld HD1.4' and 'Inc HD1.4'. As they are using the IATG, they should at least have explained (and correctly cited) IATG 02.20 Section 10.2: "Distances from a PES containing ammunition and explosives of HD 1.4 are not a function of NEQ. Separation distances should be based on the fire risks and fire-fighting capability available. The separation distance for a PES of open stacks or light buildings to any type of ES should be greater than 10m. For more robust buildings the separation distance should be that required for emergency access."

Cognitive and Intellectual Skills 15/20

The student has demonstrated excellent critical thinking, analysis, synthesis and evaluation skills through the discussions of feasibility of the proposal. The student has shown critical analysis of the proposal and its limitations in the provided context in how it is not feasible with a standard explosive limit licence due to its violation of inhabited building distance. The student also provides a good discussion of how compatibility groups of explosives could be stored in the suggested number of explosive store houses. The student has provided discussion of potential solutions to resolve the flaws in the proposal by way of suggesting a non-standard licence and the requirements therein. This could be improved by making arguments more detailed and structured demonstrating exceptional critical thinking, analysis and evaluation using sophisticated and nuanced judgements.

Practical Application Skills 26/30

The student has demonstrated exceptional practical application skills, applying a range of methods and tools by applying the principles of OME safety management to the proposal. The student has demonstrated good application of the IATG tools and guidance throughout and applied knowledge to evidence arguments. Additionally, the student has applied their knowledge in distributing the

explosives among the ESH using the compatibility mixing rules. The student has also provided a detailed explosion consequence analysis to support the non-standard licence.

Additional marks could be gained by using a wider range of more sophisticated tools such as blast and fragmentation (Primary, secondary and tertiary effects) estimation tools and information.

Following Table 2, the student makes the 'presumption [sic]' that suitable segregation can be implemented within the ESH but does not venture any examples of how that might be achieved.

Table 3 presents QDs for the worst-case max NEQ of 3000kg 'with directional effects perpendicular to the direction of the ESH', which does not take into account the front wall of the ESH, which would face in a roughly SSW direction and be untraversed, - in this direction lie the docks which have hitherto not been mentioned. This omission follows through into Table 6, although the omission does not change the outcome, their example ELL would have been less open to scrutiny.

Transferable Skills for Life and Professional Practice 7/10

The student has demonstrated they can communicate professionally confidently and consistently in a suitable format in the presentation of the report. This is evidenced by the inclusion of a contents page, table of tables and figures, numbered sections and paragraphs and a well-structured, coherent report. This could be further improved by moving the executive summary to the top of the report in place of the abstract and ensuring there is a clear and coherent progression to the report so that the arguments, evidence and solutions clearly follow from one to the next and are clearly linked. The list of questions was well thought out for the client themselves and for them to put to the proposer.

Important terms that the student should understand is the distinction between 'principal' and 'principle' as well as 'presumption' and 'assumption'.

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