BESS Fire risk and safety

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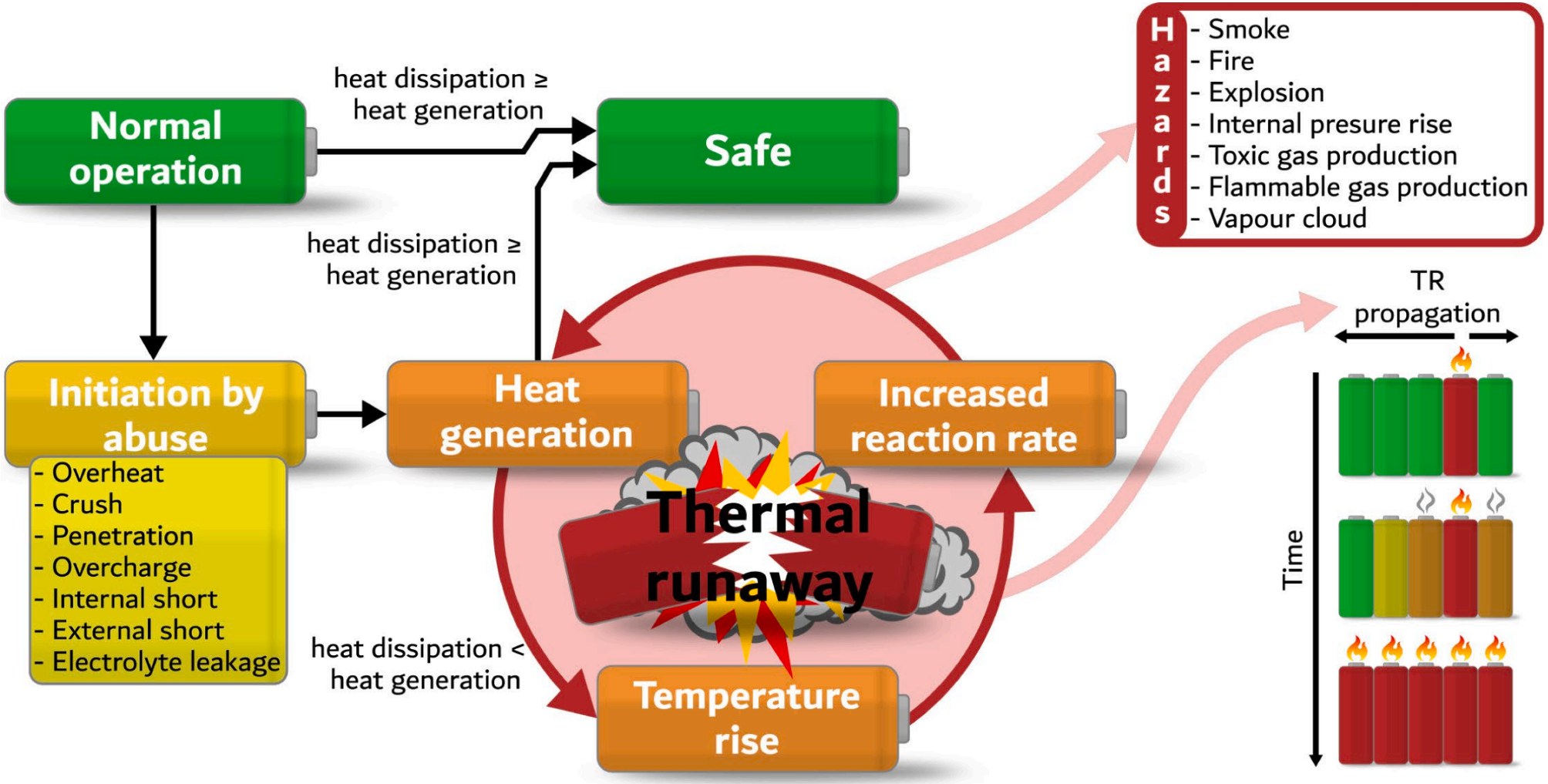
Overview

- Lithium Battery fires – technical
- Incident rates
- Safety
- UK Government Guidelines
- Smoke plumes
- Safety concerns of the proposed 500MW site in Blackford

LITHIUM BATTERY FIRES – TECHNICAL

Thermal runaway



Technical work

- A technical paper cited by the British Government "**Key Challenges for Grid-Scale Lithium-Ion Battery Energy Storage".** Yimeng Huang, Ju Li (2022)
- "While the chance of an individual battery cell failure under normal use is on the order of 10^{-7} (very low) in its life, due to the cascading nature of fire accidents, the probability of an BESS facility catching fire with millions of cells, leading to severe accidents, is apparently not low with the present generations of BESS" Yimeng Huang, Ju Li (2022)
- "Although cell-level materials development has seen significant progress, thermal runaway risks within the cell cannot be fully eliminated" Yimeng Huang, Ju Li (2022)
- "A defence-in-depth design and rapid response strategy are needed to minimize life loss and collateral damage"

This current thinking strongly suggests that it may be impossible to eliminate fires and that planning for major fire, however unlikely, is as important as preventing the fire in the first place.

Substance	Hazard
Carbon dioxide, CO_2	Cause headaches, dizziness, confusion, loss of consciousness, and asphyxiation at high concentrations [52].
Carbon monoxide, CO	Toxic if inhaled, may damage the unborn child, causes damage to organs through prolonged or repeated exposure and is an extremely flammable gas.
Hydrogen, H_2	Extremely flammable.
Hydrocarbons	Flammable.
Hydrogen fluoride, HF	Fatal if swallowed, is fatal in contact with skin, is fatal if inhaled and causes severe skin burns and eye damage.
Hydrogen chloride, HCl	Severe skin burns and eye damage, is toxic if inhaled, may damage fertility or the unborn child, causes serious eye damage, may cause damage to organs through prolonged or repeated exposure, may be corrosive to metals, may cause respiratory irritation and contains gas under pressure and may explode if heated.
Hydrogen cyanide, HCN	Fatal if swallowed, is fatal in contact with skin, is fatal if inhaled, causes damage to organs through prolonged or repeated exposure, is very toxic to aquatic life (with long lasting effects) and is an extremely flammable liquid and vapour.
Nitrogen dioxide, NO_2	Fatal if inhaled, causes severe skin burns and eye damage; and may cause or intensify fire (oxidiser).
Sulphur dioxide, SO_2	Severe skin burns and eye damage and is toxic if inhaled.
Solvents	Highly flammable liquid and vapour [53]. Very irritating to eyes, skin and airways [44].

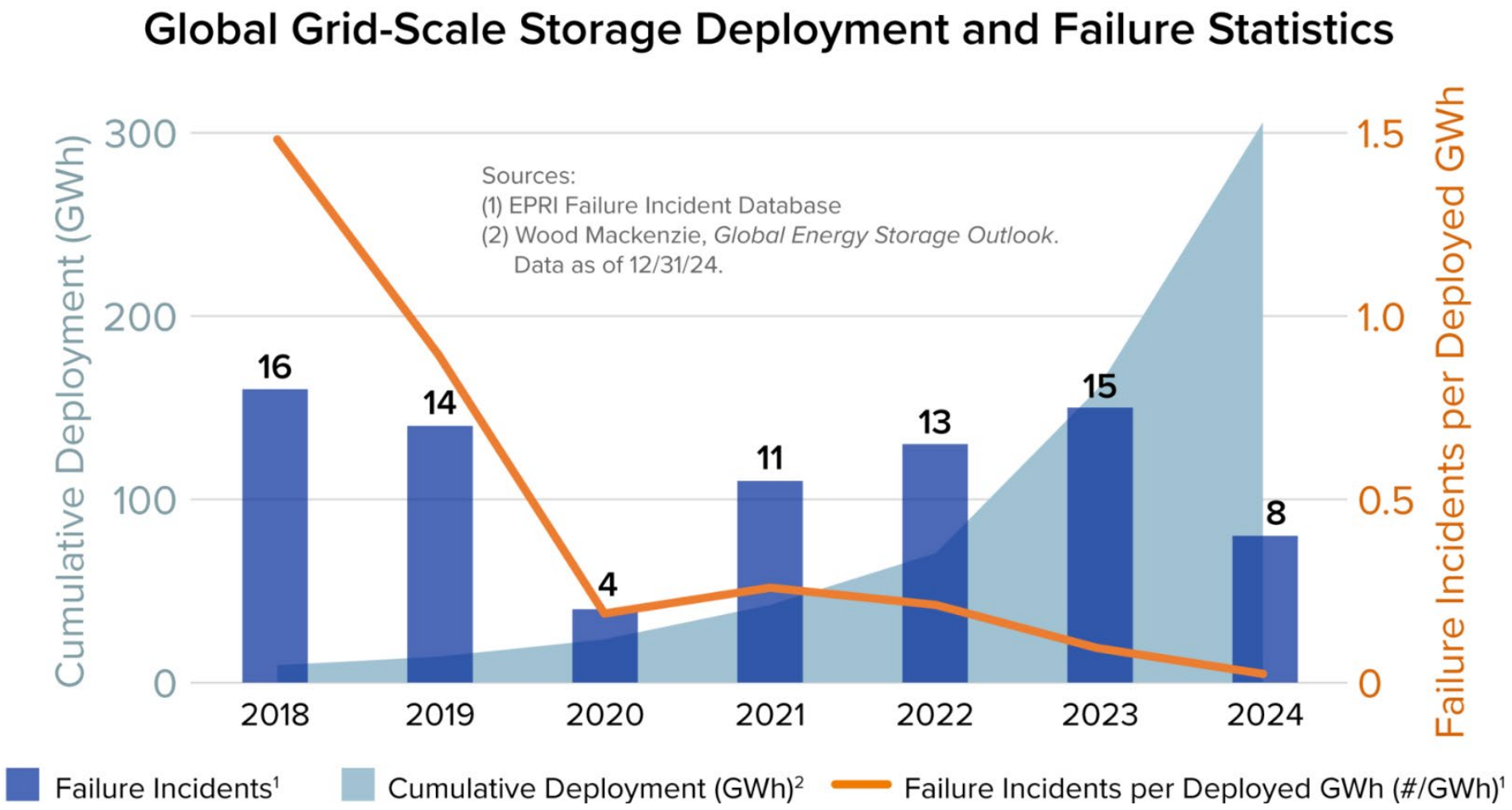
Journal of Energy Storage
Volume 87, 15 May 2024, 111288
Review article
Review of gas emissions from lithium-ion battery thermal runaway failure — *Considering toxic and flammable compounds*

One take away from this paper: the understanding of the volumes of gas and the safety of current storage systems is still evolving.

The is article is only 8 months old.

INCIDENT RATES

Incident rates through time

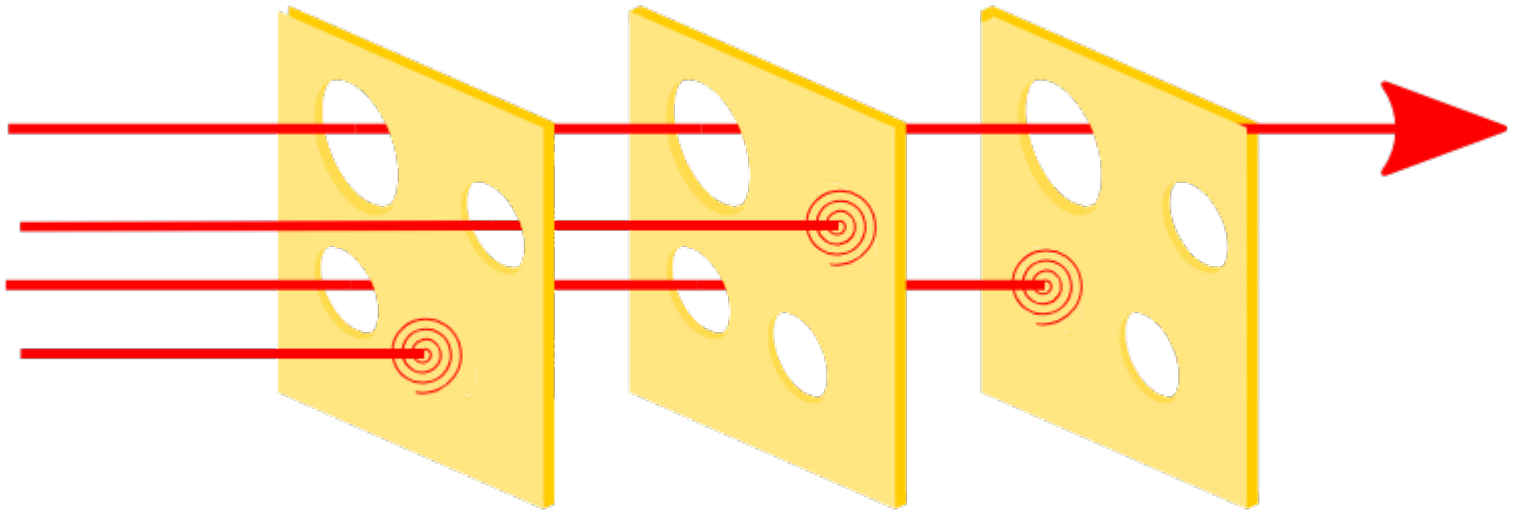


SAFETY

Safety – Swiss cheese model

- Each element can prevent a major incident.
- Industry is littered with major accidents that were reliant on just prevention.
- This why we still need lifeboats.

Prevention | Containment | ~~Mitigation~~



Optimal product design.....

Better design has resulted in much fewer incidents

In the event of failure, a small fire does not become a large fire.

Better containment prevented fire escalating

A plan for the worst-case scenario.

Good safety means planning for unexpected.

Rember despite the recent jumps in reliability – *none of these battery units or the containment technology have been around for very long* (***they have not stood the test of time***)

History tells us...

- The Titanic did not have enough lifeboats to accommodate all passengers and crew.
- Only 20 lifeboats, which could hold about 1,178 people, while there were over 2,200 people on board. This meant more than 1,000 people had no access to a lifeboat when the ship sank.
- Why So Few Lifeboats?
- 1. Outdated Maritime Regulations – The Titanic followed the British Board of Trade regulations, which only required ships over 10,000 tons to carry 16 lifeboats (plus a few collapsible ones). These rules hadn't been updated despite ships growing much larger. – poor regulation
- 2. Overconfidence in the Ship's Design – Titanic was considered "practically unsinkable," so lifeboats were seen as a formality rather than a necessity.
- 3. Aesthetic and Space Considerations – More lifeboats would have cluttered the deck and were deemed unnecessary.
- Consequences

• Lifeboats were launched half-full in many cases due to panic and poor evacuation procedures (poor planning).

• Over 1,500 people perished, with many dying in the freezing Atlantic Ocean.

• The disaster led to major changes in maritime laws, requiring ships to have enough lifeboat capacity for all passengers and crew.

GUIDELINES

Fire and Rescue Services Act 2004

- Whilst FRSs (Fire & Rescue Service) are not a statutory consultee for planning, they do have a statutory responsibility under the Fire and Rescue Services Act 2004 for obtaining information to assist with the extinguishing of fires and the protection of life and property in their area.

Battery energy storage systems house of commons report 2024

- Planning authorities and Scottish ministers will decide planning applications in line with the area's local development plan and the Scottish Government's National Planning Framework 4 (NPF4).
- The NPF4 provides that planning authorities should support proposals for "all forms" of renewable and low-carbon technologies, including BESSs.
- The NPF4 also states that planning authorities should place "significant weight" on the contribution of a development to renewable energy and greenhouse gas emissions targets.
- Must take in account certain other impacts (including on the *surrounding landscape, the environment, and nearby communities*).

The Fire Safety (Scotland) Regulations 2006

- Nothing specific in Scottish regulations regarding BESS sites

Relevant UK documents – BESS Fires

NFCC (National Fire Chiefs Council) document "Grid Scale Battery Energy Storage System planning – Guidance for FR (2022)

Two principal considerations described in the above document are particularly relevant to the approval of the 500MW site in Blackford:

1. *That the "surrounding communities, buildings and infrastructure" need to be considered (point 2 in the above document)*

2. *Evidence that site geography has been taken into account (e.g. prevailing wind conditions).*

3. *That the "Owner (of the battery site) to have a comprehensive Emergency Response Plan, showing full understanding of hazards, risks, and consequences" (point 12 in the above document).*

NFCC Grid Scale Energy Storage System Planning – Guidance for Fire and Rescue Services. *July 2024 Revision*.

- *Section 15 – Site Location:* - The document goes into more detail with regards the areas surrounding the site

"The choice of BESS site and the associated safety measures should account for the impact that an incident on the site could have on the local environment. A plan should be prepared to assist in discussions with developers and planners regarding the suitability of a site location highlighting all ***sensitive receptors[1]*** *within a 1km radius of the site to allow for appropriate emergency planning".*

[1]Sensitive receptors*: include residential areas, bore holes, wells and springs supplying water for human consumption.*

NFCC Grid Scale Energy Storage System Planning – Guidance for Fire and Rescue Services. ***July 2024 Revision***

- As a minimum, it is recommended that hydrant supplies for boundary cooling purposes should be located close to BESS containers (but considering safe access in the event of a fire) and should be capable of delivering no less than 1,900 litres per minute for at least 2 hours. (228,000 litres of water or 5 X 50,00.0 litre tanks).

SMOKE PLUMES

Smoke

Note: the image does not depict a lithium fire.

- The heat from the fire produces hot gases (smoke).
- This makes the smoke less dense than air, so it drifts up and away.
- When there is little or no wind the smoke the continues to rise and disperse.
- Dense compounds will sink as they cool down.

Effect of wind

Note: the image does not depict a lithium fire.

- Wind makes the plume more turbulent.
- Flattening the plume.

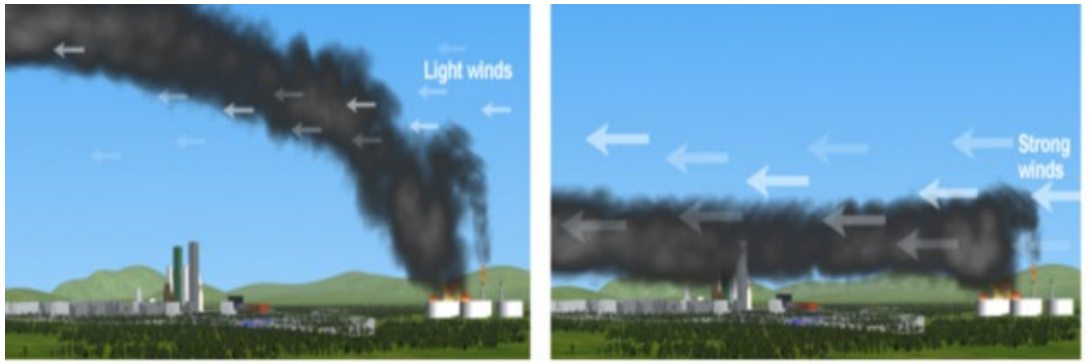


Figure 5. Left: smoke plume rises to the atmosphere and does not threaten the people in the nearby urban area. Right: smoke plume stays very close to ground level due to different atmospheric conditions, which exposes the nearby population to toxic pollutants.

Avonmouth Docks Fire 7th October 2020

Moonrise: 07:17 PM Moonset: 09:50 AM 06:18 AM 05:38 PM

Time	Weather	Temp	Rain	Cloud	Pressure	Wind	Gust	Dir
00:00		11 °c	0.0 mm	77%	988 mb	10 km/h	18 km/h	
03:00		11 °c	0.0 mm	100%	989 mb	9 km/h	15 km/h	
06:00		11 °c	0.0 mm	64%	991 mb	13 km/h	20 km/h	
09:00		12 °c	0.0 mm	100%	993 mb	18 km/h	28 km/h	
12:00		12 °c	0.4 mm	100%	996 mb	24 km/h	44 km/h	
15:00		12 °c	0.0 mm	100%	997 mb	26 km/h	44 km/h	
18:00		12 °c	0.0 mm	86%	999 mb	25 km/h	44 km/h	
21:00		11 °c	0.0 mm	9%	1000 mb	19 km/h	36 km/h	

Wind affected fire – Margate 6.20 am 31st August 2022

Weather History

Wednesday, 31 August 2022 — Min/max 19°/21°c — Patchy rain possible

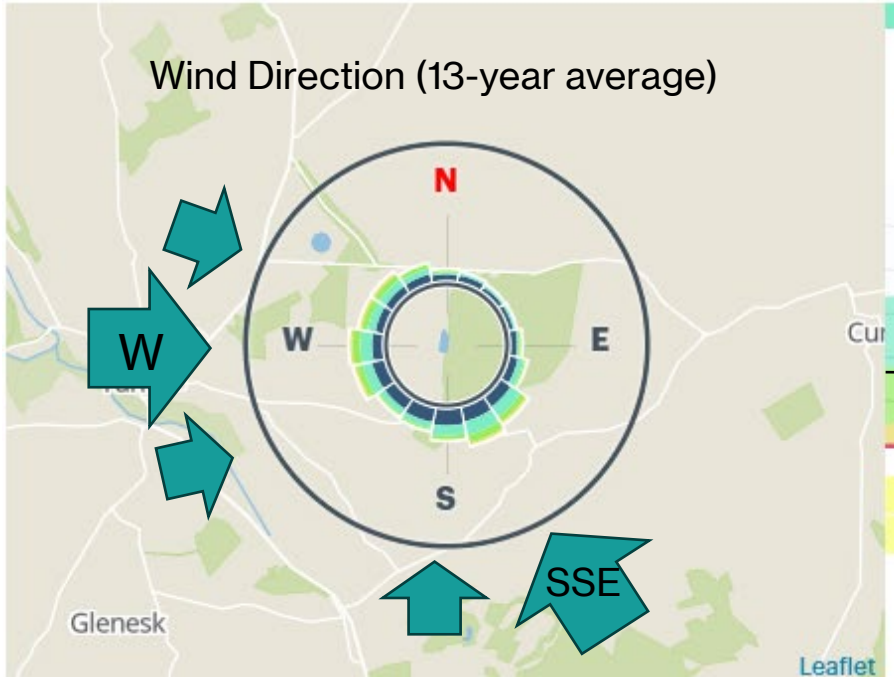
Moonrise: 09:38 AM — Moonset: 08:17 PM — 05:06 AM — 06:43 PM

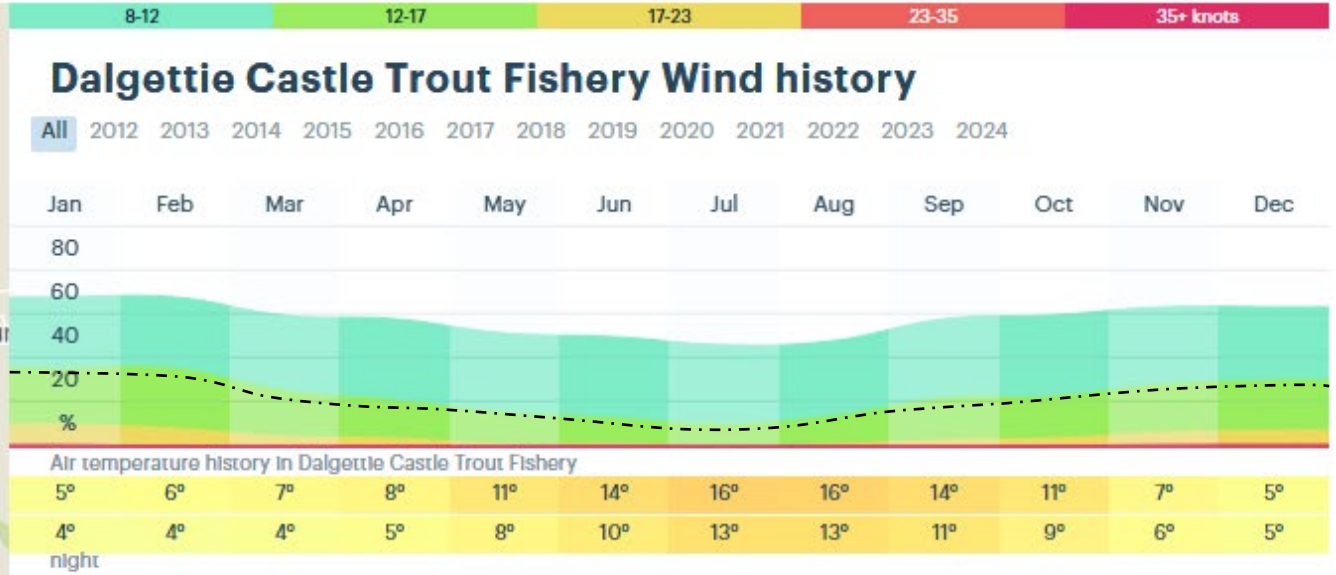
Time	Weather	Temp	Rain	Cloud	Pressure	Wind	Gust	Dir
00:00		19 °c	0.0 mm	0%	1022 mb	25 km/h	42 km/h	
03:00		19 °c	0.0 mm	7%	1021 mb	25 km/h	39 km/h	
06:00		19 °c	0.0 mm	19%	1021 mb	25 km/h	37 km/h	
09:00		20 °c	0.1 mm	77%	1022 mb	28 km/h	45 km/h	

Relating this to NE Scotland
(13.49 knots = 6.94ms = 25kph)

Recording station near Oldmeldrum all data 2012 to 2024

Units in Knots





Dashed Line = average above 25kph
Winter = 15-16% (of the time)
Summer = 5% (of the time)

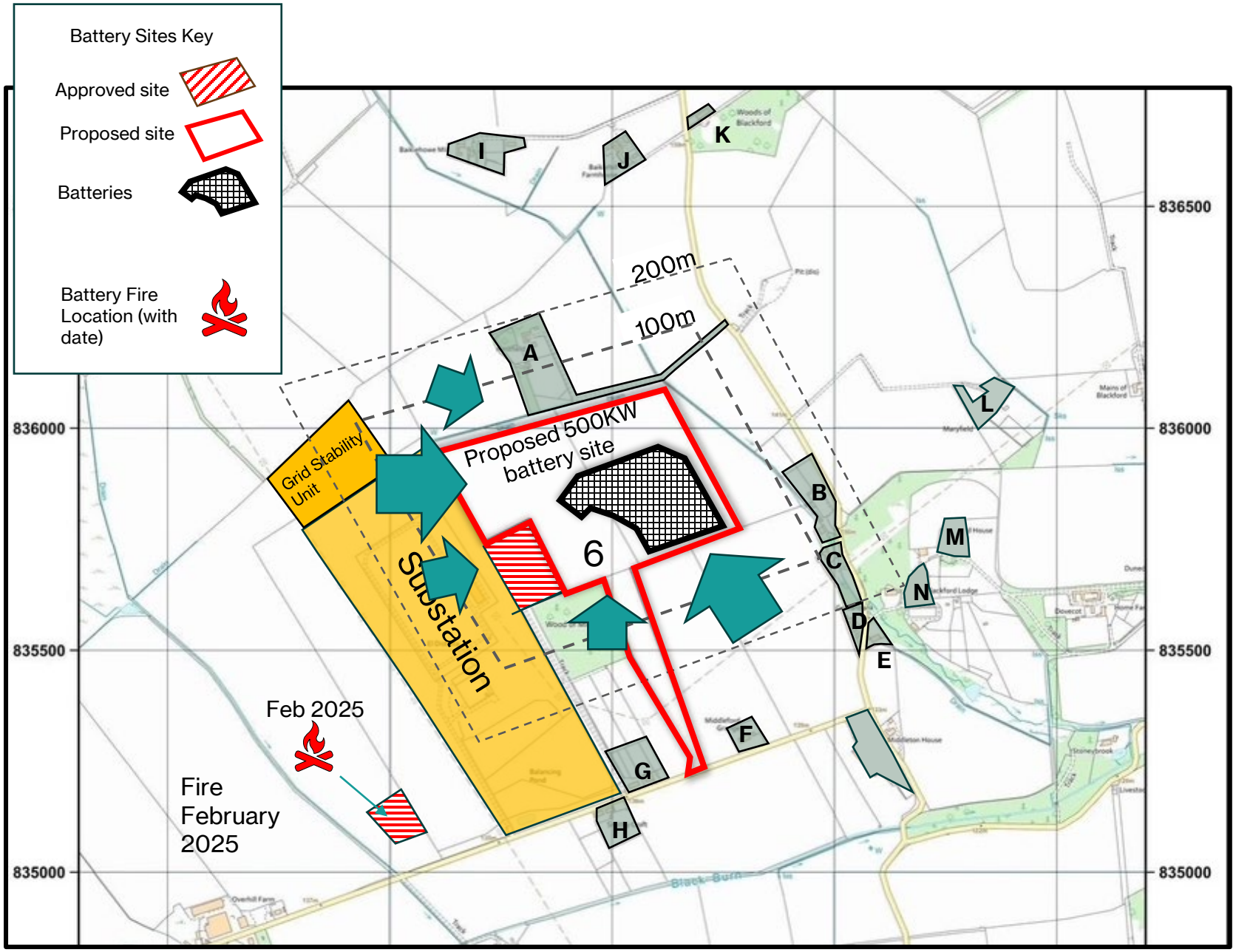
To sum up

- Heat from the fire drives the smoke plume upward.
- However strong winds flatten out smoke plumes – this can make the plumes run along the ground.
- Smoke travelling away from a fire, vertically or laterally, will thin out and become less concentrated.
- Proximity to a fire is a very important safety factor.

SAFETY CONCERNS OF THE PROPOSED 500MW SITE IN BLACKFORD

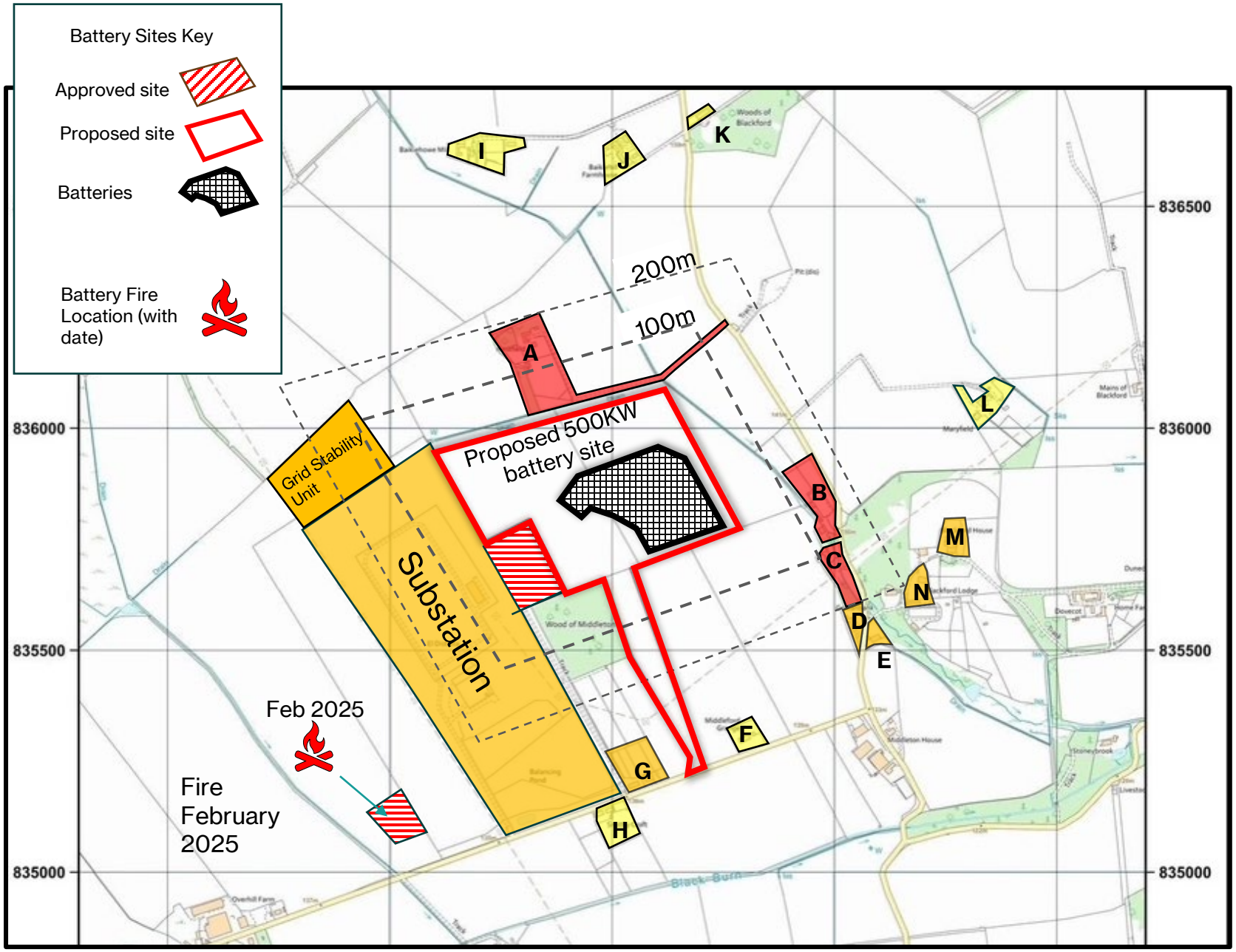
People proximity

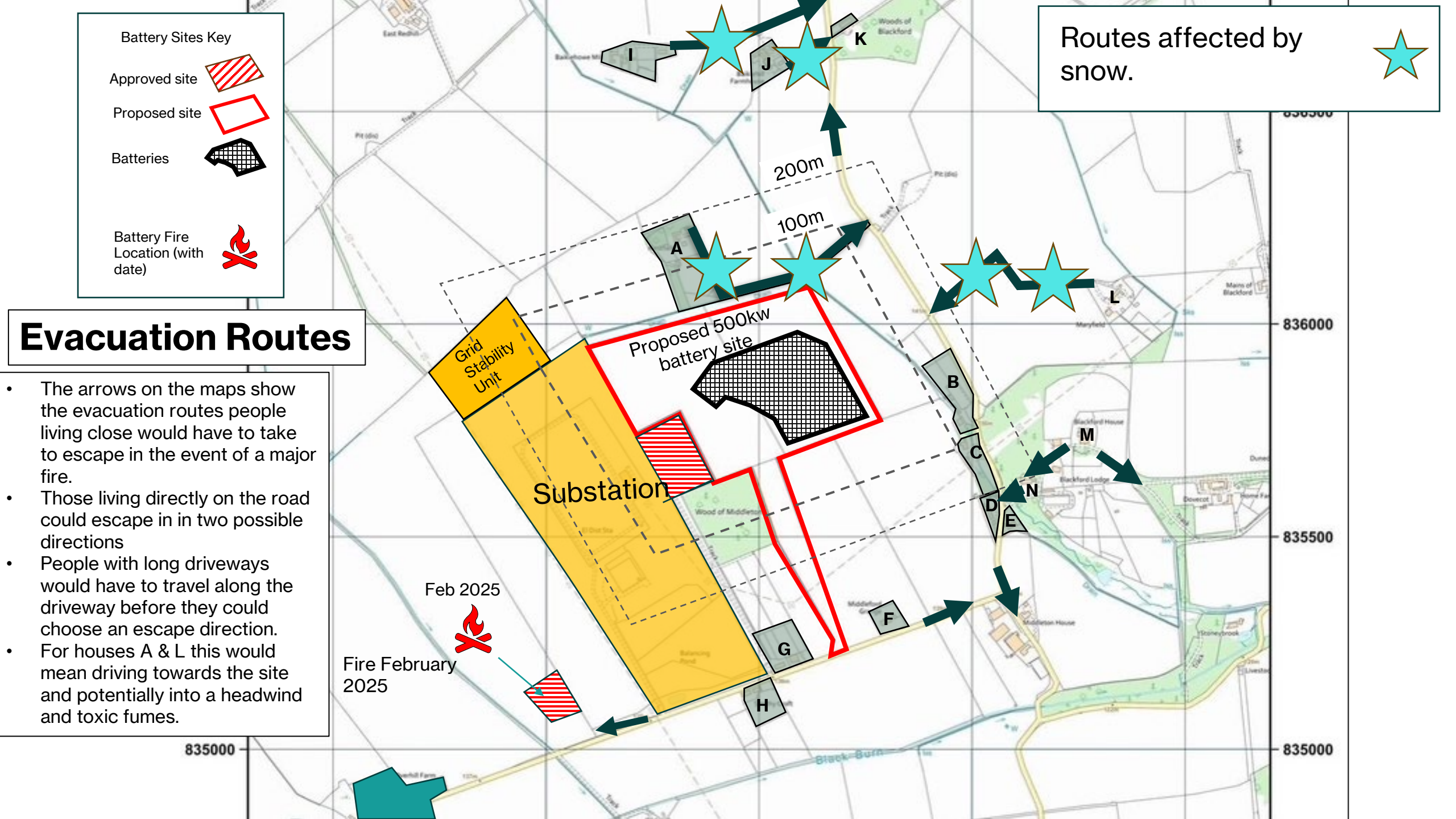
Property	Distancce to Property (m)	Distance to dwelling (m)
A	5	125
B	110	120
C	100	115
D	200	210
E	220	220
F	310	320
G	300	340
H	400	420
I	450	470
J	400	420
K	450	460
L	420	440
M	300	320
N	210	220
Rothienorman	2000	2000



Property	Time Time to reach Property (seconds)	Time to reach Dwelling (seconds)
A	1	25
B	22	24
C	20	23
D	40	42
E	44	44
F	62	64
G	60	68
H	80	84
I	90	94
J	80	84
K	90	92
L	84	88
M	60	64
N	42	44
Rothienorman	400	400
		less than 30 seconds
		less than a minuite
		less than 2 minutes

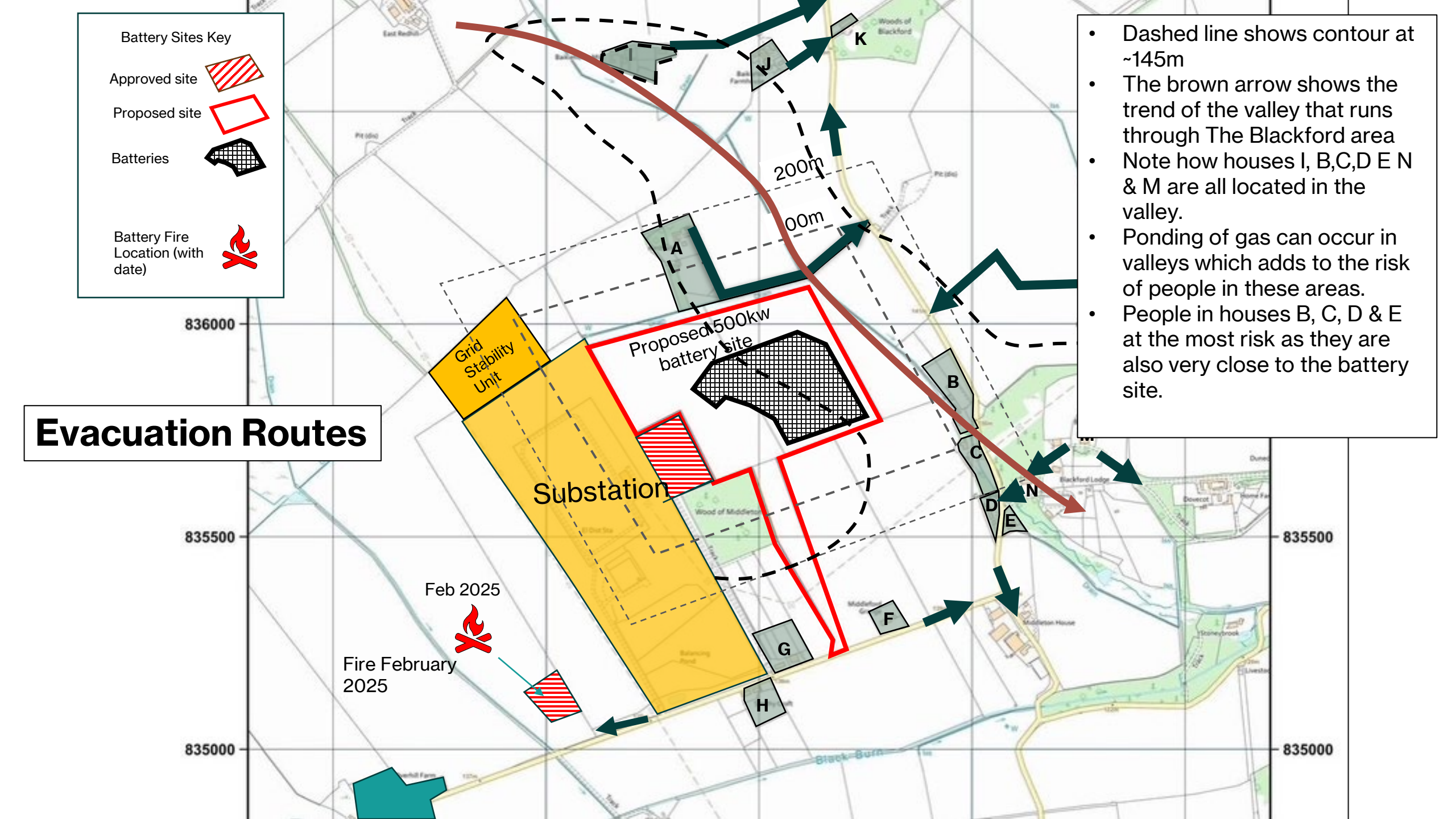
Wind speed	kilomters per hour	meters per second
Summer average	14.4	4
Winter average	18	5




Battery Sites Key
Approved site
Proposed site
Batteries
Battery Fire Location (with date)
Routes affected by snow.
Evacuation Routes
The arrows on the maps show the evacuation routes people living close would have to take to escape in the event of a major fire.
Those living directly on the road could escape in in two possible directions
People with long driveways would have to travel along the driveway before they could choose an escape direction.
For houses A & L this would mean driving towards the site and potentially into a headwind and toxic fumes.
200m
100m
Proposed 500kw battery site
Grid Stability Unit
Substation
Feb 2025
Fire February 2025
A
B
C
D
E
F
G
H
I
J
K
L
M
N
836000
835500
835000
835000

Fire escape route for house A

Unblocked after 2 weeks of being snowed in.


Battery Sites Key
Approved site
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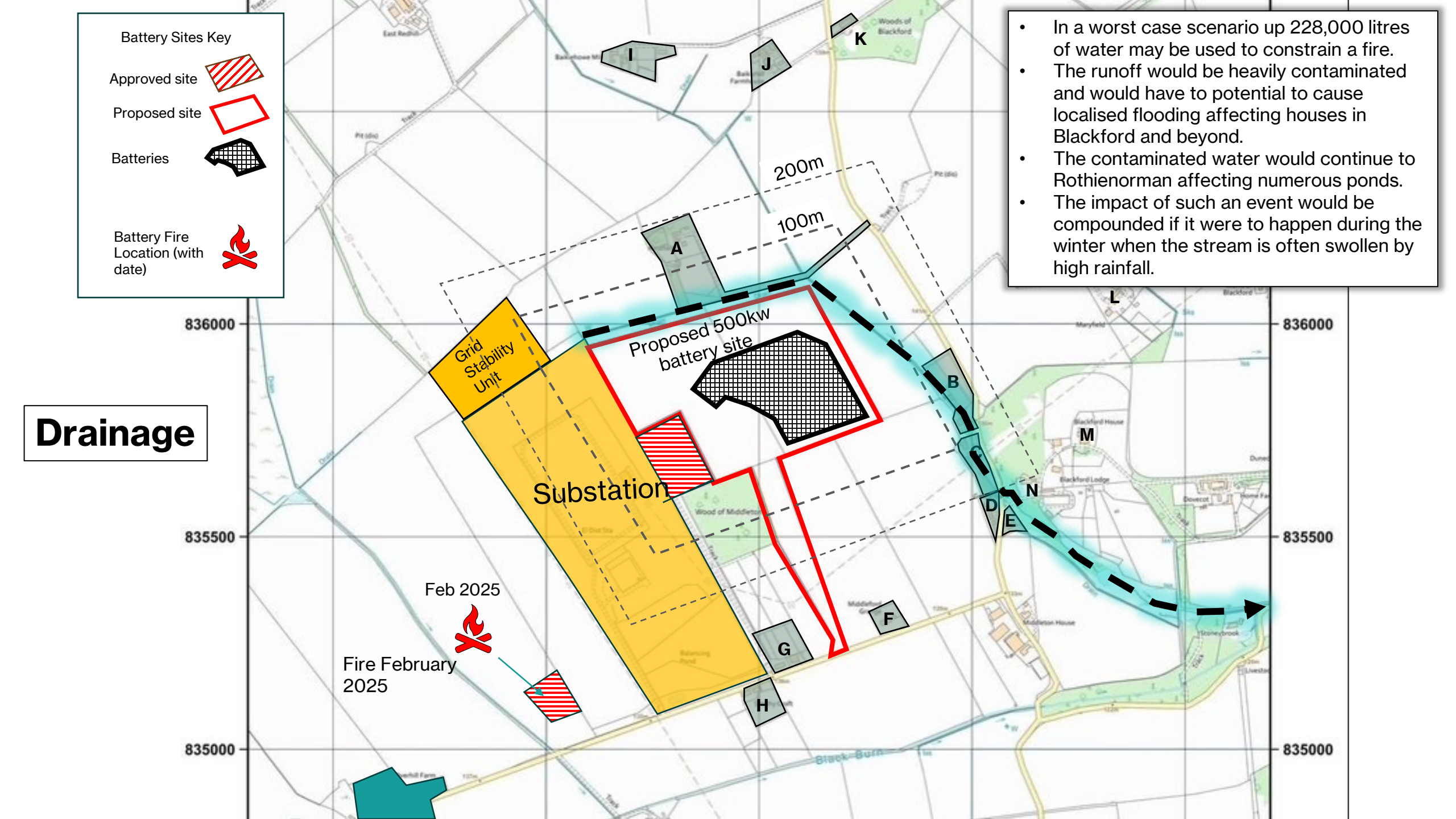
Battery Fire Location (with date)
Evacuation Routes
Grid Stability Unit
Proposed 500kw battery site
Substation
200m
00m
A
B
C
D
E
F
G
H
I
J
K
N
Feb 2025
Fire February 2025
836000
835500
835000
Black Burn
Woods of Blackford
Middleton House
Blackford Lodge
Dovecot
Stoneybrook
• Dashed line shows contour at ~145m
• The brown arrow shows the trend of the valley that runs through The Blackford area
• Note how houses I, B,C,D E N & M are all located in the valley.
• Ponding of gas can occur in valleys which adds to the risk of people in these areas.
• People in houses B, C, D & E at the most risk as they are also very close to the battery site.


Battery Sites Key
Approved site
Proposed site
Batteries
Battery Fire Location (with date)
Drainage
In a worst case scenario up 228,000 litres of water may be used to constrain a fire.
The runoff would be heavily contaminated and would have to potential to cause localised flooding affecting houses in Blackford and beyond.
The contaminated water would continue to Rothienorman affecting numerous ponds.
The impact of such an event would be compounded if it were to happen during the winter when the stream is often swollen by high rainfall.
200m
100m
Proposed 500kw battery site
Grid Stability Unit
Substation
Feb 2025
Fire February 2025
A
B
C
D
E
F
G
H
I
J
K
L
M
N
836000
835500
835000

Conclusions

1. Smoke and vapours emitted from lithium fires can propagate quickly and produce very toxic smoke.
2. Safer designs and containment have improved considerably – this makes the risk of fire much less likely, but the risk has not gone away.
3. BESS Technology is still evolving – these batteries and containment systems have not stood the test of time
4. Risk Management: too reliant on prevention & containment?
    1. *History has shown that unlikely events do occur and not planning for them costs lives.*
5. There are many people living within 500m of the proposed site.
6. A significant number of people are living within 200m of the site.
7. Escape routes for some residences are in completely wrong direction.
8. People living in the NW-SE valley close to the site are also at a higher risk of ponded fumes.
9. Is the safety of people a secondary concern with respect to optimal location of the site for cut costs on connecting to the substation?

END