Frodsham Solar
Outline Battery Safety Management Plan

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1. INTRODUCTION

1.1 Purpose of this document

1.1.1 This Outline Battery Safety Management Plan (OBSMP) document, produced on behalf of Frodsham Solar Limited (hereafter referred to as 'the Applicant'), outlines the key safety provisions in the event the Battery Energy Storage System (BESS) proposed to be installed as part of the Frodsham Solar project (hereafter referred to as 'the Proposed Development') fails, including measures to reduce system failure risk and failure outcome mitigation measures.

1.1.2 The Proposed Development comprises a new solar energy generating station and an associated on-site BESS, including the associated development for connection to the local electricity distribution network, as well as a private wire electricity connection that would enable local businesses to utilise the renewable energy generated by the Proposed Development. A full description of the Proposed Development and a description of the design is provided in ES Vol 1 Chapter 2: The Proposed Development [EN010153/DR/6.1].

1.1.3 This document provides a summary of the safety related information requirements which will be provided in advance of construction of the BESS. The purpose of this OBSMP is to identify how the Applicant will use good industry practice to reduce risk to life, property, and the environment from the BESS.

1.1.4 Prior to the commencement of construction of the BESS, the Applicant will be required to prepare a Battery Safety Management Plan (BMSP) which must be in accordance with this Outline BSMP. As part of the preparation of the BSMP, the Applicant will take into account the latest good practices for battery system failure prevention and detection, consequence modelling, risk analysis, and emergency response planning, as guidance continues to develop in the UK and around the world.

1.1.5 This document details the types of safety systems available on the market at present, along with risk reduction barriers which are likely to be incorporated into the storage system to be installed at the Site. It is possible that by the time of construction, an alternative battery chemistry may be on the market and available for commercial use. This would, however, need to be fully tested and certified to the latest BESS safety standards, reflected in the final BSMP to be approved by Cheshire West and Chester Council, in consultation with Cheshire Fire and Rescue Service (CFRS) and the Environment Agency.

1.1.6 As the operation and maintenance phase is anticipated to commence in 2029, reference to current measures and guidelines are included here. However, measures outlined here will be updated prior to construction of the BESS to take account of prevailing guidance, as necessary.

1.2 Description of the BESS Development

1.2.1 There are several battery storage technologies available to system designers. The generic system used for indicative planning purposes is a BESS system integrating seven battery racks. The exact technology and system chemistry type is to be determined at the post-consent stage, but it will be a lithium-ion battery cell type. The popular types of this chemistry within the lithium-ion family are Lithium Nickel Manganese Cobalt Oxide ($LiNiMnCoO_2$), known as “NMC” after the three key cathode materials; or Lithium Iron Phosphate ($LiFePO_4$), known as “LFP”. The final battery chemistry will be confirmed as part of the detailed design, prior to the commencement of construction.

1.2.2 For the purposes of this document only, a concept design has been considered that uses a BESS system based upon LFP lithium-ion battery technology. This is considered to be a reasonable worst case for the purposes of the assessment in terms of BESS toxic gas emission potential (Hydrogen Fluoride production) and explosion risk (significant levels of hydrogen produced during thermal runaway).

1.2.3 The design of the BESS and its potential impacts will be controlled in several ways, including by being designed in accordance with both UK and internationally recognised good practice guidance available at the time.

1.2.4 Prior to commencement of construction of the BESS, a BSMP (in accordance with this Outline BSMP) is required to be submitted to Cheshire West and Chester Council and approved by them, in consultation with the Environment Agency (EA) and Cheshire Fire and Rescue Service (CFRS). The BSMP must be implemented as approved and maintained throughout construction, operation and decommissioning.

1.2.5 The outline BESS design, forming part of the Proposed Development, consists of a fenced compound accommodating the BESS enclosures, a control room and the associated energy storage system (ESS) equipment i.e. transformers, inverters and switchgear. The Proposed Development includes provision for a BESS compound at one of two locations within the Site. The final location of the BESS compound would be determined during detailed design. To view the location options (Option 1 and Option 2), please refer to ES Vol 1 Chapter 2: The Proposed Development, Figure 2.2: Indicative Site Layout Plan.

1.2.6 The BESS enclosures and auxiliary systems, such as cooling, uninterruptible power supply (UPS), fire and gas detection, explosion protection mechanisms, suppression system, monitoring and control, will be designed in accordance with internationally recognised standards and the latest industry best practice guidance.

1.2.7 Once operational, the plant will be designed to operate unmanned with access required for maintenance only. The plant may be replaced approximately 2-3 times, during the 40-year operational life of the Proposed Development.

1.3 Potential for BESS Failure

1.3.1 Causes of battery cell failure, which could lead to a thermal runaway event where a battery cell enters an uncontrolled self-heating state, include manufacturing defects (contaminants / imperfections), electrical abuse (overcharging/ over-discharging), and physical or mechanical damage (puncture / crushing).

1.3.2 BESS hazards for first responders, in the unlikely event of a battery failure and thermal runaway event, depend on the BESS design but are typically defined as: fire hazards, explosion hazards, electrical hazards (shock or arc flash), and chemical hazards (i.e. the release of toxic gases).

1.3.3 Regardless of the type of failure or the cause, the main potential hazard is thermal runaway and ultimately, if not controlled, a significant flaming or battery gas venting incident; therefore, this plan focusses on reducing fire and explosion risks associated with the BESS and managing the hazard, in the unlikely event that it occurs.

1.3.4 In addition to the batteries, the other electrical systems which form part of the BESS can also carry fire risks. However, due to the extensive historic long-term deployment of the other technologies such as transformers, inverters and switchgear, these risks are regulated through longstanding industry guidance and codes. Therefore, only the battery component of the BESS is addressed in this report.

1.4 Safety Objectives

1.4.1 The overall approach is to follow the Health and Safety Executive's (HSE) hierarchy of controls (REF 1):

i. Elimination;

ii. Substitution;

iii. Engineering Controls;

iv. Administrative Controls; and

v. Personal Protective Equipment.

1.4.2 The safety objectives for the design of the BESS are:

i. To minimise the likelihood of an event. This is an overriding priority;

ii. To minimise the consequences should an event occur;

iii. To contain any event to inside the BESS compound and minimise any impact on the surrounding areas;

iv. To automatically detect and begin to fight a fire as soon as possible;

v. To ensure any personnel on Site are able to escape safely away from the Site;

vi. To ensure that firefighters can operate in reasonable safety where necessary;

vii. Final BESS design and site layout would minimise the requirement for direct CFRS intervention in a thermal runaway incident i.e. direct hose streams or spray directly on BESS battery systems. CFRS intervention in worst case scenarios would ideally be limited to boundary cooling of adjacent BESS and ESS units to prevent the fire from spreading. This strategy should be finalised with CFRS as part of finalising the BSMP;

viii. If the BESS system does not incorporate an automatic fire suppression system and is designed to safely burn out to remove the risk of stranded energy in the battery systems, then full scale free burn testing will have been conducted to demonstrate that loss will be safely limited to one container, without the intervention of the CFRS. The approach to be taken will be set out in the BSMP;

ix. To ensure that fire, smoke, and any release of toxic gases does not significantly impact site operatives, first responders and the local community;

x. To ensure that firewater run-off is contained and tested before release or, if necessary, removed by tanker and treated offsite.

1.4.3 A summary of the anticipated BESS failure safety provisions are as follows:

i. The BESS will be designed, selected and installed in accordance with international guidance, good practice and related standards.

ii. Risk assessments will be carried out for the entire system and elements across the project lifecycle.

iii. The location of the BESS compound will be located to minimise impacts on offsite receptors (albeit this is inherent in the DCO Application as it has been factored into the design process to date and the two options for the BESS compound location put forward).

iv. Separation distances between components will be selected to minimise the chance of fire spread.

v. Equipment will, where possible, be selected to be fire limiting, such as selection of transformer oils with low flammability and non-combustible BESS enclosures with high levels of thermal insulation (fire and heat resistance). The BESS facility will be designed with multiple layers of protection to mitigate and minimise the probability of a fire or thermal runaway incident.

vi. In the case of the BESS design, it will integrate multiple layers of prevention and mitigation features to minimise the chances of a BESS failure incident (equipment failure / burning or gas venting thermal runaway scenario).

vii. All equipment will be monitored, maintained, and operated in accordance with manufacturer instructions and be compliant with requisite safety standards (UL, IEC, IEEE, NFPA). A specific maintenance programme will be in place for the automatic shutoff valves.

viii. The BESS design will include integrated fire and explosion prevention and protection systems. Following key industry safety standards (e.g. NFPA 855 (REF 2), UL 9540 (REF 3), BS EN IEC 62933-5-2(REF 4)) and based on comprehensive UL 9540A (2025, 5th Edition) (REF 5) and / or 3rd party full scale destruction testing. A BESS system and site-specific Emergency Response Plan (ERP) will be developed at the detailed design stage, based on national and international best practice measures.

ix. 24/7 monitoring of the system via a remote dedicated control facility. The control facility will have the capability to shut the system down should the need arise and will also be responsible for implementing the emergency response plan and acting as a point of contact for the emergency services.

x. Communication with the local fire and rescue services (CFRS) with engagement early in the project and continuing across detailed design and construction phases. This will ensure robust emergency response planning, risk management planning and ensure all safety materials and equipment is available in an emergency for first responders.

1.4.4 As recommended in NFCC revised guidelines (2024) (REF 6), a BESS Plume Study (EN010153-7.8 Appendix 7-1) has been conducted using the concept design to assess the proposed BESS for smoke (Particulate matter PM10 and PM2.5) and toxic gas hazards in the event of a thermal runaway incident, with consideration to sensitive receptors within a 1 km radius of the BESS compound.

1.4.5 A consequence-based study, using Computational Fluid Dynamics (CFD), modelled the impact of a battery failure event and assessed the impact of visibility and toxicity on the neighbouring area, in the event of a fire. The study evaluated the credible worst-case scenario in terms of consequences for a fire event, where safety systems and barriers to prevent failure escalation were assumed to have failed, and a reasonable worst-case (BESS unit) fire was modelled. The closest BESS unit to each defined sensitive receptor was included in the CFD modelling, results are presented in terms of recognised hazardous exposure thresholds. The fire was modelled with varying wind speeds and directions to obtain the maximum impact that could be caused by the smoke plume, as experienced at each of the identified sensitive receptors.

1.5 Consultation with Cheshire Fire and Rescue Service

1.5.1 The local fire and rescue service, Cheshire Fire and Rescue Service (CFRS) has been consulted during pre-application discussions and as part of the Section 42 Statutory Consultation exercise.

1.5.2 The Applicant and representatives from CFRS conducted a site visit on 17th March 2025 to introduce the scheme and share preliminary site plans.

1.5.3 CFRS advised that Draft NFCC Grid Scale Energy Storage System Planning – Guidance for Fire and Rescue Services (July 2024 Revision) (REF 6) should be incorporated into site design and safety documentation.

1.5.4 The Applicant emailed a range of BESS safety materials for fire service training and education purposes, and a number of full-scale BESS destruction testing reports on 18th March 2025. The Applicant confirmed that NFCC guidance will be followed, and that any deviations will be fully discussed and agreed with CFRS.

1.5.5 The Applicant confirmed that they will share all requisite BESS safety and design documentation for the Proposed Development with CFRS, once available.

1.5.6 The Applicant has complied with NFCC guidelines (REF 6) and engaged with CFRS throughout the outline design phase and will ensure that the BSMP accounts for any subsequent revisions made to NFCC guidelines. Close consultation will continue with CFRS throughout the development process.

1.6 Relevant Guidance

1.6.1 The detailed design and BSMP for the proposed BESS will be produced in accordance with the following best-practice guidance and British Standard publications:

i. National Fire Chiefs Council (NFCC) Grid-Scale Battery Energy Storage System planning – Guidance for FRS (2023 and draft revision 2024).
ii. National Fire Protection Agency (NFPA) NFPA 855 (2023): Standard for the Installation of Stationary Energy Storage Systems
iii. NFPA 68 (2023): Standard on Explosion Protection by Deflagration Venting.
iv. BS EN 14797 (2006): Explosion venting devices.
v. NFPA 69 (2024): Standard on Explosion Prevention Systems.
vi. Underwriters Laboratories, UL 9540A (2025) Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems;

vii. UL 1642 (2020): Standards for Lithium Batteries.

viii. UL 1973 (2022): Batteries for Use in Stationary and Motive Auxiliary Power Applications.

ix. UL 9540 3rd Edition (2023): Standard for Energy Storage Systems and Equipment.

x. UL 2941 (2023) Outline of Investigation for Cybersecurity of Distributed Energy and Inverter-Based Resources.

xi. IEEE 2686 (2025) standard: Recommended Practice for Battery Management Systems in Stationary Energy Storage Applications.

xii. FM DS 5-33 (2023) FM Global Datasheet. Lithium-Ion Battery Energy Storage Systems.

xiii. UN 38.3: Recommendations on the Transport of Dangerous Goods – Manual of Tests and Criteria – (Lithium Metal and Lithium-Ion Batteries).

xiv. United Kingdom Power Networks (UKPN) Engineering Design Standard 07-0116: Fire Energy Storage Systems, 2016.

xv. DNV GL-Recommended Practice-0043: Safety, Operation and Performance of Grid-Connected Energy Storage Systems, 2017.

xvi. Scottish and Southern Energy TG-PS-777: Limitation of Fire Risk in Substations, Technical Guide, 2019.

xvii. BS 5839 Part 1 2017: Fire Detection and Fire Alarm Systems for Buildings.

xviii. BS 9990: 2015: Non-automatic firefighting systems in buildings - Code of practice

xix. The Regulatory Reform (Fire Safety) Order (RRO) 2005.

xx. The Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) Assessment

xxi. BS EN IEC 61936, Power installations exceeding 1 kV AC and 1,5 kV DC – AC.

xxii. BS EN IEC 62619 (2022) Secondary cells and batteries containing alkaline or other non-acid electrolytes. Safety requirements for secondary lithium cells and batteries, for use in industrial applications.

xxiii. BS EN IEC 62933-5-2 (2020) Electrical Energy Storage (EES) systems. Part 5-2: Safety requirements for grid integrated EES systems. Electrochemical-based systems

xxiv. BS EN IEC 62281: 2019 + A2:2023: Safety of primary and secondary lithium cells and batteries during transport.

xxv. BS EN IEC 62477-1 (2022) Safety requirements for power electronic converter systems and equipment. General.

xxvi. BS EN 16009 (2011) Flameless Explosion Venting Devices.

xxvii. BS EN 14373 (2021) Explosion Suppression Systems.

xxviii. BS EN IEC 61000-6-2 (2016) Electromagnetic compatibility (EMC). Generic standards. Immunity standard for industrial environments.

xxix. BS EN IEC 61000-6-4 (2018) Electromagnetic compatibility (EMC). Generic standards. Emission standard for industrial environments.

2 BESS SAFETY REQUIREMENTS

2.1 Procurement

2.1.1 The Applicant recognises that robust quality processes are essential for the BESS development and procurement stages, in terms of ensuring safe and continuous operation.

2.1.2 The Applicant only works with leading battery integrators with global presence, whose expertise in system integration of battery cells and modules, inverters and transformers, in combination with intelligent software for management and optimisation of energy services from the battery, ensures successful operation of every battery project.

2.1.3 The Applicant's policy is to work with battery storage integrators and component manufacturers which are ISO 9001, ISO 14001 and OHAS 18001 certified companies. The Applicant requires the designs to incorporate fully tested active and passive BESS failure protection systems, adhere to all relevant UL, IEC, and IEEE safety standards and be fully compliant with NFPA 855 (REF 2), as well as conform to local and UK industry standards.

2.2 Safe BESS Design

2.2.1 The BESS will be designed to address prevailing industry standards and good practice at the time of design and implementation. The BESS and components used to construct the facility will be certified to UL 9540 (2023) (REF 3) and/or BS EN IEC 62933-5-2 (2020) (REF 4) standards (or any future standards which supersede this).

2.2.2 As a minimum, the battery system will have completed unit or installation level UL 9540A (5th Edition) (REF 5) testing, demonstrating that either thermal runaway propagation will not spread between modules or between battery racks; or that full-scale free burn (destruction) testing has validated that loss will be safely limited to one BESS enclosure and demonstrated that either deflagrations do not occur or that they can be safely contained. UL 9540A heat flux test data can establish safe distances between BESS enclosures and ESS equipment but will not be conclusive if full propagation of the battery system does not occur in the test. In such instances, third-party full-scale destruction testing, as outlined in NFPA 855 (2026 revision), will be undertaken to validate equipment spacing.

2.2.3 NFPA 855 (2023) (REF 2) currently provides the most comprehensive guidelines for BESS design and site installation specifications for the UK. BESS design structural integrity will be demonstrated through full-scale destruction performance testing and / or by integrating rigorously tested NFPA 69 (explosion prevention) (REF 7) and NFPA 68 (Explosion protection through deflagration venting) (REF 8) features.

2.2.4 If the BESS design integrates hybrid systems, sparker system or performance design explosion protection systems should be validated through BESS full-scale destruction testing, lean gas mixture testing and requisite pressure testing, as required by NFPA and EN standards.

2.2.5 If a BESS automatic fire suppression system or Thermal Runaway Propagation Prevention (TRPP) system (engineered to directly access cells within battery modules) is integrated within each BESS enclosure, this will conform to NFPA 855 (REF 2) standards and be tested to UL 9540A (REF 5) protocols or through significant scale third party fire and explosion testing. The suppression or TRPP system will be capable of operating effectively in conjunction with a gas exhaust / ventilation system to minimise deflagration risks. The system design must be capable of controlling or fully suppressing a fire, without the direct intervention of CFRS. Fire suppression system performance should be benchmarked against free burn testing. An independent Fire Protection Engineer specialising in BESS will review all UL 9540A (REF 5) test results, plus any additional fire and explosion test data which has been provided and validate the suppression system design.

2.2.6 If the BESS design does not integrate automatic fire suppression systems and a dry pipe sprinkler or spray system is integrated instead, then NFCC (2024) (REF 6) revised guidance will be followed. Connections to any dry pipe systems that are required to be installed on the BESS compound should be installed in accordance with BS 9990 Non-automatic Firefighting Systems in Buildings Code of Practice (Current Edition) (REF 9) and should be identified in accordance with BS 3251 Indicator Plates for Fire Hydrants (Current Edition) (REF 10). If a dry pipe system is integrated for the scheme, CFRS instantaneous connection points will be located at a safe distance from enclosures and clearly signed for CFRS response, in accordance with NFCC guidelines. Water supply for this type of system will be separate from the water supply designated for CFRS boundary cooling firefighting requirements.

2.2.7 If the BESS enclosure is a walk-in design (this is a very low probability), an automatic water fire suppression system must be installed. The suppression system must be capable to operate effectively in conjunction with a gas exhaust/ventilation system to minimise deflagration risks. System design and water supply requirements will be fully agreed with CFRS.

2.2.8 If the BESS system is designed to safely burn-out without internal fire suppression systems (to remove the risk of stranded energy in the battery systems), full-scale destruction performance testing will be conducted to demonstrate that loss will be safely limited to one BESS enclosure without the intervention of CFRS. UL 9540A (REF 5) heat flux test data can also establish safe distances between BESS enclosures and ESS equipment but will not be conclusive if full propagation of the battery system does not occur in the test.

2.2.9 As best practice, additional third-party fire and explosion testing should be utilised by the BESS Original Equipment Manufacturer (OEM) to demonstrate that structural integrity is maintained and toxic gas emissions to the closest receptors are below relevant public health exposure limits, when the battery system is fully consumed (burnt out). An independent Fire Protection Engineer specialising in BESS will review all UL 9540A (REF 5) test results, and any additional 3rd Party fire and explosion test data which has been provided, and share conclusions with CFRS i.e. the need for additional water supply for boundary cooling or a dry pipe sprinkler system.

2.2.10 In addition to this, good practice guidance for electrical sites within the UK has been consulted with regards to BESS layouts and separation distances for the transformers and inverters.

2.2.11 Safety Certifications and mitigation features typically found within battery module design, which the Applicant will commit to for the proposed BESS, include:

- i. Internal fuses;
- ii. Liquid cooling system;
- iii. Active thermal management system (TMS);
- iv. Contactor at rack/string and bank level;
- v. Overcharge safety device;
- vi. Internal passive protection products;

vii. Venting systems and gas channels;

viii. Thermal or multi-sensor monitoring devices.

2.2.12 Battery cell will be certified to UL 1973 (REF 11) and / or BS EN 62619 (REF 12) and tested to UL 9540A (REF 5) unit or installation level for BESS designs.

2.2.13 Module design will be certified to UL 1973 (REF 11) and / or BS EN 62619 (REF 12) and tested to UL 9540A (REF 5) unit or installation level.

2.3 System Location

2.3.1 The BESS that forms part of the Proposed Development is designed to provide peak generation and grid balancing services to the electricity grid by allowing excess electricity generated either from the solar PV panels, or imported from the electricity grid, to be stored in batteries and dispatched, when required.

2.3.2 The indicative design for the Proposed Development has provision for up to 200 BESS units, to be enclosed inside a single BESS compound. However, the precise number of individual battery energy storage enclosures will be ascertained at the detailed design stage and will depend upon the level of power capacity and duration of energy storage that the project will require.

2.3.3 Within the Site, the identification of the two proposed location options for the BESS has been based on a number of factors. The most pertinent factors being the options are not located inside the high probability flood zone, and they are sited a safe distance from existing infrastructure on site i.e. gas pipelines and wind turbines. The option locations were also selected to minimise the proximity to sensitive receptors with distance to residential and commercial properties maximised, as far as possible. This has the benefit of reducing the visual and noise impact but also minimises any potential impacts on the local population should a BESS failure event occur. The minimum distances to key sensitive receptors from the BESS location options are listed below:

i. Moorditch Lane – 86 metres

ii. Skylark migration area – 100 metres

iii. Traveller Site – 300 metres

iv. M56 Motorway – 410 metres

v. Nursing Care Home – 524 metres

vi. Hover Force Activity Centre – 865 metres

vii. Non-breeding bird mitigation area – 970 metres

2.4 System Layout

2.4.1 Both the indicative site design and final detailed site design will provide separation between key system components or groups of key system components.

2.4.2 The BESS will be broken into discrete groups consisting of battery enclosures, inverters and transformers. Each group will be separated from the next. This separation will limit any fire that is not able to be contained to the affected group or part of the battery system and also allow emergency access in case of an intervention.

2.4.3 National Fire Protection Agency (NFPA) 855 (2023) defines basic operation Health & Safety (H&S) protocols for all BESS site designs which should be incorporated into emergency response plans:

A) Potential debris impact radius is defined as 100 feet (ft) or 30.5 metres (m) i.e. this is a typical explosion risk safe exclusion zone radius as modelling and previous BESS incidents typically show 25 m to be the maximum radius.

B) Automatic building evacuation area is defined as 200 ft or 61 m from the affected BESS enclosure.

2.4.4 NFPA 855 (2023) (REF 2) also defines five BESS hazard categories – hazards are assessed under both normal operating conditions and emergency / abnormal conditions:

a) Fire and explosion hazards;

b) Chemical hazards;

c) Electrical hazards;

d) Stored / stranded energy hazards; and

e) Physical hazards.

2.4.5 The separation distance between the battery enclosures and Order limits boundary will be a minimum of 100 metres. The separation of the inverters and transformers will, depending on the design, be optimised at detailed design stage to minimise the likelihood of any spread of fire between adjacent components.

2.4.6 The layout of the proposed BESS provides adequate separation between battery enclosures, additional ESS (Energy Storage System) equipment, and other key site structures and infrastructure that form the other parts of the Proposed Development. The UK National Fire Chiefs Council (NFCC) 'Grid Scale Battery Energy (REF 6) Storage System planning – Guidance for FRS (2023 and 2024 draft revision)' has been followed at the indicative design stage, which comprises:

viii. The indicative BESS layout (refer to ES Vol 1 Chapter 2: The Proposed Development, Figure 2-5d: Indicative BESS and Frodsham Substation layout) conforms to NFCC revised guidance and NFPA 855 (2023) (REF standard, allowing a separation distance of 3m spacing.

ix. NFCC guidelines allow reduced separation distances if suitable design features can be introduced. If the BESS system is designed to safely burn out to remove the risk of stranded energy in the battery systems, then full scale free burn / destruction testing will have been conducted to demonstrate that loss will be safely limited to one BESS unit, without the intervention of CFRS.

x. If reducing distances, a clear, evidence-based case for the reduction will be shown in the detailed design phase and agreed with CFRS i.e. UL 9540A unit or installation testing and / or third-party full-scale destruction testing heat flux data. An independent Fire Protection Engineer specialising in BESS will validate all UL 9540A (REF 5) and / or third-party test and site-specific consequence modelling data which will be provided.

xi. The separation of the inverters and transformers will, depending on the design, be optimised at detailed design stage to minimise the likelihood of any spread of fire between adjacent components.

xii. Areas within 10m of BESS enclosures do not contain combustible vegetation and would not be planted with any new combustible vegetation, wherever possible. Where this is not feasible, a full risk assessment would be conducted, and mitigation features applied, if required by the CFRS. Any other vegetation on site would be kept in a condition such that they do not increase the risk of fire on site.

xiii. To protect BESS enclosures from exterior risks, they shall be provided with impact protection to prevent damage by vehicles or construction equipment, as well as using Damage Limiting Construction (DLC) techniques.

xiv. The BESS enclosure would have an internal fire resistance rating of at least one hour (according to NFPA 855 (REF 2), BR 187 (REF 14) and FM Global Datasheet 5-33 (REF 15)).

xv. The BESS compound would be designed to integrate pressure fed (pump driven) fire hydrants and/or static water tanks for firefighting, dependent on available water supply. Two water tanks will be located in the BESS compound, at least 10m from the nearest BESS enclosure and no further than 300m from the furthest BESS enclosure. Water access points, whether hydrants or tank connections, would be located in consultation with the CFRS to provide redundancy and safe operating distances for firefighters with 30 – 50m, which is considered an optimal safe distance.

xvi. Tanks and water outlets would be clearly labelled with appropriate signage and marked on site plans. Additionally, to avoid any mechanical damage, outlets and hard suction points would be safeguarded with bollards.

2.4.7 By adhering to the separation distances noted above, risk should be adequately minimised to limit a fire event to a single BESS unit or ESS structure.

2.5 Battery System Enclosures

2.5.1 Battery enclosures will house the battery systems, electrochemical components and associated equipment. Being either one, or multiple containers joined, or close coupled to each other. They will be mounted on a concrete foundation.

2.5.2 Each BESS enclosure will be installed by a certified and qualified installer. Each BESS enclosure will be UL 9540 (REF 3) and / or BS EN IEC 62933-5-2 (REF 4) certificated. Ingress protection testing of the enclosures is conducted under UL 9540 and / or BS EN IEC 62933-5-2 certification of any BESS system. IEC Factory Acceptance Testing (FAT) or an independent manufacturing audit will be carried out to ensure the supplied BESS enclosures comply with the requisite certified Ingress Protection (IP) levels.

2.5.3 IP ratings of the enclosures will be shared with CFRS at the detailed design stage so that risks associated with boundary cooling can be understood and implemented into the ERP. Potential boundary cooling water ingress points such as Heating, Ventilation and Air Cooling (HVAC) systems and deflagration vents will be considered as part of an incident response strategy.

2.5.4 Enclosure gas exhaust vents and deflagration panels must direct flaming or toxic gases away from site personnel or first responders in line with NFCC guidance (REF 6) and NFPA 68 (REF 8) and BS EN 14797 (REF 13) standards; doors cannot be used as sole deflagration vents.

2.5.5 The BESS enclosures will be locked to prevent unauthorised access and will have an internal fire resistance rating of at least one hour (according to NFPA 855 (REF 2), BR 187 (REF 14) and FM Global Datasheet 5-33 (REF 15)).

2.5.6 Where required, BESS enclosure walls will have a minimum one-hour fire resistance rating to BS EN 13501-2 (REF 16) and BS EN 1364-1 (REF 17) standards.

2.6 Detection and Suppression Systems

2.6.1 In order to achieve the safety objectives, the proposed BESS will employ monitoring systems that will help identify any abnormal operation and safely shutdown the system before it develops. These systems will be independent of the control systems and equipment that can cause the abnormal event and avoid the use of Safety Integrity Level (SIL) rated risk controls. Other measures include:

a) Thermal monitoring of the battery containers and automated cut-out beyond safe parameters;

b) Battery liquid cooling systems with automated fail-safe operation (air cooling systems will not be considered);

c) Emergency Stop – both remote and local;

2.6.2 In the event of a fire, the battery system and the transformers serving the BESS will be automatically electrically isolated when a fire is detected within a BESS Enclosure. However, the batteries housed within the BESS Enclosures will still hold charge in the event of a fire, even after the electrical system is isolated. It will not be possible to confirm that there is no residual risk from the energised batteries within the BESS Enclosures, and this will inform the strategy for firefighting in the BSMP drafted at the detailed design stage.

2.6.3 The fire and gas detection system for the proposed BESS will comply with NFPA 855 (2023) (REF 2) and NFPA 69 (REF 7) standards. This means that smoke, fire and gas detection equipment will be installed on site. BESS multi-sensor equipment which is not included in NFPA 855 standards, which measures combinations of air temperature, hydrogen, volatile organic compounds, overpressure, shock and vibration, and moisture ingress will also be permitted if fully performance tested with the selected BESS design. The gas detection systems would have an external beacon and audible alert facility if required. All fire detection systems would be installed and commissioned to BS EN 54 (REF 18), BS EN 9999 (REF 19), NFPA 855 (REF 2), NFPA 850 (REF 20). The final BESS failure detection design will be validated by an independent Fire Protection Engineer under the responsibility of the Operations, Engineering and Maintenance Contractor prior to construction, and will be approved by CFRS.

2.6.4 If the BESS design does not integrate internal fire and gas detection equipment in alignment with NFPA 855 (REF 2) standards and instead monitors failure parameters through a local Supervisory Control and Data Acquisition (SCADA) system, then fire and explosion mitigation protection systems must be validated through full scale destruction testing and deflagration modelling i.e. Tesla Megapack 2XL design. The final fire detection design (BESS enclosure and BESS site) should be validated by an independent Fire Protection Engineer prior to construction and will be approved by CFRS.

2.6.5 NFPA 855 (2023) (REF 2) confirms that water is the most effective battery fire suppression agent, therefore a dedicated water-based suppression system may be provided within each BESS Enclosure designed to control or fully suppress a fire, without the intervention of CFRS. The suppression system must be capable to operate effectively in conjunction with a gas exhaust / ventilation system to minimise deflagration risks.

2.6.6 If an automatic fire suppression system or Thermal Runaway Propagation Prevention (TRPP) system (engineered to directly access cells within battery modules) is integrated within each BESS enclosure, this will conform to NFPA 855 (REF 2) standards and be tested to UL 9540A (REF 5) protocols or through significant scale third-party fire and explosion testing. The suppression or TRPP system will be capable of operating effectively in conjunction with a gas exhaust / ventilation system to minimise deflagration risks. The system design must be capable to control or fully suppress a fire, without the direct intervention of CFRS. Fire suppression system performance should be benchmarked against free burn testing. An independent Fire Protection Engineer specialising in BESS will review all UL 9540A test results plus any additional fire and explosion test data which has been provided and validate the suppression system design. System design and water supply requirements must be fully agreed with CFRS.

2.6.7 If a BESS enclosure design does not integrate automatic fire suppression systems and a dry pipe sprinkler or spray system is integrated, then NFCC (2024) revised guidance (REF 6) will be followed. Connections to any dry pipe systems that are required to be installed inside the BESS compound should be installed in accordance with BS 9990 Non-automatic firefighting systems in buildings code of practice (Current Edition) (REF 9) and should be identified in accordance with BS 3251 Indicator Plates for Fire Hydrants (Current Edition) (REF 10). If a dry pipe system is integrated for the scheme, CFRS instantaneous connection points will be located at a safe distance from enclosures and clearly signed for CFRS response, in accordance with NFCC guidelines. Water supply for this type of system will be separate from the water supply designated for CFRS boundary cooling requirements.

2.6.8 The NFPA 855 (2026) working group is also proposing to prohibit the use of clean agent or aerosol fire suppression systems within BESS enclosures unless fire and explosion testing can demonstrate that use of such systems does not present a deflagration hazard. If an aerosol fire suppression system (FSS) is integrated into each BESS enclosure, then the system must be designed and certified to discharge specifically for an ‘electrical fault’ fire and shall not discharge in any thermal runaway scenario ensuring a gas exhaust system can remain in operation.

2.6.9 Draft NFCC (2024) revised guidance (REF 6) acknowledges that it is increasingly common for BESS enclosures to be designed without integrated automatic fire suppression systems because high levels of thermal insulation are integrated, which allows enclosures to be closely spaced whilst preventing propagation of fire to adjacent enclosures. If the BESS system is designed to safely burn out to remove the risk of stranded energy in the battery systems, then full scale free burn / destruction testing will have been conducted to demonstrate that loss will be safely limited to one enclosure, without the intervention of CFRS.

2.6.10 If the BESS system is designed to safely burn out without internal fire suppression systems, UL 9540A (REF 5) heat flux test data (if full propagation of battery system occurs) will establish safe distances between BESS enclosures and ESS equipment. Additional 3rd Party fire and explosion testing will be required to also demonstrate that structural integrity is maintained and toxic gas emissions to the closest receptors are below relevant public health exposure limits, when the battery system is fully consumed (burnt out). An independent Fire Protection Engineer specialising in BESS will review all UL 9540A test results and any additional 3rd Party fire and explosion test data which has been provided.

2.6.11 A post-incident recovery plan shall be developed, as recommended by the NFCC guidance (REF 6) that addresses the potential for reignition of battery systems, as well as removal and disposal of damaged equipment. A fire watch will be present until all potentially damaged BESS batteries and equipment are removed from the area following a fire event. The water supply for suppression systems and / or firefighting will be replenished as quickly as feasible.

2.7 BESS Active and Passive Safety Systems

2.7.1 Other measures to minimise the risk and consequences of a BESS failure event that could be implemented include:

i. As a minimum, a BESS active ventilation system will comply with NFPA 855 (2023) (REF 2) / NFPA 69 (REF 7) guidelines which require the prevention of a dangerous build-up of explosive gases (25% LEL). The gas exhaust / ventilation system must have redundancy and can be separate to any HVAC system providing climate control. Heating and cooling of the battery modules will be provided by an independent liquid cooling system which is separate to any HVAC system providing climate control for the BESS enclosure. Backup power for the gas detection system must have a 24-hour duration in standby and 2 hours in alarm, as demonstrated via NFPA 72 (REF 21) compliant battery calculations and required by NFPA 855.

ii. When mechanical ventilation is required to maintain concentrations below the required limits, it shall be interlocked, so that the system shuts down upon failure of the ventilation system. Where emergency ventilation is used to mitigate an explosion hazard, the disconnect for the ventilation system should be clearly marked to notify personnel or first responders to not disconnect the power supply to the ventilation system during an evolving incident.

iii. The ventilation / gas extraction system shall also be designed to exhaust flames and gases safely outside the enclosures, without compromising the safety of first responders. The ventilation system shall be provided with suitable ember protection to prevent embers from penetrating BESS enclosures (HVAC, gas exhaust, deflagration panels). An NFPA 69 (REF 7) compliance report should be provided to demonstrate the compliance of the gas exhaust system with NFPA 855 (REF 2) explosion prevention system requirements.

iv. Explosion protection systems not covered directly by NFPA 68 (REF 8) and NFPA 69 (REF 7) standards are commonly referred to as performance design explosion mitigation systems, these include automatic doors or vents which open to ventilate explosive gas mixtures and / or relieve pressure. If the BESS design integrates hybrid systems, sparker system or performance design explosion protection systems it would be validated through BESS free burn testing, lean gas mixture testing and requisite pressure testing required by NFPA and EN standards. Further, the BESS enclosure would have completed full UL 9540A (REF 5) testing or large-scale Third-Party Fire and Explosion testing without pressure waves occurring or shrapnel being ejected. An independent Fire Protection Engineer specialising in BESS would review all UL 9540A test results and any additional fire and explosion test and consequence modelling data which has been provided.

v. The BESS enclosure will be designed to withstand overpressures generated by the battery system during thermal runaway. As a minimum, an explosion prevention system to NFPA 69 (REF 7) standards will be integrated which should be complimented by an explosion protection system to NFPA 68 (REF 8) and BS EN 14797 (REF 13) standards. NFPA 68 design key performance requirements are:

vi. The BESS enclosure strength shall exceed the vent opening pressure by a safety factor of over two (including the doors)

vii. The total vent size shall be selected such that the reduced deflagration pressure (Pred) is below two thirds (2/3) of the enclosure strength.

viii. Any BESS explosion prevention or control / protection system would be validated through full scale BESS destruction testing, lean gas mixture testing and requisite pressure testing required by NFPA and EN standards. An independent Fire Protection Engineer specialising in BESS should review all UL 9540A (REF 5) test results and any additional fire and explosion test and consequence modelling data which has been provided.

3 BESS CONSTRUCTION AND OPERATION

3.1 Safe BESS Construction

3.1.1 The BESS would be constructed in two distinct phases. Firstly, the civil works and balance of plant equipment would be started. Then at the appropriate stage, the BESS equipment would be delivered to be installed on the foundations and connected to the balance of plant.

3.1.2 The installation would be subject to pre-requisites, such as a contractor emergency protocol, detailing the actions to be taken in an emergency, as part of the development of the CEMP. In addition, installation would not take place until practical provisions were completed such as the water tanks being installed and filled for use in an emergency.

3.1.3 The transportation of the system from the factory will be a combination of sea and land freight. The system is certified for transportation in all potential environmental conditions. The equipment will be certified for transport to UN 38.3 (REF 22). Transportation will be managed in accordance with the European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR) 2019 (REF 23) and the UK guidance on the transport of dangerous goods "Moving dangerous goods, Guidance" (REF 24) Government webpage.

3.1.4 The appointed contractor will ensure the transported BESS equipment will be prepopulated with batteries and it will have undergone Factory Acceptance Testing (FAT) to IEC 62933-5-2 (REF 4) standards. Site Acceptance Tests (SAT) will follow IEC 62933-5-2 and IEEE P2962 (in development) (REF 25) standards and protocols.

3.1.5 By following a logical sequence of works with each step being built upon the preceding one, the system can be safely assembled with minimal risk, and all mitigations against residual risk in place, before the next step occurs.

3.2 Safe BESS Operation

Control Room

3.2.1 The BESS area will be monitored by the on-Site control facilities, as well as 24/7 monitoring by a remote-control facility provided by the BESS manufacturer or operator. Operations would be controlled as follows:

i. The control room (when operational) will be responsible for the security of the BESS site with state-of-the-art detection and monitoring systems. These can be repurposed in an emergency to support first responders.

ii. The control room will have the ability and authority to immediately shut the system down should the need arise.

iii. The control room (when operational) will be responsible for the implementation of the Emergency Response Plan (ERP), acting as a point of contact to emergency services.

iv. Staff will be fully trained and familiar with the BESS technologies and will be responsible for alerting CFRS and, if required, for connecting CFRS with BESS incident Subject Matter Experts (SMEs).

v. The 24/7 remote control facility will monitor the security of the BESS site, and monitoring and detection systems will be repurposed in an emergency to support first responders. NFPA 855 (2023) (REF 2) defines the minimum monitoring and control standards.

vi. The 24/7 remote control facility will have the capability to immediately shut the system down should an incident occur, and the need arise. It can also implement the ERP, acting as a point of contact to the emergency services.

vii. In some circumstances it will be necessary to discharge stored electricity from the batteries to enable the first / second responders to deal with the incident. This capability could potentially be achieved through the 24/7 remote control facility. The precise methodology in this regard will be agreed in the ERP and also documented in the BSMP once the detailed design of the BESS is known. This will be prepared in conjunction with CFRS.

3.2.2 Signage should be installed in a suitable and visible location on the outside of the BESS units, identifying the presence of a BESS system. Signage would be as per NFCC guidelines (REF 6) and will also include details of:

viii. Relevant hazards posed i.e., the presence of High Voltage DC Electrical Systems is a risk, therefore their location should be identified.

ix. The type of technology associated with the BESS.

x. Any suppression system fitted.

xi. 24/7 Emergency Contact Information.

xii. Signs on the exterior of a building or enclosure will be sized such that at least one sign is legible at night at a distance of 30m or from the site boundary, whichever is closer.

Control Architecture

3.2.3 NFPA 855 (2023) (REF 2) stipulates that a Battery Management System (BMS) should at a minimum provide the following safety functions:

i. High cell temperature trip to isolate the module or rack when detecting cell temperatures that exceed limits.

ii. Thermal runaway trip to isolate the battery system when a cell is detected to have entered a thermal runaway condition.

iii. Rack switch fail-to-trip to disconnect the rack if any failure is detected. Inverter/charger fail-to-trip to isolate the BESS enclosure at the breaker if the inverter/charger fails to respond to a trip command.

iv. Inverter/charger fall-to-trip (supervisor level): This function initiates a trip command to an upstream breaker to isolate the ESS if the inverter/charger fails to respond to a trip command. The 'supervisor' control system controls the entire system, including the combination of racks, the environmental support systems, and the charging/discharging status. The supervisor level should isolate the ESS if the inverter/charger fails to trip on an appropriate signal, or if communication is disrupted between the inverter/charger and the supervisor control.

3.2.4 Energy Management Systems (EMS) / BMS controls would as a minimum incorporate NFPA 855 (2023) (REF 2) monitoring and control features and conform to the new IEEE 2686 (2025) standard (REF 26): Recommended Practice for Battery Management Systems in Stationary Energy Storage Applications. Additional IEEE standards in development (IEEE P2688 (REF 27) and IEEE P2962 (REF 25)) should also be adopted by the BESS system provider, these cover BESS data analytics, electrical controls and maintenance / replacement of battery components / systems.

3.2.5 If data analytics are not directly integrated by the BESS OEM or BESS integrator, the Applicant will ensure a Data Analytics package is integrated to provide a greater range of performance and safety data i.e. predict ageing of the cells in battery systems, alert BMS faults or malfunctions, identify electrical abuse during operations, alert the operator when modules need maintenance or decommissioning. Data Analytics facilitate more accurate assessment of operating temperature variations, voltage anomalies, State of Charge (SOC), and State of Health (SOH). Data Analytics can also monitor complimentary BESS safety features i.e. smoke and gas sensors, BESS multi-sensor equipment, ground fault detectors, etc.

3.2.6 Cybersecurity will form a fundamental part of the system design and architecture as there is an increasing focus in this area from national and international regulatory bodies. International standards such as IEC 62443 (REF 28), UL 1741 (REF 29), IEEE 1815 (REF 30), and IEEE 1547.3 (REF 31) will be consulted and guidance from national sources such as National Cybersecurity Centre inform the implementation and protection measures. Reference would be made to the Health and Safety Executive (HSE) Operational Guidance document OG86 (REF 32).

3.2.7 UL published 'UL 2941 (2023) Outline of Investigation for Cybersecurity of Distributed Energy and Inverter-Based Resources' (REF 33). UL 2941 provides testable requirements for photovoltaic inverters, electric vehicle chargers, wind turbines, fuel cells and other resources essential to advancing grid operations. These new requirements prioritise cybersecurity enhancements for power systems that deal with high penetration inverter-based resources, including those interfacing with bulk power systems for periods of instantaneous high wind, solar and hybrid/storage generation. UL 2941 promotes the necessity to have cybersecurity designed into new inverter-based resources (IBR) and distributed energy resource (DER) systems, and the Scheme at the detailed design stage will conform to these requirements.

Security

3.2.8 The Site security profile will be assessed by the Applicant's dedicated security team and the output from this assessment will inform the level of security measures used.

3.2.9 Where practical and required by CFRS or risk assessment, the BESS compound will have security fencing with a minimum of two points of ingress / egress for first responders and will be clearly signed, with incident emergency response contact details, clear identification of BESS site hazards, details of site access arrangements such as key codes, which will be provided to the CFRS.

3.2.10 Depending on the outcome of the future risk assessment, the BESS site may require thermal Imaging Cameras to alert and locate on site fire risks and integrate high-definition CCTV with video analytics to alert and respond to unauthorised site access.

Maintenance

3.2.11 The BESS will be maintained and operated by skilled personnel ensuring that the system is in optimal condition and that all parts of the system are fully serviced and functional at all times.

3.2.12 Routine maintenance will be undertaken on the BESS equipment every 6-12 months, depending on the risk profile of the equipment to be selected. This typically consists of a major maintenance period and a minor maintenance period. This will encompass all BESS and supporting equipment supplied by the Original Equipment Manufacturer (OEM) including the fire protection and explosion prevention system. The maintenance schedule will also include a specific maintenance programme for the automative shutoff valves within the drainage system, with a clearly defined frequency of checks. Minor maintenance is typically a visual inspection and rectification of any accumulated noncritical defects. All maintenance will be undertaken in a carefully controlled manner, following the site safety rules and in accordance with the Operational Environmental Management Plan (OEMP) [EN010153/DR/7.6] approved pursuant to DCO Requirements.

3.2.13 During operation, all works on the site will be controlled under safe systems of work. This will mean all work is risk assessed to protect both personnel and equipment. Therefore, safety systems such as fire systems will not be stopped or taken out of service without appropriate mitigation, following the system being made safe so far as is reasonably practicable, and only for the minimum time required to undertake any specific maintenance tasks.

3.2.14 Upon any large-scale replacement / augmentation of BESS enclosures, the safety measures associated with the BESS will be reviewed for their appropriateness considering the prevailing guidance at that time and the technology installed, in consultation with the CFRS and the outcomes of that review shall be shared with Chesire West and Chester Council.

End of life disposal

3.2.15 Regarding the decommissioning of the BESS, the requirements will be determined at the procurement contract stage, with the contractor remaining clear that they are the producer of the battery components and as the party placing the battery components on the UK market, pursuant to the Waste Batteries and Accumulators Regulations 2009 (REF 34) (or such equivalent regulations in force at the time of decommissioning), they have certain obligations in respect of battery disposal.

3.2.16 In the event of a defective battery module or cell being identified, the defective module shall be immediately placed out of service and be electrically disconnected from the system. A specific risk assessment shall be conducted prior to the removal of the defective module to ensure the safety of employees and contractors.

3.2.17 All components replaced during the defects notification and warranty period will be returned and recycled.

3.2.18 The Applicant will follow the hierarchy of waste management through the life of the scheme as follows:

Reduce – the lithium-ion batteries have finite life based on a number of factors, primarily the total number of cycles undertaken. The operation will attempt to manage the degradation by the selection of services and cycling that maximises the overall life. Consideration will be given to supplementation of the equipment or operation at a lower output.

Recycle – The supplying manufacturer will have obligations under the Waste Batteries and Accumulators Regulations 2009 (as amended) (or such equivalent regulations in force at the time of decommissioning) and will be contractually obliged to offer a recycling service.

Recovery – The recycling should allow any useful materials to be recovered and re-enter the supply chain.

Disposal – Any disposal of batteries shall be undertaken in compliance with all applicable laws and all regulatory requirements, product stewardship, registration disposal and recycling or take back requirement.

4 FIREFIGHTING

4.1 Safe BESS Construction

4.1.1 Guidance for the Fire Service for dealing with sites such as powerplants, substations etc. is contained in the Fire Service Manual Volume 2 Fire Services Operations – Electricity (REF 35).

4.1.2 The Fire Service Manual stipulates that in all cases involving electrical apparatus, it is essential to ensure, on arrival, that the apparatus is electrically isolated and safe to approach. This would be carried out by the operator at the premises concerned. It is strongly advised that electrical or associated equipment should not be touched or even approached unless it is confirmed to be isolated and safe.

4.1.3 BESS hazards for first responders, and site operatives once a BESS failure event occurs, depend on both the failure scenario and the BESS design but are typically defined as: fire, explosion, chemical hazards, carbon monoxide, carbon dioxide, hydrocarbon gases, and hydrogen. Full PPE would be worn, and operations would not generally be conducted within any identified blast exclusion zones (close proximity to doors and deflagration vents).

4.1.4 Fire Hydrants and connections to any dry pipe systems that are required to be installed as part of the BESS, compound would be installed in accordance with BS 9990 (Non-automatic firefighting systems in buildings - Code of Practice) (current edition) (REF 9) and should be identified in accordance with BS 3251 Indicator Plates for Fire Hydrants (current edition) (REF 10).

4.1.5 If a dedicated automatic water-based suppression system or TRPP system (engineered to directly access cells within battery modules) is provided within each BESS enclosure, this will be tested at UL 9540A (REF 5) installation level or through significant scale third-party fire and explosion testing. The suppression or TRPP system will be capable of operating effectively in conjunction with a gas exhaust/ventilation system to minimise deflagration risks. The system design must be capable to control or fully suppress a fire, without the direct intervention of CFRS.

4.1.6 The Applicant has consulted NFCC guidelines (REF 6) and engaged with CFRS throughout the pre-application phase, and will ensure that the detailed BSMP will include any subsequent revisions made to NFCC guidelines. Close consultation will continue with CFRS throughout the planning process.

4.2 Fire Service Access

4.2.1 UK National Fire Chiefs Council BESS planning guidance document. published in April 2023 (REF 6), stipulates that suitable facilities for safely accessing and egressing the BESS compound should be provided. Designs would be developed in close liaison with CFRS, as specific requirements may apply due to variations in vehicles and equipment.

4.2.2 This would include:

i. At least two separate access points to the BESS compound to account for opposite wind conditions/direction.

ii. Roads/hard standing capable of accommodating fire service vehicles in all weather conditions within the BESS compound, and on supporting access tracks. The Main Access Route and the alternative options via Brooks Furlong and Weaver Lane are all capable of accommodating fire service vehicles. As such there should be no extremes of grade.

iii. Roads to have passing places suitable for fire service vehicles - the Main Access Route and the alternative options via Brooks Furlong and Weaver Lane provide for this.

iv. Road networks on sites must enable unobstructed access to all areas of the facility – this will be possible on all routes to and within the Site.

v. Turning circles, passing places etc size to be advised by CFRS depending on fleet.

vi. Emergency access route plans for first responders will be included in the Emergency Response Plans and hard copies will be available on site. Route sign requirements will be agreed with CFRS.

4.2.3 In the event of a fire, the battery system and the transformers serving the BESS will be automatically electrically isolated when a fire is detected within a BESS enclosure. However, the batteries within the BESS enclosures will still hold charge in the event of a fire, even after the electrical system is isolated. It will not be possible to confirm that there is no residual risk from the energised batteries within the BESS enclosures, and this will inform the strategy for firefighting in the emergency plan.

4.2.4 As noted in paragraph 3.2.2, signage will be installed in a suitable and visible location on the outside of BESS enclosures identifying the presence of a BESS system. Safety signage will be installed in accordance with Health and Safety (Safety Signs and Signals) Regulations 1996 (REF 36). Signage will include details of:

i. Relevant hazards posed.

ii. The type of technology associated with the BESS.

iii. Any suppression system fitted.

iv. 24/7 Emergency contact information.

4.2.5 Signs on the exterior of a building or enclosure should be sized such that at least one sign is legible at night at a distance of 30 metres or from the Order limits, whichever is closer.

4.2.6 In accordance with latest NFCC revised guidance (2024) (REF 6), the final BSMP will include a site plan that shows all sensitive receptors within a 1 km radius of the Order limits that could be affected by a fire. The plan will have a compass rose showing north and the prevailing wind direction.

4.2.7 A site plan will be provided at the detailed design stage to CFRS that may include, as relevant:

i. The layout of buildings.

ii. Any areas where hazardous and flammable materials are stored on site (location of gas cylinders, process areas, chemicals, piles of combustible wastes, oil and fuel tanks).

iii. All permanent ignition sources within the Order limits and show they are a minimum of 6 m away from combustible and flammable waste.

iv. Any areas where combustible waste is being treated or stored including non-waste material.

v. All separation distances.

vi. Any areas where combustible liquid wastes are being stored.

vii. Any area where depollution of end of life vehicles (ELVs) takes place.

viii. Any area where crushing, shredding, baling of metals or ELVs takes place.

ix. Main access routes for fire engines and any alternative access.

x. Access points around the perimeter of the Order limits to assist firefighting.

xi. Hydrants and water supplies.

xii. Areas of natural and unmade ground.

xiii. Drainage runs, pollution control features such as drain closure valves, and fire water containment systems such as bunded or kerbed areas (this may be easier to show on a separate drainage plan).

xiv. Storage areas with pile dimensions and fire walls (where applicable) – this includes wastes stored in a building, bunker, or containers – include indicative pile layouts and ensure it is geographically representative.

xv. The location of fixed plant or storage location of mobile plants when not in use.

xvi. The location of spill kits.

xvii. The quarantine area.

xviii. Anything site specific considered needing to be added.

4.3 Fire Water Supply

4.3.1 The BESS compound will be designed to integrate pressure fed (pump driven) fire hydrants and/or static water tanks (tanks can be integrated above or below ground) for firefighting, depending on available water supply. Water provision will be designated for the cooling of adjacent BESS or ESS equipment. Water tanks will be located at least 10m from the nearest BESS enclosure. Water access points, whether hydrants or tank connections, would be located in consultation with the Cheshire Fire and Rescue Service (CFRS) to provide redundancy and safe operating distances for firefighters with 30 – 50m, which is considered an optimal safe distance. Tanks and water outlets would be clearly labelled with appropriate signage and marked on site plans. Additionally, to avoid any mechanical damage, outlets and hard suction points would be safeguarded with bollards.

4.3.2 The firefighting water requirement will be fully assessed at the detailed design stage based upon BESS fire and explosion test data by an independent Fire Protection Engineer, and water storage volumes will be agreed with CFRS during detailed design.

4.3.3 The BESS compound design will contain a minimum of two firefighting water storage units of no less than 228,000 litres in capacity, capable of delivering 1900 litres per minute for 4 hours (exceeding NFCC guidance).

4.3.4 Water storage will either be in sectional steel panel tanks, or cylindrical steel tanks, above or below ground. Where above ground, tanks will be supported on structural concrete slab foundations to a maximum depth of 1m.

4.3.5 Site and BESS design principles and ERP content will ensure that the CFRS are expected to employ a defensive strategy i.e. only boundary cooling should be employed for cooling of adjacent BESS or associated supporting equipment, this ensures that environmental pollution risks are minimised. Boundary cooling typically involves firefighters directing water fog or spray pattern discharge to ensure the incident does not spread to adjacent BESS enclosures. NFCC guidance (REF 6) states: *“If it can be confirmed that the recommended firefighting tactic for the BESS is to defensively fire fight and boundary cool whilst allowing the BESS to consume itself, this will reduce the water requirements, and thus the drainage/environmental protection requirements significantly.”* A BESS design which may require direct CFRS firefighting engagement tactics will not be selected for this facility.

4.3.6 The BESS scheme will integrate an external firefighting water capture drainage system. In the event of a fire, a system of automatically self-actuating valves at the outfalls from the BESS compound will be closed, isolating the BESS compound drainage from the wider environment. Fire water runoff may contain particles from a fire. The BESS compound design would include a dedicated pipe network which would enable firewater from an affected Battery Storage Unit to be piped to a dedicated firewater collection lagoon. During a firefighting event, the valve from the lagoon would be shut and firewater held, tested and either removed from Site via tanker to a suitable disposal / treatment facility, or treated onsite and reused as firewater provision. The lagoon and drainage system would be cleaned before the valve from the firewater lagoon is reopened.

4.3.7 Fire hydrants and connections to any dry pipe systems that are installed on the BESS compound will be installed in accordance with BS 9990 Non-automatic Firefighting Systems in Buildings Code of Practice (Current Edition) (REF 9) and should be identified in accordance with BS 3251 Indicator Plates for Fire Hydrants (Current Edition) (REF 10).

4.3.8 If an internal BESS water based fixed suppression system (automatic or dry pipe) is integrated in the BESS enclosures, a separate water supply and water containment system will be integrated, water runoff is likely to contain higher levels of pollutants compared to water used for external boundary cooling of BESS and ESS equipment. All process water used in the system shall be prevented from contaminating potable water sources, in accordance with local regulations through the use of check valves or other means as part of the system design. Pollution analysis will be conducted before removing and treating offsite.

4.3.9 The provision for water storage tanks to be incorporated into the BESS compound is included in the Proposed Development, as shown in ES Vol 1 Chapter 2: The Proposed Development, Figure 2-5d: Indicative BESS and Frodsham Substation layout.

4.4 Emergency Planning

4.4.1 The proposed BESS will have a robust and validated emergency plan, developed in consultation with CFRS. Some example BESS and site design information which is anticipated to be shared with CFRS, to establish a risk profile for first responders, is listed below:

i. Battery chemistry integrated into BESS – can provide fire and explosive risk profile.

ii. Battery form factor (cylindrical, pouch, prismatic).

iii. Battery energy Wh / kWh – confirmation of new battery cell (second life cells will not be accepted).

iv. Battery module cooling system details (e.g., liquid cooling design, air cooling design) – cooling system capability assessment to stop or reduce battery cell thermal runaway propagation. Air cooled designs will not be accepted for the Scheme.

v. Battery module vent or gas exhaust specifications.

vi. Battery module kWh energy + number of cells contained in the module + battery circuitry details (number of cells in series vs number of cells in parallel).

vii. Direct suppression system details – direct module TRPP or rack level FSS integration.

viii. Rack design – number of modules and kWh energy, spacing between modules, passive protection features, gas exhaust features, electrical isolation functions, heat or thermal runaway sensor integration, etc.

ix. Rack configuration – spacing to adjacent racks, number of racks in BESS, spacing to walls, doors, gas vents and roof.

x. Type of BESS enclosure design e.g., container or cabinet, gas exhaust / ventilation features, deflagration vent design features, BESS enclosure level fire protection and suppression system details (proof of testing with BESS design and test data), additional fire or explosion protection features i.e., thermal barriers.

xi. EMS / BMS data monitoring capabilities and incident response integration capacity.

xii. Number of BESS enclosures on site.

xiii. Size and MWh capacity of each BESS enclosure.

xiv. BESS and ESS equipment spacing; spacing to other equipment, boundaries, vegetation, roads or access routes, fire hydrants / water tanks, site building structures, etc.

xv. Access routes, observation points, turning areas, FRS equipment and assets, water supply locations and capacity, drainage, and water capture design.

xvi. Definition and frequency of BESS equipment testing and maintenance requirements.

4.4.2 Digital provision of safety information and procedures must be provided to site operatives, first responders and SMEs during BESS incident response – hard copy printed materials must be available onsite (location agreed with CFRS). As a minimum content should include:

i. Digital emergency response plans.

ii. Remote emergency shutoff procedures.

iii. SDS / Hazardous material documentation.

iv. Maps or design drawings.

v. Gas detection capabilities; could include multi-sensor data metrics e.g., Carbon Dioxide (CO2), Carbon Monoxide (CO), Hydrogen (H2), VOC off gas + overpressure + localised temperatures.

vi. Fire protection system data e.g., temperature, alarming, suppression status, etc. – establish discharge warrantee clauses, emergency BESS venting procedures, discharge times, impact on ventilation and detection systems, etc.

vii. ERP training drills for site operatives + FRS engagement (site familiarisation + training drills) + SME engagement (fire protection experts or battery experts)

viii. Other documentation as required by specific BESS project i.e., local response stipulations, contact information for nominated response personnel, community contacts, etc.

4.4.3 An ERP will be developed post planning consent to facilitate effective and safe emergency response. It will follow UK National Fire Chiefs Council (NFCC) (REF 6) and NFPA 855 (REF 2) guidelines and will include as a minimum:

i. How the fire service will be alerted and incident communications and monitoring capabilities.

ii. Facility description, including infrastructure details, operations, number of personnel, and operating hours.

iii. Site plan depicting key infrastructure:

iv. Site access points, internal roads, agreed access routes, observation points, turning areas, etc.

v. Firefighting facilities (water tanks, pumps, booster systems, fire hydrants, fire hose reels etc).

vi. Water supply locations and capacity.

vii. Drainage and water capture design and locations.

viii. Up-to-date contact details of the emergency response co-ordinator including the subject matter expert (SME) for the Order limits.

ix. Safe access to and within the facility for emergency vehicles and responders, including to key site infrastructure and fire protection systems.

x. Details and explanation of warning systems and alarms on site and locations of alarm annunciators with alarm details (smoke, gas, temperature).

xi. Hazards and potential risks at the facility and details of their proposed management.

xii. The role of the FRS at incidents involving a fire, thermal event or fire spreading to the Order limits.

xiii. Emergency shutoff or isolator locations.

xiv. A list of dangerous goods stored on site.

xv. Site evacuation procedures.

xvi. Site operation Emergency Management protocols - 4 phases: discovery, initial response / notification, incident actions, resolution and post incident actions / responses

xvii. Emergency procedures for all credible hazards and risks, including building, infrastructure and vehicle fire, wildfires, impacts on local respondents, impacts on transport infrastructure.

xviii. The operator will develop a post-incident recovery plan that addresses the potential for reignition of the BESS and de-energizing the system, as well as removal and disposal of damaged equipment.

xix. Incident response procedure to alert the Environment Agency and defined downstream river/groundwater abstractors in the event of a fire should there be uncontrolled release of firewater to surface or groundwater.

4.4.4 The site owner during design development, as well as the operator once appointed, will work closely with CFRS to provide all relevant information on BESS and site design features to inform all necessary hazard and risk analysis studies and assist in the development of comprehensive Risk Management Plan and Emergency Response Plan.

4.4.5 Information will be supplied as early as possible in the detailed design stage to allow an initial appraisal of the BESS to be made. This information will be provided to CFRS with appropriate evidence provided to support any claims made on performance, and with appropriate standards cited for installation. Such information should also be made available to CFRS for inclusion in Site Specific Risk Information (SSRI) records.

4.4.6 A Risk Management Plan shall be developed with CFRS post consent at the detailed design stage as part of the BSMP which, as a minimum, will provide advice in relation to potential emergency response implications including:

a) The hazards and risks to the facility and their proposed management.

b) Any safety issues for firefighters responding to emergencies at the BESS facility.

c) Safe access to and within the facility for emergency vehicles and responders, including to key site infrastructure and fire protection systems. Establishment of response times and site arrival protocols.

d) The adequacy of proposed fire detection and suppression systems e.g., water supply on-site.

e) Natural and built infrastructure and on-site processes that may impact or delay effective emergency response i.e., firefighting water runoff capture.

4.5 Firefighting Consequences

Firefighting techniques

4.5.1 Due to the BESS not having personnel access into the battery enclosures, there is unlikely to be any immediate threat to life arising from a BESS fire.

4.5.2 The fire and rescue service – CFRS – in foreseeable and credible emergency response scenarios, would most likely adopt a defensive firefighting strategy by using water on neighbouring areas such as battery enclosures and structures to cool down and prevent further fire spread. The scheme will select a BESS design that has undertaken full scale free burn testing to demonstrate thermal insulation protection capabilities of the BESS enclosure design, validate equipment spacing distances, and demonstrate that deflagrations do not occur and/or can be safely constrained. In accordance with NFCC guidance (REF 6), the Proposed Development will be managed in such a way so as to prevent a fire spreading to the BESS or inadvertently fire loading, by providing a ‘bridge’ or path between BESS enclosures to transmit flaming or radiant heat.

4.5.3 As recommended in NFCC revised guidance (2024) (REF 6), it is not anticipated that firefighting techniques will require direct hose streams or spray directly on battery systems, and techniques will be limited to boundary cooling of adjacent BESS enclosures and supporting equipment to prevent the fire from spreading. IP ratings of BESS enclosures will be shared with CFRS so that risks associated with boundary cooling can be understood. This strategy will be finalised with the CFRS at the detailed design stage and be clearly communicated in the Emergency Response Plan (ERP).

4.5.4 The emergency services would most likely commit to fighting fire by using water on neighbouring areas such as other BESS enclosures, trees, and structures to cool down and prevent further fire spread.

Surface-water runoff

4.5.5 As set out in ES Chapter 9: Flood Risk and Drainage (EN010153-6.1), the base of the permeable stone surfacing in the BESS compound will be lined with an impermeable geotextile. In normal operation, the stoned areas of the compound would allow rainwater to be captured, attenuated to a greenfield runoff rate and then drain to a nearby watercourse.

4.5.6 A BESS fire could result in the mobilisation of pollution within surface water run-off. If an internal fire suppression system (sprinkler or spray system) is integrated into each BESS unit and discharged in a BESS failure event, the BESS compound design includes a dedicated pipe network which would enable firewater from an affected BESS unit to be piped to a dedicated firewater collection lagoon.

4.5.7 During a firefighting event, the valve from the lagoon would be shut off and firewater held, tested and either removed from Site via tanker to a suitable disposal / treatment facility, or treated onsite and reused as firewater provision. Water samples would be sent to a UKAS accredited laboratory for analysis, using UKAS and MCERTS accredited methods (where applicable). Water samples would be checked against the list of hazardous substances in the Environment Agency 'Surface water pollution risk assessment for your environmental permit' guide. The lagoon and drainage system would be cleaned before the valve from the firewater lagoon is reopened. The stone surfacing shall be cleaned if it has been polluted as a result of a firefighting event, or contaminated stones shall be removed and replaced before any drainage valves are reopened.

4.5.8 The shut off valve on the fire water lagoon outfall and will be automated (set in the off position when fire water sprinklers are activated). This will prevent discharge of fire water to the wider water environment. An outfall from the fire water lagoon to the site drainage system is required to ensure the lagoon does not fill up with rainwater, ensuring the lagoon is empty and ready to accommodate fire water. The automatic shutoff valves will also include a manual override, in case the automation fails.

4.5.9 Full details of firewater management will be provided in the surface water drainage strategy, required by the DCO and which is stipulated in the oOEMP [EN010153/DR/7.6], and in the detailed battery safety management plan to be approved by CWaC prior to construction commencing.

Smoke Plume

4.5.10 The Plume Study (Appendix 7-1) assesses the battery fire emission impact in worst case fire locations (using the concept BESS design) on sensitive receptors within a 1km radius of the BESS compound. The evaluation is a consequence-based study using Computational Fluid Dynamics (CFD) to evaluate potential impact of a battery failure event and assess the impact of visibility and toxicity on the neighbouring area in the event of a fire. The analysis has evaluated the credible worst-case scenario in terms of consequence for a fire event, where safety systems and barriers to preventing escalation were assumed to have failed, and a reasonable worst-case (BESS unit) fire was modelled. Results are presented in terms of recognised hazardous exposure thresholds. The hazardous threshold is known as Immediately Dangerous to Life and Heath.

4.5.11 Four scenarios were modelled that varied the wind speed and direction for the BESS fire. The main findings from the simulations were:

i. There is no impact to the M56 Motorway, Nursing Care Home and Traveller Site to the South-East of the Site, or to the Hover Force Centre and Moorditch Lane to the South-West of the Site, for any toxic gas or visibility impairment for any wind conditions modelled.

ii. The 5 m/s wind speed results in the longest impairment distances, as the higher wind speed of 10 m/s disperse the flame, shortening its length and diluting the smoke plume.

iii. The concentrations measured of toxic gases show that the hazards posed by a battery unit fire are confined to the immediate surrounds of the battery unit (BESS enclosure), HF remaining within 4 m and CO within 6 m. This is due to the relatively high concentrations of smoke required to reach the IDLH thresholds. Additionally, results are provided at 1 ppm for HF, which is representative of the most restrictive Acute Exposure Guideline Levels (AEGL) / Emergency Response Planning Guideline (ERPG) threshold, no impairment is observed at any sensitive receptor.

iv. The Particulate Matter IDLH concentration of 0.71 ppm has a maximum distance of 22 m, which remains significantly below the distance to the nearest sensitive receptor, Moorditch Lane, located 86 m away.

4.5.12 The maximum impairment distance for Moorditch Lane and the M56 Motorway are listed below:

- Moorditch Lane (30 mph stopping distance) – 6 m impairment, where the sensitive receptor is located 86 m away.
- M56 roadway (70 mph stopping distance) – 16 m impairment distance, where the sensitive receptor is located 410 m away.

4.5.13 To add confidence to the results of the study, conservative assumptions have been used. For example, peak fire loads have been modelled. Whereas in reality, the peak fire would last for 1-2 hours and the rest of the fire, another 6-8 hours, would be at a low intensity and subsequently smouldering for more than a day. The aim of the analysis was to demonstrate the consequences of the reasonable worst case Battery Unit (BESS enclosure) fire. Even with this conservatism, no impairment was observed at the nearest residence (Traveller Site, 300 m from the nearest battery unit) or the nearest road (Moorditch Lane, 86 m from the nearest battery unit).

4.5.14 From the Plume Study, it can be concluded that there is no impact due to toxic gas or visibility impairment on any sensitive receptor in the proximity of the proposed BESS compound, arising from a reasonable worst-case (BESS Unit) fire. The effects of the fire are restricted to the proximity of the BESS.

4.5.15 First responders are expected to wear full Personal Protection Equipment (PPE) for incident response, this is especially critical within the immediate area of the BESS enclosure that is on fire due to toxic gases potentially exceeding IDLH values at these distances. The residential areas and road sensitive receptors are sufficiently far away from the BESS compound to not be impaired by any of the simulated fires, in terms of visibility or toxicity.

4.5.16 Notwithstanding, at the detailed design stage a BESS system and site-specific Plume Analysis study will be conducted and reported on in the full BSMP, to assess the environmental impact of a site incident to sensitive receptors within a 1 km radius. This analysis will ensure that toxic gas emissions to sensitive receptors, arising from the detailed design of the scheme, remain below relevant public health exposure limit guidelines, when the battery system of a BESS is fully consumed (burnt out). Production of Particulate Matter (PM) and a visibility impact assessment on any transport links within a 1 km radius of the BESS compound will also be included. The emergency response plan (ERP) produced at the detailed design stage (template outlined in section 3.4.4) will incorporate all necessary emergency response procedures and actions based upon thermal runaway test data supplied by the BESS system provider.

5 PRE-CONSTRUCTION REQUIREMENTS

5.1 Summary

5.1.1 The detailed design phase of the Scheme will consider the lifecycle of the battery system from installation to decommissioning. At the detailed design stage, risk assessment tools will be utilised together with detailed consequence modelling to provide a comprehensive site operations and emergency response safety audit.

5.1.2 The battery system mitigation measures adopted in a final BSMP, will reflect the latest BESS safety codes and standards applicable at that time. Mitigation measures will be discussed and coordinated with Chesire Fire and Rescue Service (CFRS).

5.1.3 As stipulated in NFPA 855 (2023) (REF 2), a Failure Modes and Effects Analysis (FMEA) of the BESS (BS EN IEC 60812 (REF 37)), or Layer of Protection Analysis (LOPA) of the BESS, will be conducted to lay the foundation for predictive maintenance requirements and will complement the fault indicator capabilities of the BMS data analytics system. This key analysis minimises the probability of a BESS failure in relation to the specific BESS system and site design, and analyses key mitigation solutions to minimise the impact of a BESS failure in the unlikely event that this would occur. These types of risk analysis provide confidence to demonstrate that under day-today operation there is a low risk of a BESS failure incident, and in the event of an incident the credible hazards are understood and have been evaluated both at the illustrative and detailed design stages, to demonstrate that the risk to site operatives, first responders, and the local population remains very low.

5.1.4 Comprehensive Hazard Mitigation Analysis (HMA) will be conducted by a BESS specialist independent Fire Protection Engineer, in accordance with NFPA 855 (2023) (REF 2) guidelines and recommendations, to cover BESS system and site-specific safety issues. Typically, the main components of an HMA are:

i. BESS Information (design and site layout)

ii. Code Analysis (BESS safety and fire standards)

iii. UL 9540A (REF 5) testing, 3rd party fire and explosion test results, consequence modelling (heat flux analysis, NFPA 68 (REF 8) deflagration analysis, etc.) reports

iv. Failure Modes and Effects Analysis (FMEA)

5.1.5 A BESS system and detailed-design specific Plume Analysis study will be conducted to assess the environmental impact of a site incident to sensitive receptors within a 1 km radius. This analysis will ensure that toxic gas emissions to sensitive receptors arising from the detailed design of the scheme remain below relevant public health exposure limit guidelines, when the battery system of a BESS enclosure is fully consumed (burnt out). Production of Particulate Matter (PM), and a visibility impact assessment on any transport links within a 1 km radius of the BESS compound, will also be included.

5.1.6 A range of studies will be undertaken, with a primary focus on fire and explosion risk including (but not limited to) risk analysis and management tools to inform the overall design solution include:

i. Hazard and Operability Analysis ('HAZOP')

ii. Hazard Identification ('HAZID')

iii. Fire Risk Analysis (FRA)

iv. Explosion Risk Analysis (ERA)

v. Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) (REF 38)

5.1.7 A non-exhaustive list of additional BESS system risk analysis reports frequently provided by Tier 1 BESS manufacturers or BESS integrators, which can inform key risk analysis studies (listed in 5.1.4 and 5.1.5) and provide CFRS with detailed insights into capability of BESS system hazard mitigation systems (burning and venting thermal runaway scenarios), and provide guidance for evaluating site-specific equipment spacing templates, are listed below:

i. NFPA 69 (REF 7) Explosion Prevention Compliance report

ii. Deflagration analysis report

iii. FDS gas ventilation analysis report

iv. Heat Flux and flame tilt analysis report

v. Full scale fire test report

vi. Firefighting water analysis report

vii. UL 9540A (REF 5) test interpretation reports

viii. Emergency Response Plan (ERP) templates

ix. Decommissioning Plan templates

5.1.8 If the BESS system supplied differs from the specification considered for risk assessments and consequence modelling, then a full safety audit will be repeated for the new BESS system specification. These studies will be completed and signed off before construction commences.

5.1.9 The detailed design phase will determine the approach to addressing the following specific requirements, which will be updated prior to construction of the BESS and submitted to Cheshire West and Chester Council as a final BSMP, prior to the commencement of construction. The BSMP must include:

i. The detailed design, including drawings of the BESS;

ii. A statement on the battery system specifications, including fire detection and suppression systems;

iii. A statement on operational procedures and training requirements, including emergency operations;

iv. A statement on the overall compliance of the system with applicable legislation;

v. An environmental risk assessment to ensure that the potential for indirect risks (e.g., through leakage or other emissions) is understood and mitigated; and

vi. Emergency Response Plan(s) covering construction, operation and decommissioning phases will be developed once a construction team, and an operator have been appointed. These plans will be developed in consultation with CFRS and other local emergency services to include the adequate provision of firefighting equipment onsite and ensure that fire, smoke, and any release of toxic gases from a thermal runaway incident does not significantly affect site operatives, first responders, and the local community.

5.1.10 Provision of the above information will demonstrate that all the considerations and requirements in this document have been addressed, and the BESS installation is safe.

5.1.11 Safe decommissioning of the BESS will be addressed prior to decommissioning of the scheme in a Decommissioning Environmental Management Plan, and in accordance with the Outline Decommissioning Environmental Management Plan (EN010153/DR/7.7) submitted as part of the DCO Application.

6 CONCLUSION

6.1 Summary

6.1.1 This Outline Battery Safety Management Plan (OBSMP) has demonstrated in a systematic way the mitigation of the safety risks posed by the BESS that forms part of the Proposed Development.

6.1.2 The Applicant is committed to developing a BESS project incorporating equipment which provides optimal levels of performance and safety during its lifecycle.

6.1.3 This OBSMP demonstrates that the Applicant has relevant experience of BESS systems; that the relevant stakeholders have been consulted, and therefore safety will be inherent in the overall design, minimising the risk of a BESS failure event occurring, and reducing the impact of such an event should it occur.

6.1.4 The implementation of this OBSMP is secured through a Requirement in Schedule 2 of the DCO. This will stipulate that a detailed Battery Safety Management Plan (BSMP) will be submitted to and approved by Chesire West and Chester Council, in consultation with CFRS, prior to commencement of the construction of the BESS. That plan will be substantially in accordance with this OBSMP.

7 REFERENCES

Ref 1 https://www.hse.gov.uk/ppe/managing-risk-using-ppe.htm

Ref 2 NFPA 855 (2023): Standard for the Installation of Stationary Energy Storage Systems.

Ref 3 UL 9540 3rd Edition (2023): Standard for Energy Storage Systems and Equipment.

Ref 4 BS EN IEC 62933-5-2 (2020) Electrical Energy Storage (EES) systems. Part 5-2: Safety requirements for grid integrated EES systems. Electrochemical-based systems

Ref 5 Underwriters Laboratories, UL 9540A (2025) Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems

Ref 6 National Fire Chiefs Council (NFCC) Grid-Scale Battery Energy Storage System planning – Guidance for FRS (2023 and draft revision 2024).

Ref 7 NFPA 69 (2024): Standard on Explosion Prevention Systems.

Ref 8 NFPA 68 (2023): Standard on Explosion Protection by Deflagration Venting.

Ref 9 BS 9990: 2015: Non-automatic firefighting systems in buildings - Code of practice

Ref 10 [redacted]

Ref 11 UL 1973 (2022): Batteries for Use in Stationary and Motive Auxiliary Power Applications.

Ref 12 BS EN IEC 62619 (2022) Secondary cells and batteries containing alkaline or other non-acid electrolytes. Safety requirements for secondary lithium cells and batteries, for use in industrial applications.

Ref 13 BS EN 14797 (2006): Explosion venting devices.

Ref 14 Richard Chitty (2014) External fire spread: building separation and boundary distances (BR 187 2nd edition).

Ref 15 FM DS 5-33 (2023) FM Global Datasheet. Lithium-Ion Battery Energy Storage Systems.

Ref 16 BS EN 13501-2:2023 – TC: Fire classification of construction products and building elements - Classification using data from fire resistance and/or smoke control tests, excluding ventilation services

Ref 17 BS EN 1364- 1: Fire resistance tests for non-loadbearing elements (walls)

Ref 18 BS EN 54: fire detection & alarm systems

Ref 19 BS EN 9999:2017 – TC: Fire safety in the design, management and use of buildings.

Ref 20 NFPA 850 (2020): Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations

Ref 21 NFPA 72 (2025): National Fire Alarm and Signaling Code®

Ref 22 UN 38.3: Recommendations on the Transport of Dangerous Goods – Manual of Tests and Criteria – (Lithium Metal and Lithium-Ion Batteries).

Ref 23 [redacted]

Ref 24 https://www.gov.uk/guidance/moving-dangerous-goods

Ref 25 [redacted]

Ref 26 IEEE 2686 (2025) standard: Recommended Practice for Battery Management Systems in Stationary Energy Storage Applications.

Ref 27 [redacted]

Ref 28 BS EN IEC 62061:2021+A1:2024: Safety of machinery. Functional safety of safety-related control systems

Ref 29 UL 1741 (2021): Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources

Ref 30 IEEE 1815 (2012): IEEE Standard for Electric Power Systems Communications-Distributed Network Protocol (DNP3)

Ref 31 IEEE 1547.3 (2023): IEEE Guide for Cybersecurity of Distributed Energy Resources Interconnected with Electric Power Systems

Ref 32 https://www.hse.gov.uk/foi/internalops/og/og-0086.pdf

Ref 33 UL 2941 (2023): Outline of Investigation for Cybersecurity of Distributed Energy and Inverter-Based Resources.

Ref 34 UK Statutory Instruments (2009) The Waste Batteries and Accumulators Regulations 2009.

Ref 35 Fire and Emergency Planning Directorate (1998) Fire Service Manual Volume 2: Fire Service Operations, Electricity.

Ref 36 https://www.hse.gov.uk/pubns/books/l64.htm

Ref 37 BS EN IEC 60812:2018 – TC: Failure modes and effects analysis (FMEA and FMECA)

Ref 38 The Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) Assessment

APPENDIX 1 – BESS PLUME STUDY

BESS PLUME STUDY

Cubico Frodsham Site - BESS Plume Study

Frodsham Solar Limited

Report no.: 10552248, Rev 0
Document no.: 2522672
Date: 14-04-2025

Project name:	BESS Plume Study	DNV Services UK Limited
Report title:	Cubico Frodsham Site - BESS Plume Study	London SHE Risk
Customer:	Frodsham Solar Limited, 70 St Mary Axe, London, EC3A 8BE, United Kingdom	30 Stamford Street
		Vivo Building, 5th Floor
Customer contact:	[redacted]	SE1 9LQ
Date of issue:	14-04-2025	London
Project no.:	10552248	United Kingdom
Organisation unit:	London SHE Risk	Tel: +44 (0)20 3186 4000
Report no.:	10552248, Rev. 0	GB 440 60 13 95
Document no.:	2522672	

Applicable contract(s) governing the provision of this Report: (PO-20250000009) & (OPP-00396620)

Objective: To provide a consequence-based study using Computational Fluid Dynamics to evaluate the potential impact of a of battery failure event and assess the impact of smoke and toxic gases on the neighbouring area in the event of a fire.

Prepared by:	Verified by:	Approved by:
[redacted]	[redacted]	[redacted]

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Keywords BESS, KFX, Toxic Plume, Visibility, Frodsham

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A	2025-03-21	Draft issue	GG	DY	MH
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ABBREVIATIONS

AEGL	Acute Exposure Guideline Levels
BESS	Battery Energy Storage System
CFD	Computational Fluid Dynamics
CO	Carbon Monoxide
ERPG	Emergency Response Planning Guideline
HCL	Hydrogen Chloride
HF	Hydrogen Fluoride
PM	Particulate Matter
HVAC	Heating, Ventilation and Air Cooling
IDLH	Immediately Dangerous to Life or Health
KFX	Kameleon FireEx
NFPA	National Fire Protection Association
NO_2	Nitrogen Dioxide
PPE	Personal Protech Equipment

DEFINITIONS

Battery Cell	The basic functional unit of a battery unit contains an assembly of electrodes, electrolyte, separators, and terminals in a container. It is a source of electrical energy by direct conversion of chemical energy.
Battery Cluster	Battery units are designed to be installed and connected in rows (often referred to as clusters).
Battery Module	A battery module is comprised of many cells and can be equipped with venting fans and communication connections for remote monitoring and switch off in response to abnormal cell behaviour that indicates a potential fault.
Battery Unit	The main functional unit of a battery energy storage system. The battery unit can hold multiple racks of battery modules and may include a Battery Management System (BMS) controller. The battery unit is housed in a rigid metal enclosure which provides protection from weather, animal and mechanical damage.
BESS	Battery Energy Storage System, describes all equipment, hardware and software that makes up a working system.
BESS Site	The Battery Clusters are installed and connected to transformers and other equipment to form a BESS Site.

1 EXECUTIVE SUMMARY

DNV has been requested by Frodsham Solar Limited to evaluate the Frodsham BESS battery storage site for smoke and toxic gas hazards. The site is located nearby to the town of Frodsham, close to the M56. DNV has extensive experience globally assessing the hazards posed by various BESS including accident investigation [Ref. /9/] 2D and 3D consequence modelling and full-scale testing at DNV's facilities in the UK, USA and Europe.

The evaluation is a consequence-based study using Computational Fluid Dynamics (CFD) to evaluate potential impact of a battery failure event and assess the impact of visibility and toxicity on the neighbouring area in the event of a fire. The analysis has evaluated the credible worst-case scenario in terms of consequence for a fire event, where safety systems and barriers to prevent escalation were assumed to have failed, and a reasonable worst-case (BESS unit) fire was modelled. Results are presented in terms of recognised hazardous exposure thresholds. The hazardous threshold is known as Immediately Dangerous to Life and Heath [IDLH, Ref. /6/].

Four scenarios were modelled that varied the wind speed and direction for the BESS fire. The main findings from the simulations were:

- There is no impact to the M56 roadway, Nursing Care Home and Traveller Site to the South-East of the Site or to the Hover Force Centre and Moorditch Lane to the South-West of the Site for any toxic gas or visibility impairment for any wind conditions modelled.
- The 5 m/s wind speed results in the longest impairment distances, as the higher wind speed of 10 m/s disperse the flame, shortening its length and diluting the smoke plume.
- The concentrations measured of toxic gases show that the hazards posed by a battery unit fire are confined to the immediate surrounds of the battery unit, HF remaining within 4 m and CO within 6 m. This is due to the relatively high concentrations of smoke required to reach the IDLH thresholds. Additionally, results are provided at 1 ppm for HF, which is representative of the most restrictive AEGL/ERPG threshold, no impairment is observed at any sensitive receptor.
- The Particulate Matter IDLH concentration of 0.71 ppm has a maximum distance of 22 m, which remains significantly below the distance to the nearest sensitive receptor, Moorditch Lane, located 86 m away.
- The maximum impairment distance for Moorditch Lane and the M56 roadway are discussed below:
  - Moorditch Lane (30 mph stopping distance) – 6 m impairment, where the sensitive receptor is located 86 m away.
  - M56 roadway (70 mph stopping distance) – 16 m impairment distance, where the sensitive receptor is located 410 m away.

To add confidence to the results of the study, conservative assumptions have been used due to the uncertainty in the analysis. For example, peak fire loads have been modelled whereas in reality, the peak fire would last for 1-2 hours and the rest of the fire, another 6-8 hours would be at a low intensity and subsequently more than a day of smouldering. The aim of the analysis was to demonstrate the consequences of the reasonable worst case Battery Unit fire. With this conservatism, no impairment was observed at the nearest residence (Traveller Site, 300 m from the nearest battery unit) or the nearest road (Moorditch Lane, 86 m from the nearest battery unit).

From the study, it can be concluded that there is no impact due to toxic gas or visibility impairment on any sensitive receptor in the proximity of the Frodsham BESS site due to a reasonable worst-case (BESS Unit) fire. The effects of the fire are restricted to the proximity of the BESS. First responders are expected to wear full Personal Protection Equipment (PPE) for incident response, this is especially critical within the immediate area of the BESS that is on fire due to toxic gases potentially exceeding IDLH values at these distances. The residential areas and road sensitive receptors are sufficiently far away from the BESS as to not be impaired by any of the simulated fires in terms of visibility or toxicity.

2 Introduction

DNV has been requested by Frodsham Solar Limited (referred to as Frodsham Solar hereinafter) to evaluate the Battery Energy Storage System (BESS) for the Frodsham site. The site is located nearby to the village of Frodsham, close to the M56. DNV has extensive experience globally assessing the hazards posed by various BESS including accident investigation [Ref. /9/], 2D and 3D consequence modelling and full-scale testing at DNV's facilities in the UK, USA and Europe.

The evaluation is a consequence-based study using Computational Fluid Dynamics (CFD) to evaluate potential impact for a battery failure event and assess the impact of smoke and toxicity on the neighbouring area in the event of a fire. The analysis will evaluate the reasonable worst-case scenario in terms of consequence for a fire event.

3 CFD Model

The 3D CFD modelled software Kameleon FireEx (KFX) will be used for the fire simulations [Ref. /1/]. KFX is capable of calculating heavy and light gas dispersion and hydrocarbon fires in connection with practical fire safety studies. It can handle liquid pool fires as well as gas jet and fires, in enclosures and in open air. It has been tested against experimental data ranging from small-scale laboratory flames to large-scale jet and pool fires. KFX can be used for most safety related analysis related to gas dispersion and fire.

3.1 Site and Location

The site is located nearby to the village of Frodsham, Cheshire. A Google Earth image with the site plan superimposed on top is shown in Figure 3-1 (including distances to sensitive receptors). The site is located nearby to the Hover Force Activity Centre, Moorditch Lane, M56 roadway, a Nursing Care Home, and a Traveller Site. Figure 3-2 shows a Google Earth image with nearby bird mitigation areas (highlighted in blue). The non-breeding bird mitigation area is located to the West-Northwest of the site and the Skylark migration area is located to the South of the site approximately 970 m and 100 m, respectively, from the nearest BESS Unit. The results for the bird mitigation areas are inferred from the sensitive receptors shown in Figure 3-1.

Figure 3-3 shows the BESS site in detail [Ref. /10/]. The two highlighted detailed BESS Units (Navy) will be used for simulations, due to their location being closest to the sensitive receptors. The geometry model of the site is configured according to this site layout. Terrain is not considered in the modelling, which is conservative as the effective distance between BESS and sensitive receptor is reduced.

It should be noted that two potential options exist for the location of the BESS on the Frodsham site. The option modelled in the analysis is nearer to the sensitive receptors and therefore is the more conservative option. The results presented in the study can be inferred for the alternative option for BESS location on the Frodsham site.

Figure 3-1: Frodsham BESS Site with Distances to Sensitive Receptors

Figure 3-2: Frodsham BESS Site and Bird Mitigation Areas

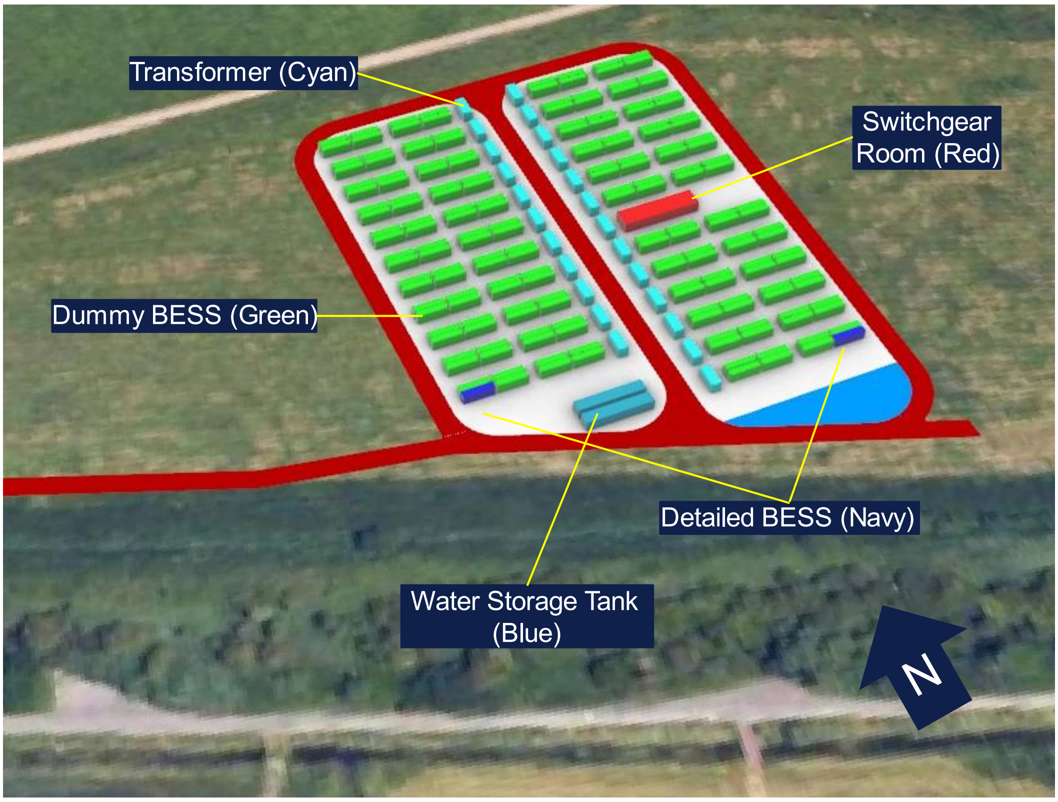

Figure 3-3: Frodsham BESS Site Details

3.2 BESS Geometry

The BESS geometry and site were built in the 3D modelling software Rhinoceros [Ref. /2/]. Figure 3-4 shows the 3D geometrical representation of the BESS Unit (detailed BESS geometry was not available for the Frodsham Site, therefore a representative BESS Unit was built based on the site specifications). The top figure shows the outside of the BESS Unit, the bottom figure shows the BESS Unit with front walls removed. The BESS Unit contains 7 Racks in a 1 x 7 arrangement and each rack measures 0.8 m x 1.3 m x 2.1 m. Each Battery Unit measures 7.8 m x 1.7 m x 2.7 m. Each Battery Unit has 7 deflagration panels, each located above a rack, measuring 0.7 m x 0.9 m. The deflagration panels are assumed to be fully opened (100% open), as the overpressure generated by the explosion preceding the fire would exceed the panels' opening pressure.

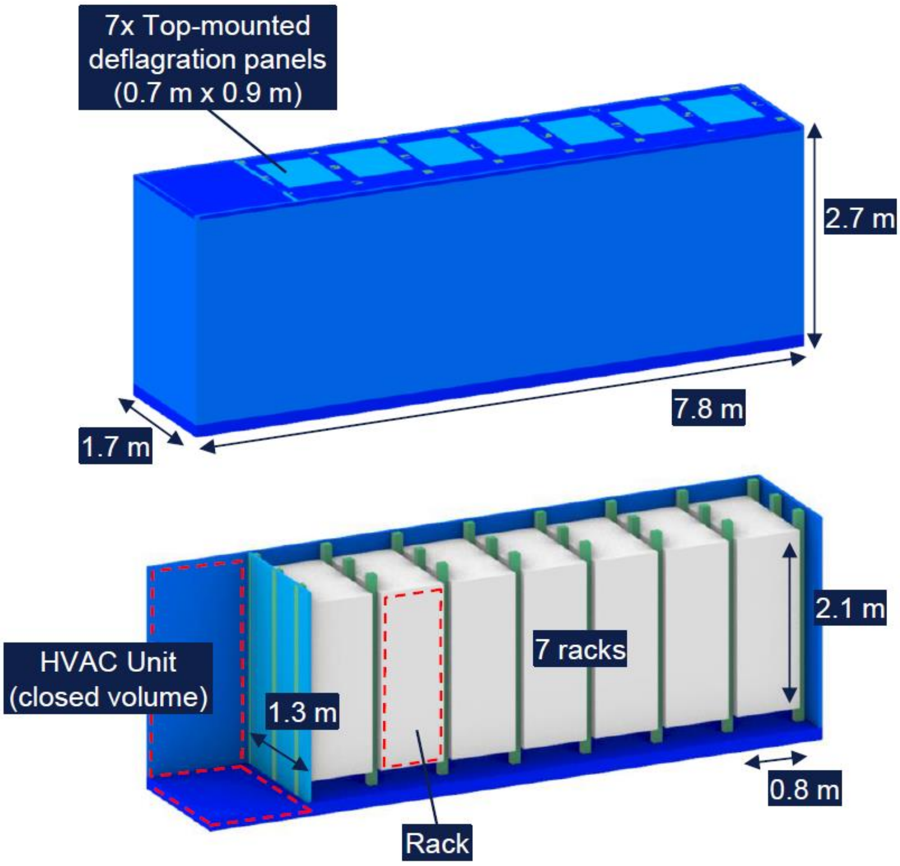

Figure 3-4: 3D Model of BESS Unit. Top – BESS Unit from outside. Bottom – Front walls removed

3.3 Input and Assumptions

A battery failure event is caused by a fault in a battery cell which can lead to thermal runaway in the cell. During thermal runaway, off-gas is produced and released from the cell. Off-gas is a flammable mixture of gases consisting mainly of hydrogen, some hydrocarbons, carbon dioxide and other gases (including hydrogen fluoride) at lower percentages. During the release, it is possible for a cascading failure of multiple cells in a module, or the entire BESS. The initial fuel source of the fire is the off-gas released by the cells. After some time, the other combustible items in the BESS are consumed in the fire, these are mainly plastic items.

The following safety systems and CFD input data have been acknowledged for the basis of the study assumptions. Test data was not available for the Frodsham Site. Instead, the assumptions are based on aggregated test data from BESS of similar size and capacity to the BESS proposed for the Frodsham Site.

Propagation between cells:

- No module level test report was available. Previous UL 9540A module level test reports have indicated it is possible to have cell to cell propagation within a module.
- **Assumption**: It is assumed that all cells within a module can fail.

Propagation between modules:

- No unit level test report was available. Previous UL 9540A unit level test reports have indicated module to module propagation is unlikely, however full scale fire tests have shown this was possible.
- **Assumption**: It is assumed that in the event of thermal runaway in the Battery Unit that module-to-module propagation will occur, and that all modules of the Battery Unit could be engaged in the fire.

Propagation between Battery Units:

- Full-scale fire tests show that Battery Unit to Battery Unit propagation is unlikely with appropriate spacing.
- **Assumption**: It is assumed that in the event of a fire in a battery unit it does not propagate to the neighbouring Battery Units, limiting the failure to the Battery Unit of origin.

Ventilation system:

- The Battery Unit would have a HVAC system for cooling the internal components. Additionally, it is expected that an explosion prevention system will be in place (i.e. a combination of exhaust fan and air intake louvre).
- **Assumption**: The HVAC will be shut down in the event of a fire. The explosion prevention system is assumed to be inactive, if properly designed, the system would reduce the likelihood of an explosion and subsequent fire.

Gas composition and properties:

- Gas composition was derived from previous UL 9540A test data.
- **Assumption**: The combustion of plastic items in the Battery Unit has also been considered with additional propane added to the offgas composition. Propane has similar yields of CO and CO2 to polypropylene plastic which is typical for battery casings [Ref. /3/]. The gas composition accounting for the plastics can be seen in Table 3-1.

Table 3-1: Gas Composition Data

Gas		Composition (%)
Hydrogen	H_2	42
Carbon Dioxide	CO_2	24
Carbon Monoxide	CO	8
Propane	C_3H_8	15
Ethane	C_2H_6	5
Methane	CH_4	6

Offgas release rate (mass/time):

- Offgas release rate was averaged from previous test data where cells are assumed to fail in a module and then propagate to adjacent cells and adjacent modules.
- **Assumption**: The peak release rate is 0.285 kg/s (285 g/s) for a BESS Unit and is aggregated from data for previous BESS of similar size and capacity to the BESS proposed for the Frodsham site. The duration of the higher intensity fire is predicted to be approximately 1-2 hours, the peak release rate modelled would be sustained for a shorter duration.

Toxic gas content in battery unit fire:

- Toxic gases are produced in a battery fire, the most dangerous of which is Hydrogen Fluoride (HF). Depending on the battery chemistry, other toxic gases are produced such as Nitrogen Dioxide (NO_2), Hydrogen Chloride (HCL) and Benzene, however, these are found at very low concentrations and hydrogen fluoride is the most abundant with the lowest threshold, meaning it is the most restrictive.
- **Assumption**: Based on DNV's experience and testing [Ref. /4/], around 0.1% of the combustion product is hydrogen fluoride. This equates to around 1000 ppm at source. It is therefore assumed that there is 0.1% of hydrogen fluoride in the combustion product.

Production of particulate matter in a battery unit fire:

- Particulate matter (PM_{10} and $PM_{2.5}$) is produced from fires. There is limited information available about the yield of PM from fires and less for battery fires. From DNV's experience, experimental estimates note yields of around 0.25 g/m^3 (equivalent to 250 ppm) of PM is produced from diesel fires and 0.15 g/m^3 (150 ppm) from a wood fire.
- **Assumption:** It is assumed that a Battery Unit fire is equivalent to a diesel fire for production of PM.

3.4 Simulations

The inputs and assumptions made in the previous section are conservative and define a reasonable worst-case fire. This fire was modelled with varying wind speeds and directions to obtain the maximum impact due to the smoke plume at the different sensitive receptors of interest.

A total of four scenarios have been identified to model the BESS Unit fires as shown in Table 3-2. Two scenarios target the M56 Roadway, Nursing Care Home, and Traveller Site to the South-East of the BESS site, and the other two scenarios target the Hover Force Centre and Moorditch Lane to the South-West. A wind speed of 5 m/s (18 km/h) was used as this is the annual average for the closest weather station (the meteorological data considered is 1 km from the Frodsham Site) [Ref. /5/], and 10 m/s (36 km/h) was used as a conservatively higher wind speed. This wind speed represents the 90th percentile wind condition, during the 3-month period of the year with the highest wind speeds. Lower and higher wind speeds are chosen to cover the range of conditions, where lower wind speeds may not sufficiently dilute the plumes, but higher wind speeds may have more potential to elongate and bend the plumes.

The M56 Roadway, Nursing Care Home, and Traveller Site are 410 m, 524 m and 300 m South-East from the nearest BESS Unit, respectively. Wind blowing from the North-West (NW) represents the worst-case scenario for these sensitive receptors as the smoke plume will be blown towards them. Wind from the NW accounts for ~15% of the average annual wind probability. The Hover Force Centre and Moorditch Lane are 865 m and 86 m South-West from the nearest BESS Unit, respectively. Wind blowing from the North-East (NE) represents the worst-case scenario for these sensitive receptors and accounts for ~6 % of the average annual wind probability. The predominant wind direction at the Frodsham site is from the Westerly direction and accounts for ~18% of the average annual wind probability.

Table 3-2: Simulation Matrix

Simulation ID	Fire Size	Sensitive Receptors	Wind Direction (from)	Wind Speed (m/s)
101	Battery Unit	M56 Roadway / Nursing Care Home / Traveller Site	NW	5
102			NW	10
103		Hover Force Centre / Moorditch Lane	NE	5
104			NE	10

3.5 Impairment Thresholds

The following thresholds are defined for impairment to people and are based on industry best practise [Ref. /6/, /7/, and /8/]. The simulation results will be compared to the below criteria to determine the severity of the consequences on the identified sensitive receptors.

3.5.1 Safe Exposure Limits

Exposure to hazardous substances can lead to adverse health effects. This is dependent on the concentration of the gas and the exposure time. One measure for exposure limits to toxic gases is the Immediately Dangerous to Life or Health (IDLH) values [Ref. /6/]. This was developed to enable the safe escape of workers if their breathing apparatus failed in a contaminated environment in 30 minutes, to provide maximum worker safety.

In this study, the IDLH values are used to indicate that there is an immediate danger to health without a breathing apparatus. The following hazardous substances and their IDLH limits are provided below.

Hydrogen Fluoride (HF):

- IDLH level is 30 ppm.

Carbon monoxide (CO):

- IDLH level is 1,200 ppm.

Particulate Matter (PM):

- Breathe London [Ref. /7/] have guidelines on long term exposure limits for PM, with 71 µg/m^3 (0.071 ppm) considered to be very high and able to cause short term respiratory issues. Based on Breathe London guidelines it is assumed that 10x long term exposure limit is immediately dangerous to health, 0.71 ppm.

Additionally, Acute Exposure Guideline Levels (AEGL) and Emergency Response Planning Guideline (ERPG) thresholds are discussed to establish potential emission impacts [Ref. /11/]. The most restrictive threshold for AEGL and ERPG are 1 ppm and 2 ppm, respectively. These thresholds relate to discomfort / irritation and are non-disabling, in the study, plots are provided at 1 ppm for HF to represent the distance at which these impairment thresholds would be observed.

3.5.2 Visibility Impairment

Reduced visibility due to smoke produced in a fire can prevent the safe escape of personnel. A visibility of 10 m is typically considered acceptable for personnel to escape from a fire.

Reduced visibility is also a hazard for vehicles driving on nearby roads that would have reduced visibility if the smoke plume obstructed the road. This is potentially dangerous as they would have a reduced effective stopping distance. The public road closest to the BESS site, Moorditch Lane, is a 30 mph road and the M56 is a 70 mph roadway. The stopping distances at 30 mph and 70 mph are 23 m and 96 m, respectively [Ref. /8/]. Any reduction on these visibilities would be considered as impaired. As such, 23 m and 96 m have been set as impairment of the roads for this study.

4 RESULTS

The results evaluate potential impact of Battery Unit failure events and assess the impact of toxicity and smoke on the neighbouring sensitive receptors in the event of a fire.

Contour plots for all simulations are presented in Appendix A for visibility impairment and toxicity. The following observations are made from the results:

- There is no impact to the M56 roadway, Nursing Care Home and Traveller Site to the South-East of the Site or to the Hover Force Centre and Moorditch Lane to the South-West of the Site for any toxic gas or visibility impairment for any wind conditions modelled.
- Based on the findings for the sensitive receptors identified above, we can conclude that no impairment is anticipated at any residential area further afield such as Frodsham or Helsby.
- By inference, the nearby bird mitigation areas would not be impacted by a battery fire. The Skylark area is located the other side of Moorditch Lane from the BESS site, which itself was not impaired by the directed plume. Additionally, the non-breeding area is a located a significant distance from the nearest BESS unit. Results can also be inferred for the second BESS location option at the Frodsham site. The distances to sensitive receptors are further away and therefore no impairment is expected.
- The wind speed of 5 m/s produces the largest distance to impairment compared to the higher wind speed of 10 m/s. This is due to the flame being dispersed by the higher wind speeds, which reduces the flame length and dilutes the smoke plume. The lower wind speed by contrast is less turbulent, disrupting the flame less and the smoke plume travels for a greater distance.
- The concentrations measured of toxic gases show that the hazards posed by a battery unit fire are confined to the immediate surrounds of the battery unit, HF remaining within 4 m and CO within 6 m. This is due to the relatively high concentrations of smoke required to reach the IDLH thresholds. Additionally, results are provided at 1 ppm for HF, which is representative of the most restrictive AEGL/ERPG threshold, no impairment is observed at any sensitive receptor.
- The Particulate Matter IDLH concentration of 0.71 ppm has a maximum distance of 22 m, which remains significantly below the distance to the nearest sensitive receptor, Moorditch Lane, located 86 m away.
- The maximum impairment distance for Moorditch Lane and the M56 roadway are discussed below:
    - Moorditch Lane (30 mph stopping distance) – 6 m impairment, where the sensitive receptor is located 86 m away.
    - M56 roadway (70 mph stopping distance) – 16 m impairment distance, where the sensitive receptor is located 410 m away.
- For the sensitive receptors identified in the study to be impacted by a battery fire, a significant number of Battery Units would need to simultaneously fail. However, the full-scale fire test showed that battery unit to battery unit escalation is unlikely when the separation distance is in line with industry best practices (NFPA 855).

To add confidence to the results of the study, conservative assumptions have been used due to the uncertainty in the analysis. For example, peak fire loads have been modelled whereas in reality, the peak fire would last for 1-2 hours and the rest of the fire, another 6-8 hours would be at a low intensity and subsequently more than a day of smouldering. The aim of the analysis was to demonstrate the consequences of the reasonable worst case Battery Unit fire. With this conservatism, no impairment was observed at the nearest residence (Traveller Site, 300 m from the nearest battery unit) or the nearest road (Moorditch Lane, 86 m from the nearest battery unit).

5 CONCLUSIONS

From the study, it can be concluded that there is no impact due to toxic gas or visibility impairment on any sensitive receptor in the proximity of the Frodsham BESS site due to a reasonable worst-case (BESS Unit) fire. The effects of the fire are restricted to the proximity of the BESS. First responders are expected to wear full Personal Protection Equipment (PPE) for incident response, this is especially critical within the immediate area of the BESS that is on fire due to toxic gases potentially exceeding IDLH values at these distances. The residential areas and road sensitive receptors are sufficiently far away from the BESS as to not be impaired by any of the simulated fires in terms of visibility or toxicity.

6 REFERENCES

/1/ [redacted]

[redacted]

/3/ SFPE Handbook of Fire Protection Engineering – 3rd edition – 2002

/4/ Considerations for ESS Fire Safety, Jan 2017

/5/ [redacted]

[redacted]

/7/ Air quality guidelines and health effects, Breathe London, https://www.breathelondon.org/air-quality-guidelines, April 2024

/8/ https://assets.publishing.service.gov.uk/media/559afb11ed915d1595000017/the-highway-code-typical-stopping-distances.pdf

/9/ McMicken Battery Energy Storage System Event Technical Analysis and Recommendations, July 2022

/10/ PAP-2022-01-C-Frodsham-BESS Layout-BESS-C, September 2024

/11/ [redacted]

APPENDIX A

Fire Result Plots Figure A 1 to Figure A 16 show the contour plots for hydrogen fluoride, carbon monoxide, particulate matter, and visibility concentration for all simulations with sensitive receptors and wind directions labelled.

Figure A 1: Case 101 – Hydrogen Fluoride Plot with Wind from NW at 5 m/s

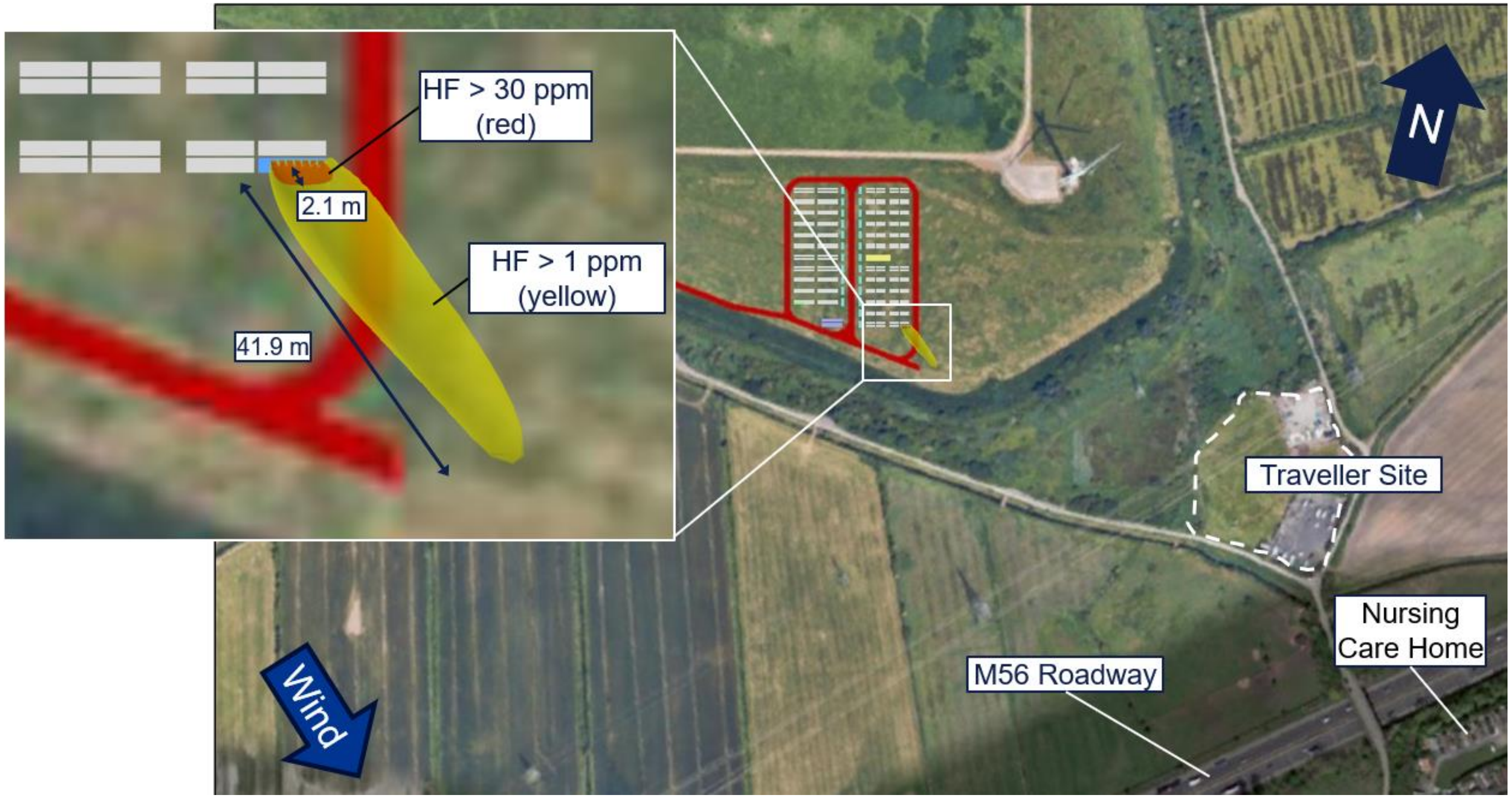

Figure A 2: Case 102 – Hydrogen Fluoride Plot with Wind from NW at 10 m/s

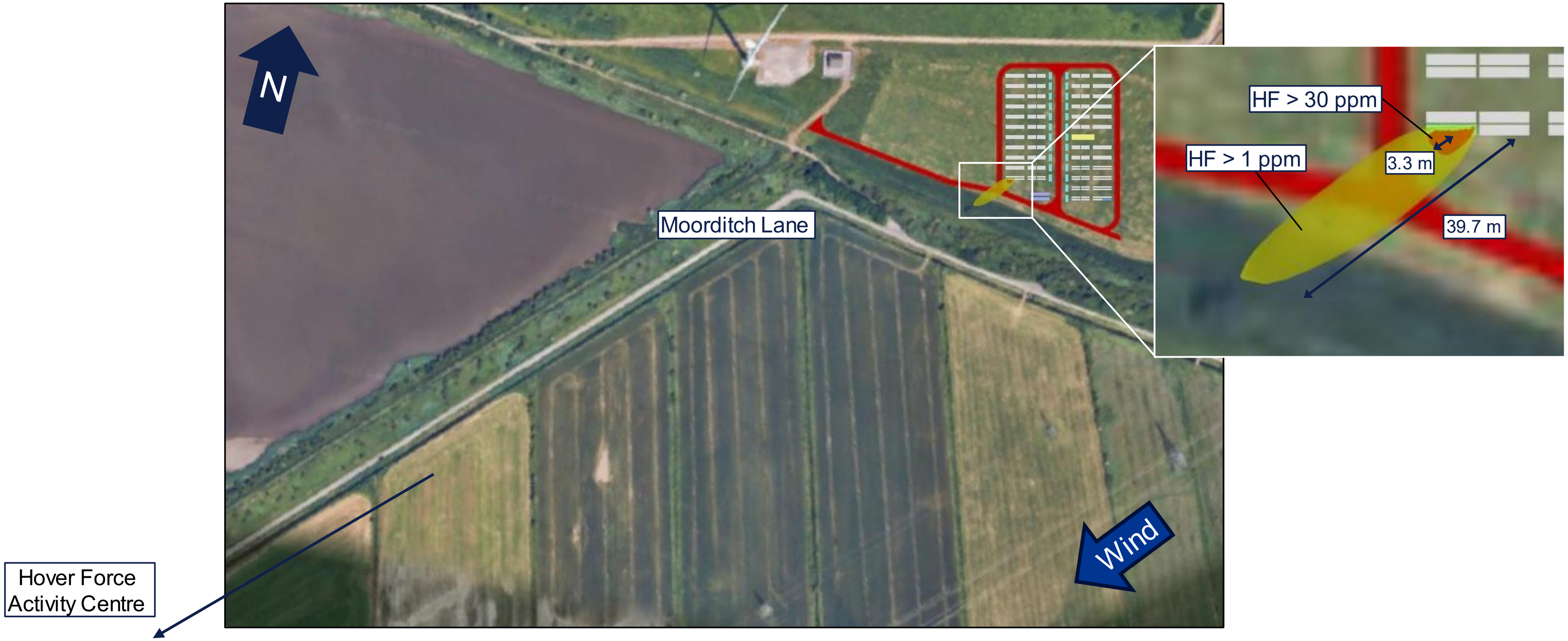

Figure A 3: Case 103 – Hydrogen Fluoride Plot with Wind from NE at 5 m/s

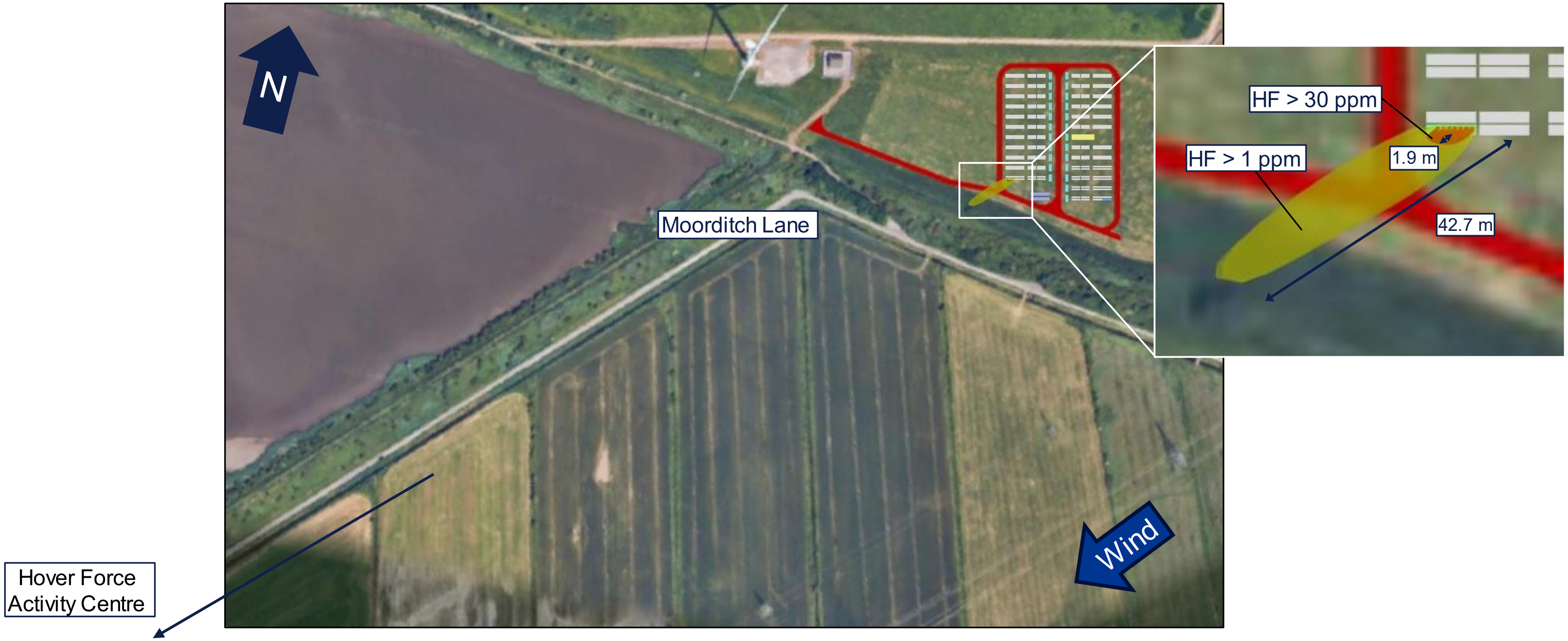

Figure A 4: Case 104 – Hydrogen Fluoride Plot with Wind from NE at 10 m/s

Figure A 5: Case 101 – Carbon Monoxide Plot with Wind from NW at 5 m/s

Figure A 6: Case 102 – Carbon Monoxide Plot with Wind from NW at 10 m/s

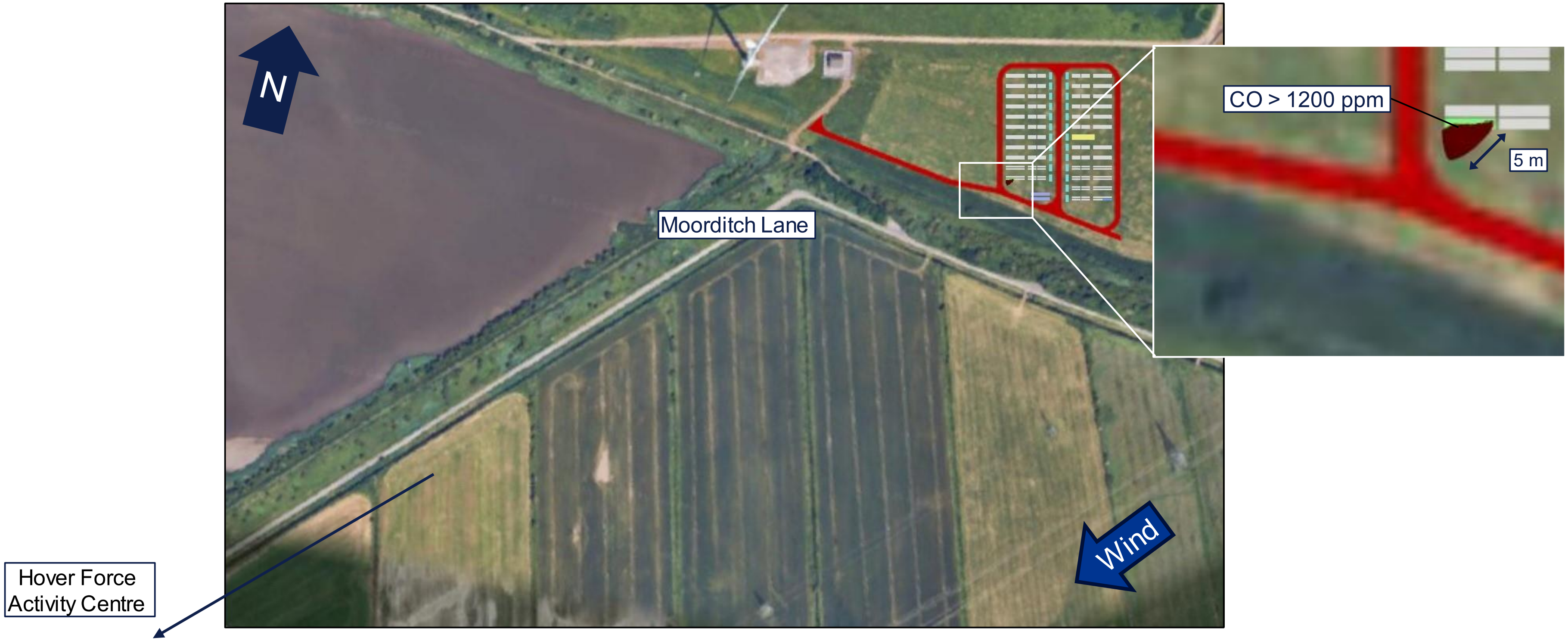

Figure A 7: Case 103 – Carbon Monoxide Plot with Wind from NE at 5 m/s

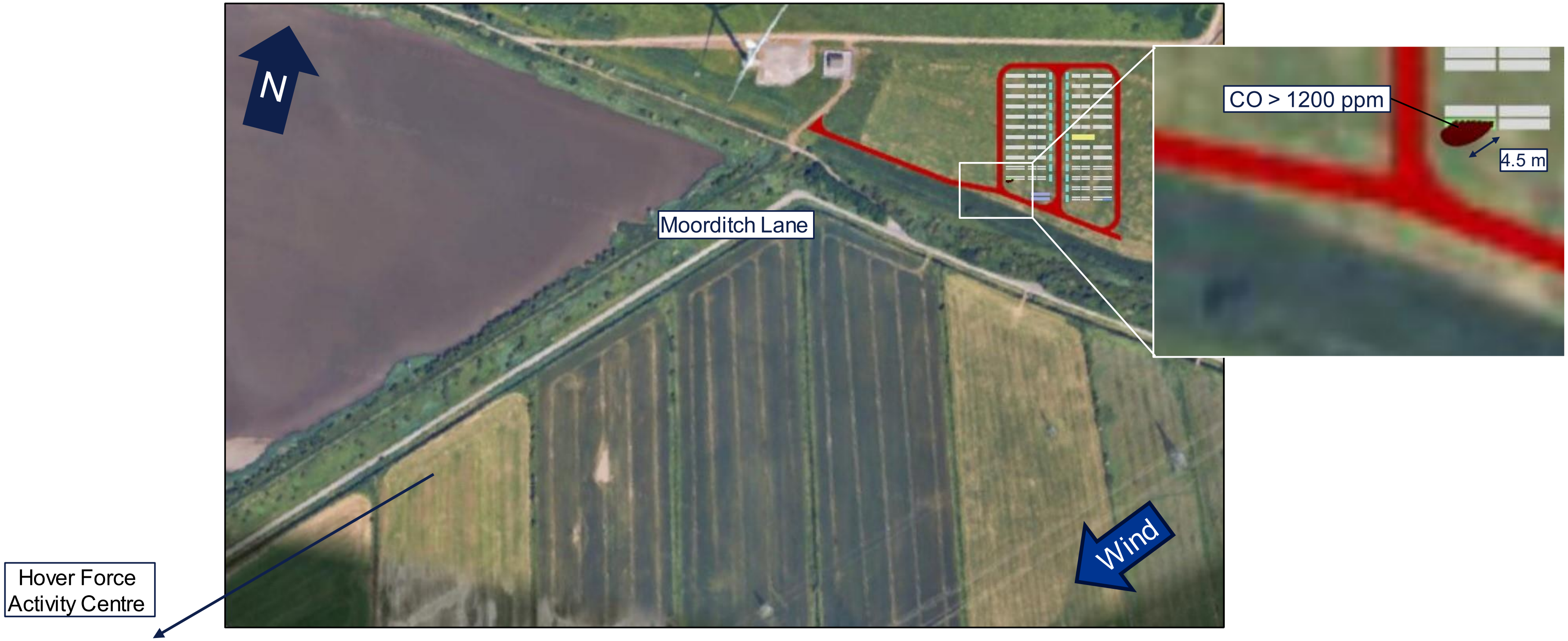

Figure A 8: Case 104 – Carbon Monoxide Plot with Wind from NE at 10 m/s

Figure A 9: Case 101 – Particulate Matter Plot with Wind from NW at 5 m/s

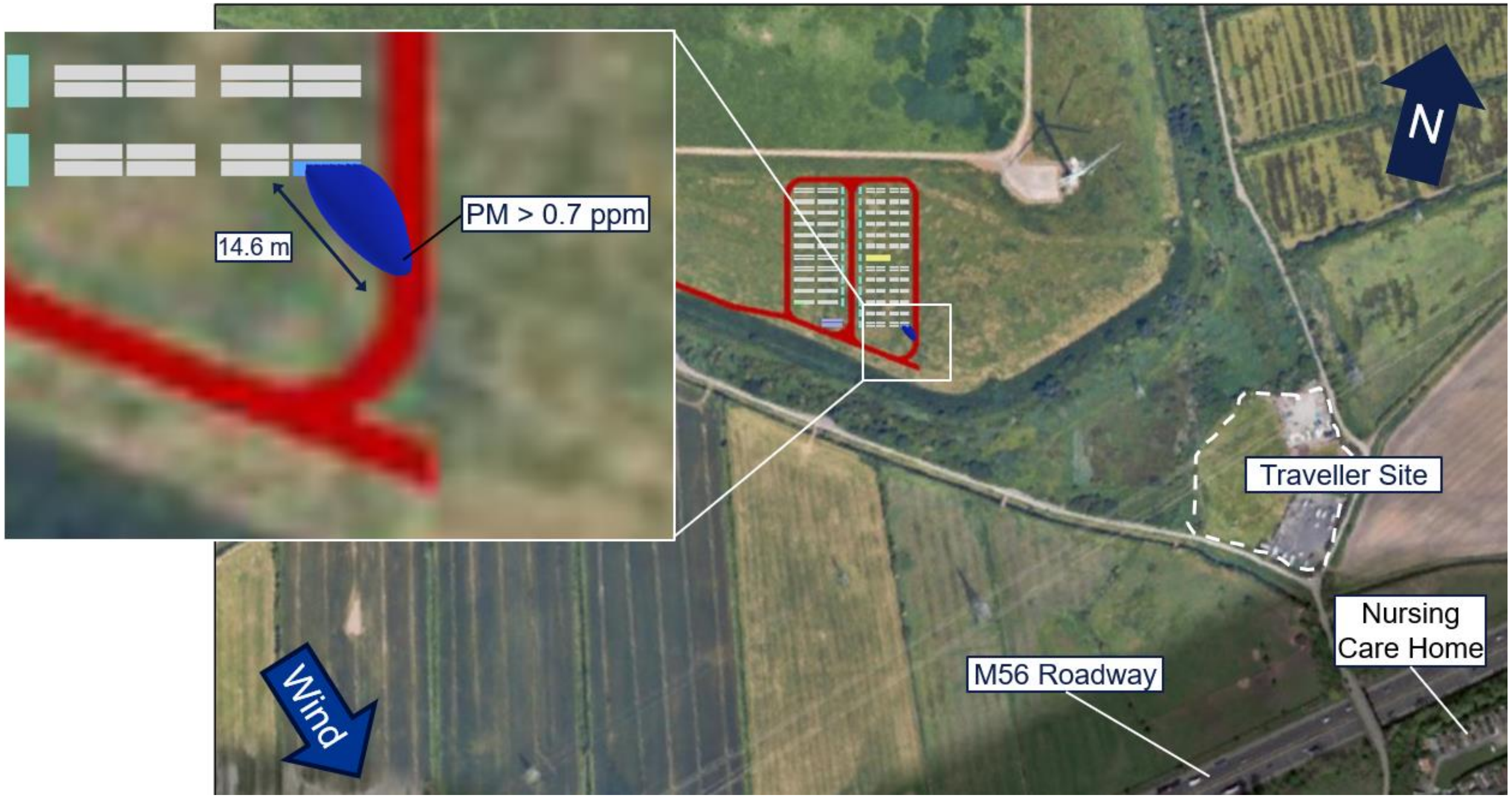

Figure A 10: Case 102 – Particulate Matter Plot with Wind from NW at 10 m/s

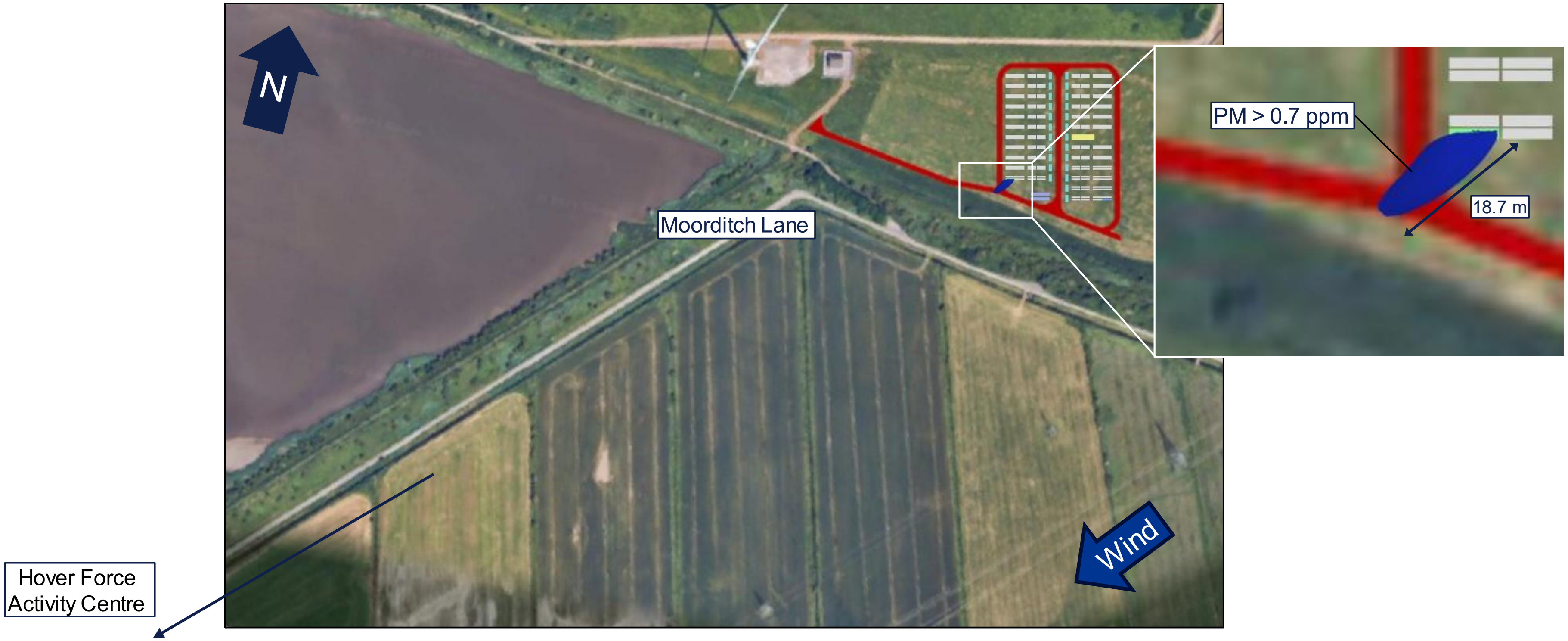

Figure A 11: Case 103 – Particulate Matter Plot with Wind from NE at 5 m/s

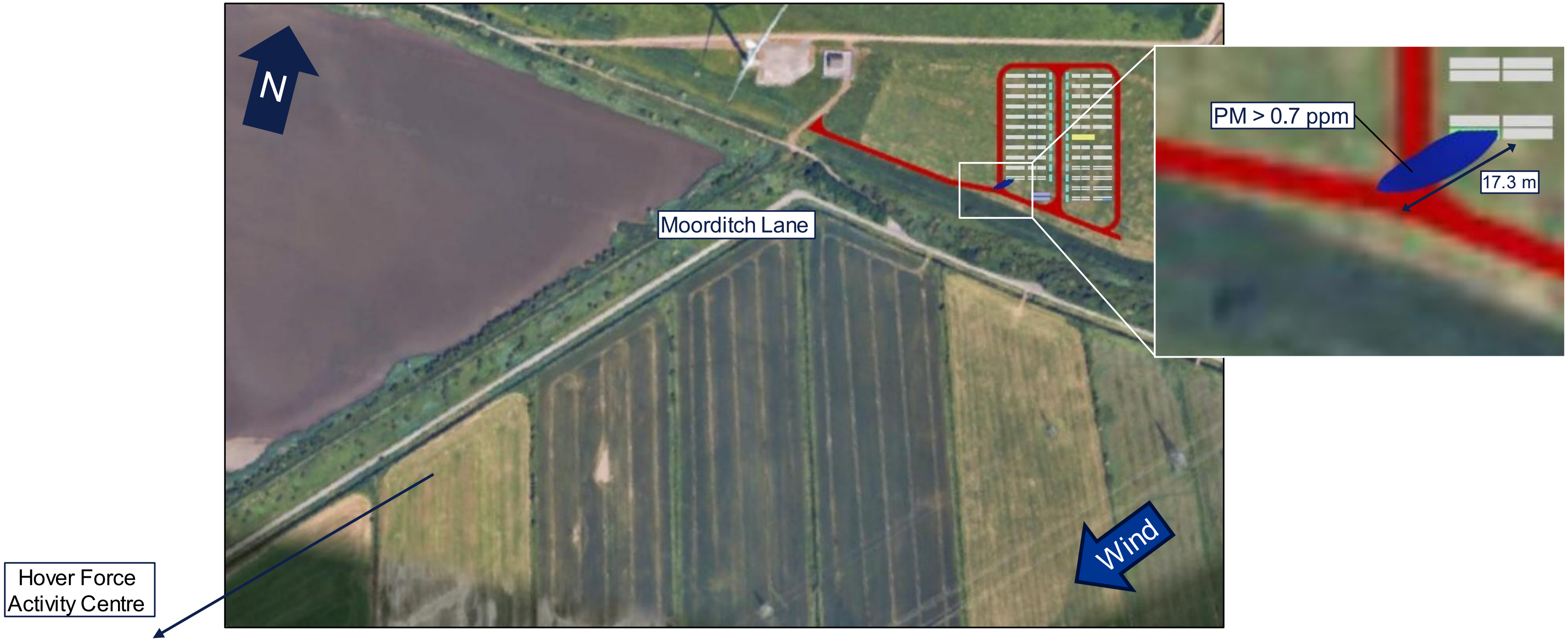

Figure A 12: Case 104 – Particulate Matter Plot with Wind from NE at 10 m/s

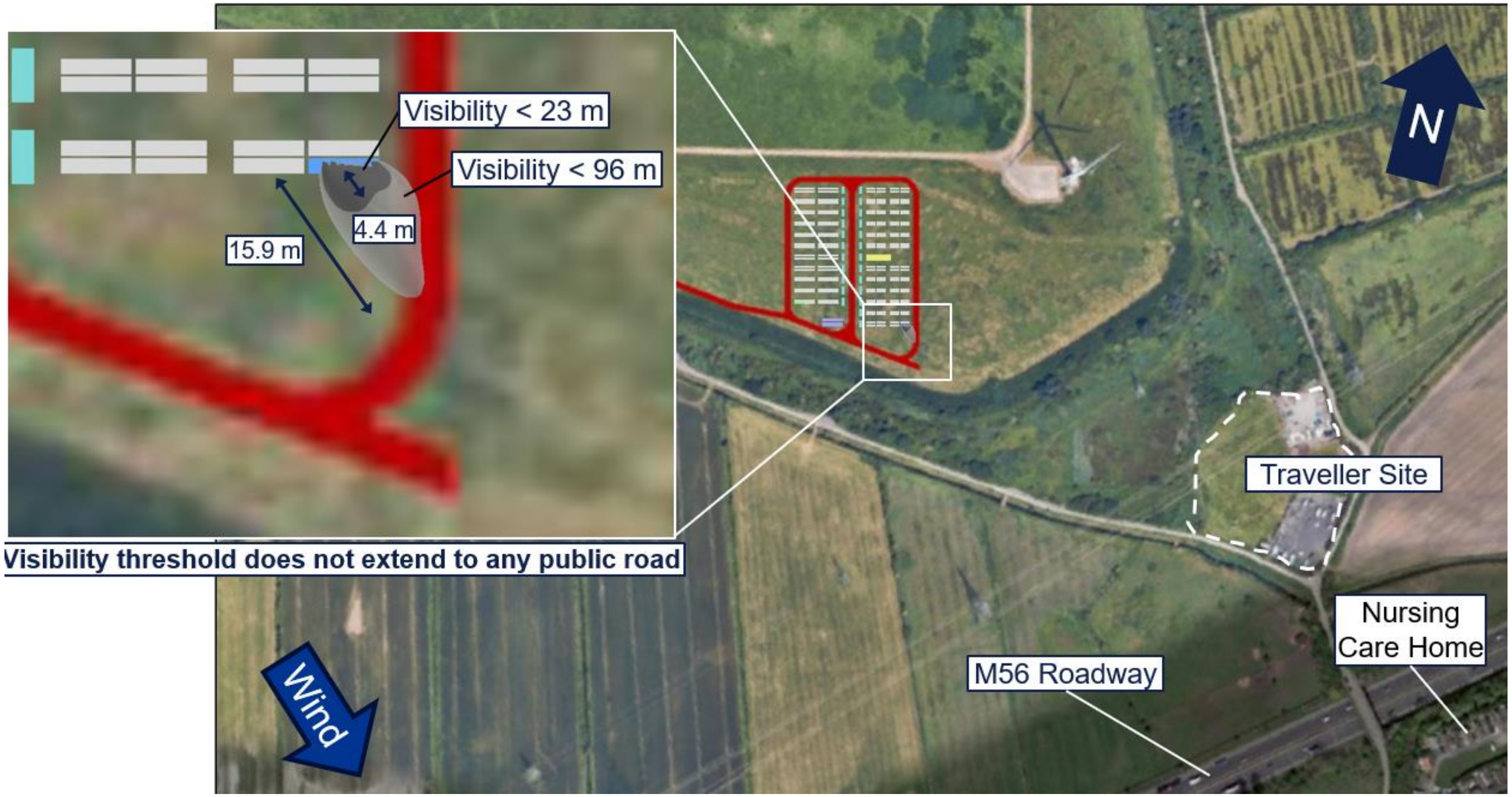

Figure A 13: Case 101 – Visibility Plot with Wind from NW at 5 m/s

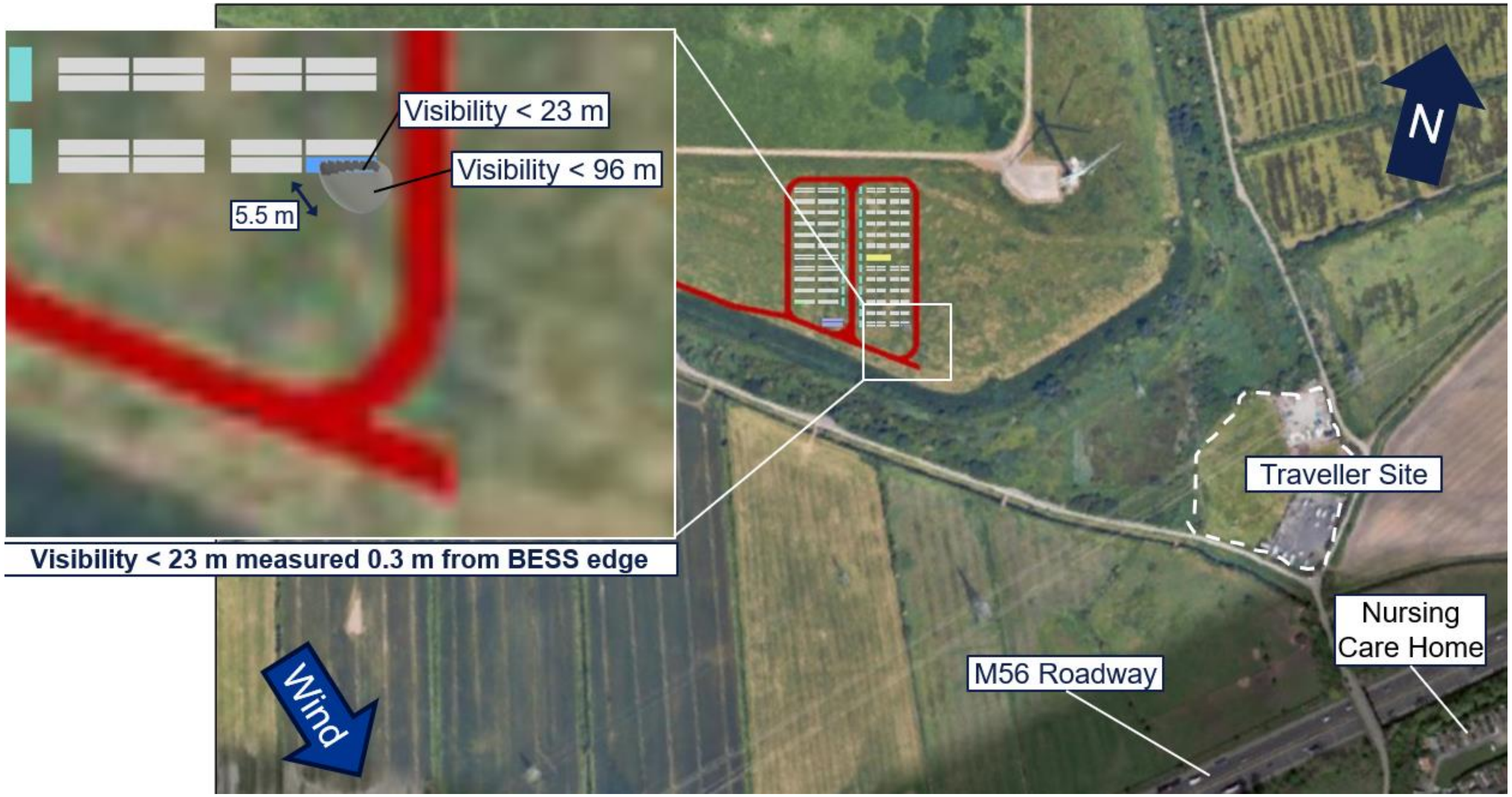

Figure A 14: Case 102 – Visibility Plot with Wind from NW at 10 m/s

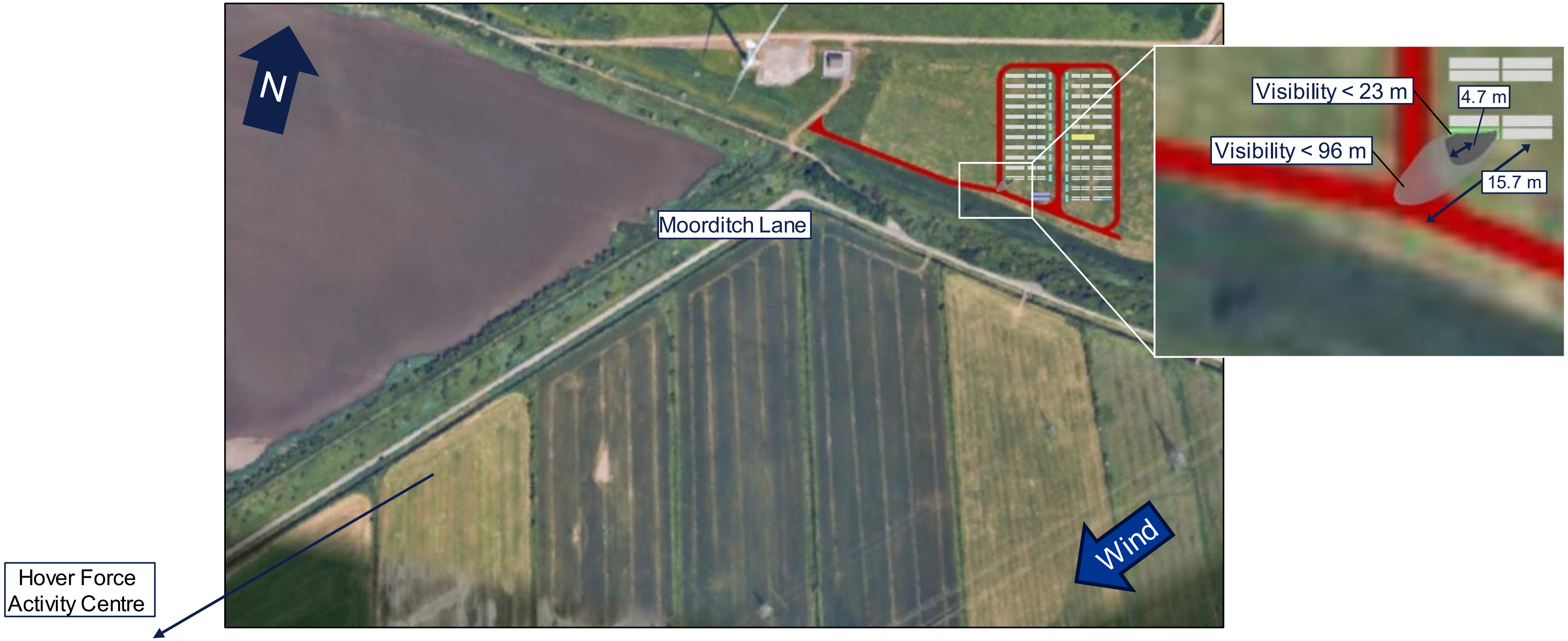

Figure A 15: Case 103 – Visibility Plot with Wind from NE at 5 m/s

Figure A 16: Case 104 – Visibility Plot with Wind from NE at 10 m/s

About DNV

DNV is the independent expert in risk management and assurance, operating in more than 100 countries. Through its broad experience and deep expertise DNV advances safety and sustainable performance, sets industry benchmarks, and inspires and invents solutions.

Whether assessing a new ship design, optimizing the performance of a wind farm, analyzing sensor data from a gas pipeline or certifying a food company's supply chain, DNV enables its customers and their stakeholders to make critical decisions with confidence.

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