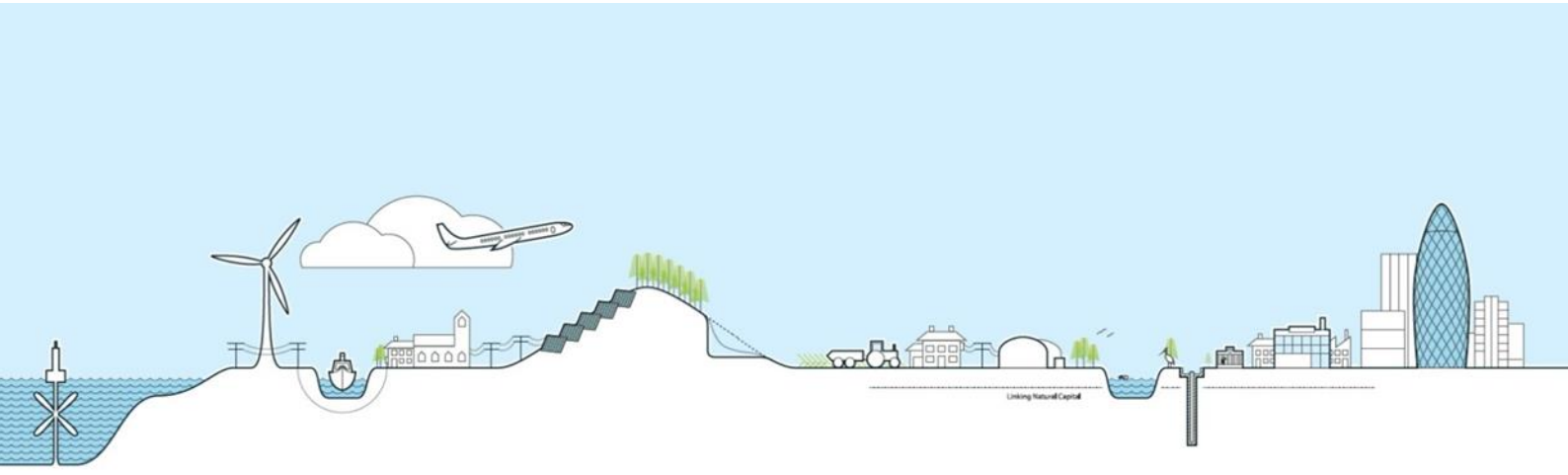
Hagshaw LDES

Outline Battery Safety Management Plan

May 2025

Prepared By

aardvark environment matters



Project Quality Control Sheet

ORIGINAL	Author	Checked by	Approved by
	Ellen Denny Dylan Leonard	Jon Pettitt	Sharon Queeney
Date	01/05/2025	01/05/2025	01/05/2025
Company	Aardvark EM Ltd	Aardvark EM Ltd	Aardvark EM Ltd

Location: Land at Conexus West, Coalburn, Lanark, ML11 0RL

Grid Co-ordinate: X 282936 Y 632476

Project Manager: Nick Leaney BSc Hons MRICS

Report Author: Ellen Denny BSc AIEMA

Dylan Leonard

Report Number: 2495-R002

Report Status: FINAL

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Report Written and Produced By

Aardvark EM Limited, Higher Ford, Wiveliscombe, Taunton, Somerset, TA4 2RL

Telephone: 01984 624989

Email: environment@aardvarkem.co.uk, Web: www.aardvarkem.co.uk

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1 Introduction

This document has been prepared to outline the design and operation of the Hagshaw Long Duration Electricity Storage (LDES) Site, the associated fire risks and mitigation techniques utilised. This document demonstrates the developer's commitment to ensuring safety and compliance through the application of good industry practice measures throughout the design, procurement, construction and operation of the Site.

1.1 Summary of Development

The Proposed Development is for the installation of a Long Duration Electricity Storage ('LDES') scheme, with a storage capacity of up to 6 Gigawatt hours (GWh), a substation, underground cabling, access tracks, landscaping, biodiversity enhancements and ancillary infrastructure.

LDES using flow batteries is an emerging technology designed to store and discharge electricity over extended periods (more than 8 hours), offering significant advantages over traditional lithium-ion batteries which generally store and discharge electricity over much shorter periods (usually around 2 hours). LDES systems will play a crucial role in maintaining a stable and reliable energy grid by storing surplus renewable energy and delivering it during times of high demand or reduced generation

The proposed scheme should not be confused with Lithium-ion Battery Energy Storage Systems (BESS) which use alternative battery chemistry and present a greater fire and pollution risk. Flow batteries are considered an emerging technology and as a result no specific guidance relating to battery safety management has been published. Therefore, the framework of this report is based on the National Fire Chiefs Council (NFCC) - Grid Scale Battery Energy Storage System planning – Guidance for FRS. The NFCC guidance relates specifically to grid scale (typically 1 MW or larger) BESS in open air environments, utilising lithium-ion technology and contains limited relevance for a site using flow battery technology. As a result, the NFCC guidance has only been applied where appropriate.

The developer will appoint suitably qualified persons to undertake the design and construction of the LDES facility. Once constructed the developer will ensure the operational and management requirements of the Site are fulfilled. The developer will take into account the following standards, guidance and documents of best practice where relevant, please see below:

- NFPA (National Fire Protection Association) 855 – Standard for the Installation of Stationary Energy Storage Systems (2023),
- EPRI (Electric power Research Institute)– Battery Storage Fire Safety Roadmap (2021),
- UL (Underwriters Laboratories) Solutions – UL 9540A Test Method,
- UL Solutions – UL 9540A Installation Level Tests with Outdoor Lithium-ion Energy Storage System Mockups (2021),
- Fire Protection Association and RISC (Rights, Insight, Strategy and Control) Authority – Need to Know Guide RE1 (2022),
- CFA (Country Fire Authority) – Design guidelines and Model Requirements, Renewable Energy Facilities.

To ensure good practice the developer will work closely with the local planning authority and Scottish Fire and Rescue Service, where possible to develop a detailed design plan which adequately

considers and address all risks associated with LDES sites prior to the commencement of operations. The developer will consult these authorities, informing the Site's Risk Assessment and Emergency Response Plan. A final Battery Safety Management Plan (BSMP) will be developed as part of the construction process once the final technology is selected, so some details may change. This can be secured by planning condition.

1.2 LDES Risk

Annex b.5.1 of the NFPA 855 provides statements surrounding the hazards associated with commercially available battery technology, please see the excerpt below in relation to flow batteries (referred to a Vanadium Redox Flow Batteries in this guidance).

*'**Flow Batteries – General Description***

A flow battery is an energy storage component similar to a fuel cell that stores its active materials in the form of one or more electrolytes external to the reactor interface. When in use, the electrolytes are transferred between reactor and storage tanks. Two commercially available flow battery technologies with two active electrolytes are zinc bromine and vanadium redox.

Vanadium redox flow batteries contain vanadium salts in various stages of oxidation in a sulfuric acid electrolyte. Charging and discharging the battery changes the oxidation state of the vanadium in the electrolyte solutions.

***B5.1.1 Vanadium Redox Flow Batteries**.*

Hazard considerations for vanadium redox flow batteries under normal operating conditions are as follows:

1. *Fire Hazards – Not applicable,*
2. *Chemical Hazards – They contain corrosive liquid that might present a safety concern under normal conditions if there is a need to handle/replenish the electrolyte as part of the maintenance,*
3. *Electrical Hazards - There are electrical hazards associated with routine maintenance of these batteries if they have hazardous voltage and energy levels,*
4. *Stranded or stored energy hazards – Not applicable,*
5. *Physical Hazards – Not applicable*

Hazard considerations for vanadium redox flow batteries under emergency/abnormal conditions are as follows:

1. *Fire Hazards – Corrosive liquid can boil off to create gases that are flammable (e.g. hydrogen). There can also be the problems with balance of plant components over-heating and creating the potential for fire hazards under abnormal conditions,*
2. *Chemical Hazards – There are large amounts of corrosives,*
3. *Electrical Hazards – Electrical hazards might be present under abnormal conditions if the system is at hazardous voltage and energy levels,*
4. *Stranded or Stored Energy hazards – Not applicable,*
5. *Physical Hazards – Depending on the design of the system, the potential exists for physical hazards under abnormal conditions if accessible parts are overheating, if there is insufficient pressure relief when the system is overheating and gas is generated, or if there is exposure*

to moving hazardous parts such as fans or exposed pump parts where guards might be missing.'

The Proposed Development has been designed using a candidate technology of Vanadium Flow Batteries (VFB) from Invinity Energy Systems, a Scotland-based company and global supplier of modular VFBs for utility-scale energy storage.

Invinity state that the Endurium Unit '*is fire-safe and has zero risk of thermal runaway. There are no chemical, electrical, or mechanical failure modes possible which will cause thermal runaway'*.

1.2.1 Thermal Runaway

Thermal runaway is a risk related to the use of certain batteries where the cell enters an uncontrollable, self-heating state. Thermal runaway in a battery cell can be caused by; internal short circuit, overcharge, incorrect discharge of the cell, external short circuit, increased and decreased temperature environments. Thermal runaway is when a certain temperature is reached within a battery, causing a chemical reaction to occur. The chemical reaction produces heat, causing further chemical reactions to occur and leading to; incredibly hot temperatures, gassing of the battery and fire.

The battery chemistry proposed for the Site is a vanadium flow style battery, which is:

- Non-flammable in nature,
- Can safely operate over a wider temperature range,
- Aqueous in nature, non-flammable and can absorb a lot of heat before being damaged.

2 Site Details

2.1 Site Location

The Site is located at land south-west of Junction 11 of the M74 motorway, South Lanarkshire, approximately 1.5km to the south of Coalburn and approximately 1.5km to the north of Douglas. The nearest main road is the M74, approximately 1.9km east of the Site. The nearest access road is the Poniel Interchange (B7078) located to the north-east of the Site. The Site red line boundary covers an area of approximately 46.6ha.

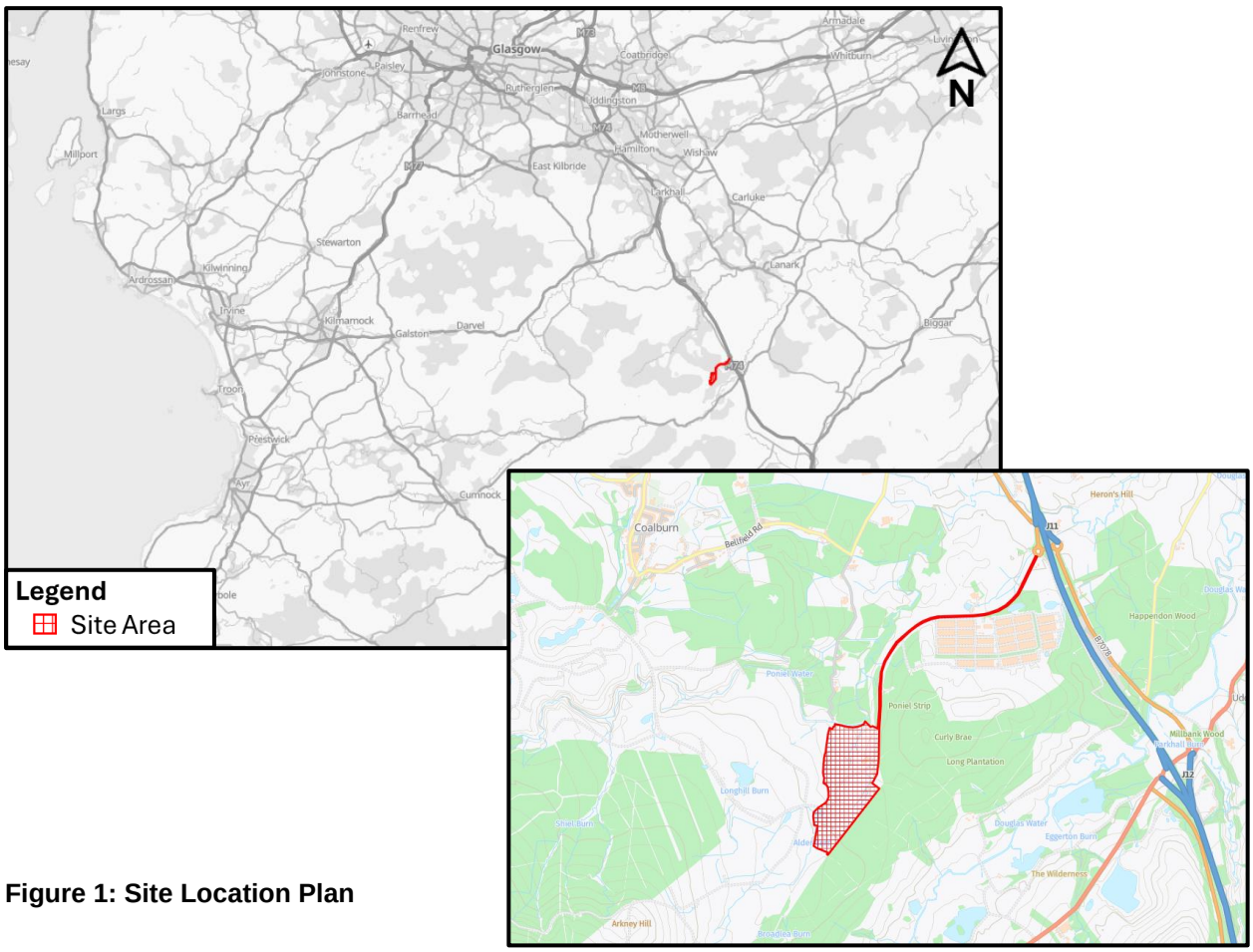

Figure 1: Site Location Plan

2.1 Nearby Sensitive Receptors

Sensitive receptors within 2km of the Site include residential properties, local businesses, industrial units, agricultural land and forestry. In the immediate vicinity of the Site is a large, forested area, bordering the Site to the east. In the vicinity there are a number of isolated dwellings and agricultural buildings including:

- Westerhouse - Approx Distance to Development infrastructure: 500m.
- Gardens House - Approx Distance to Development infrastructure: 950m.
- Douglas Estate - Approx Distance to Development infrastructure: 1,400m.
- Edgewood - Approx Distance to Development infrastructure: 1,150m.

- Station House - Approx Distance to Development infrastructure: 1,300.

Also within the vicinity of the Site is a large industrial estate approximately 800m to the north and the Cairn Lodge Services approximately 2km to the east.

See the map below highlighting the nearby sensitive receptors with a 2km radius of the Site:

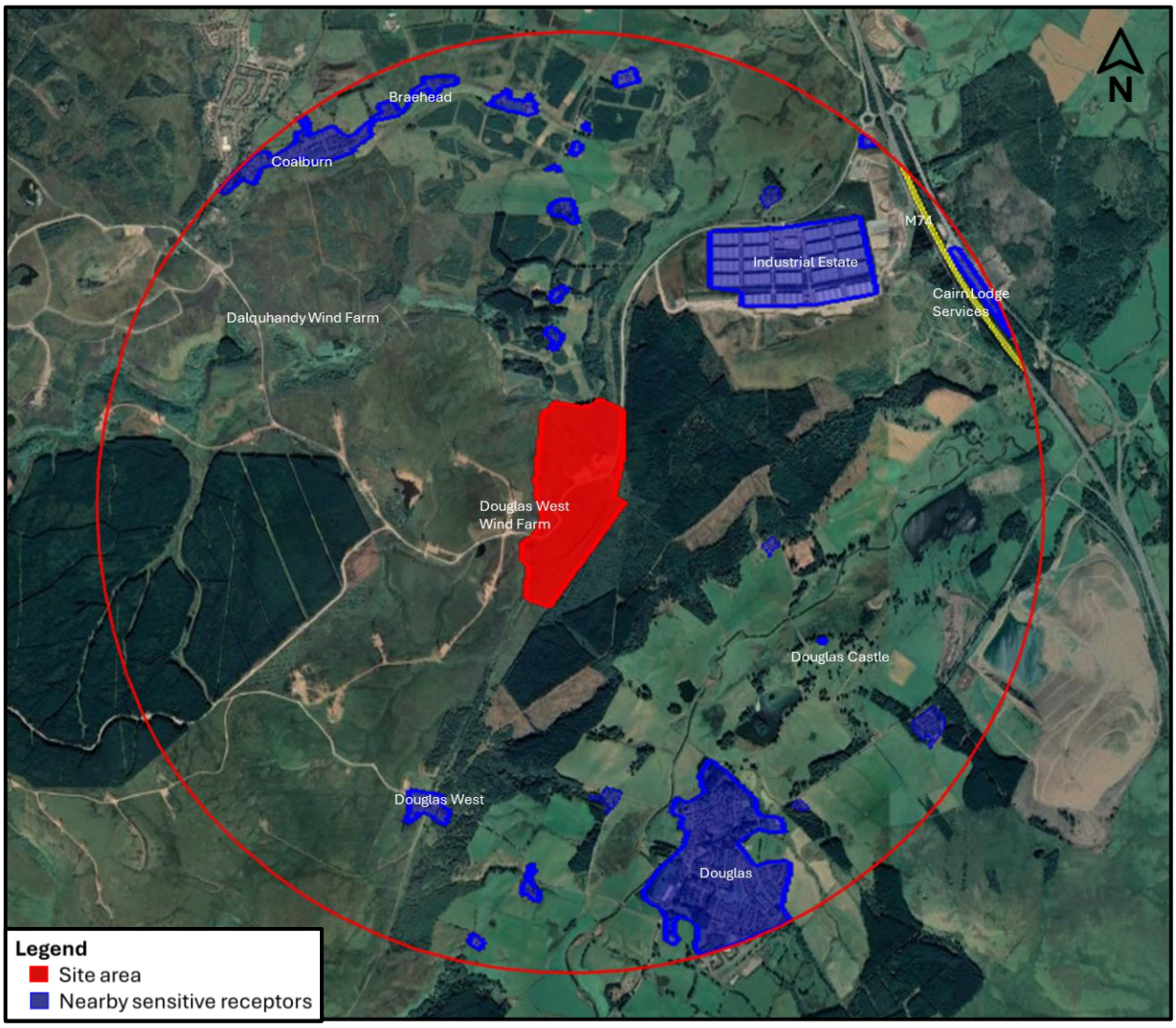

Figure 2: Nearby Sensitive Receptors

2.2 Nearby Ecological Receptors

A 2km buffer zone was utilised to detect any nearby ecological receptors. There were no ecological receptors identified within the designated buffer zone.

The following list states the location of the nearest of each European Site to the Site boundary:

- Coalburn Moss, Site of Special Scientific Interest (SSSI) and Special Area of Conservation (SAC) located approximately 2.7km to the north of Site,
- Muirkirk and North Lowther Uplands, Special Protection Area located approximately 6.8km to the south-west of the Site.

The figure below shows the 2km buffer zone and any sensitive receptors in close vicinity to the Site.

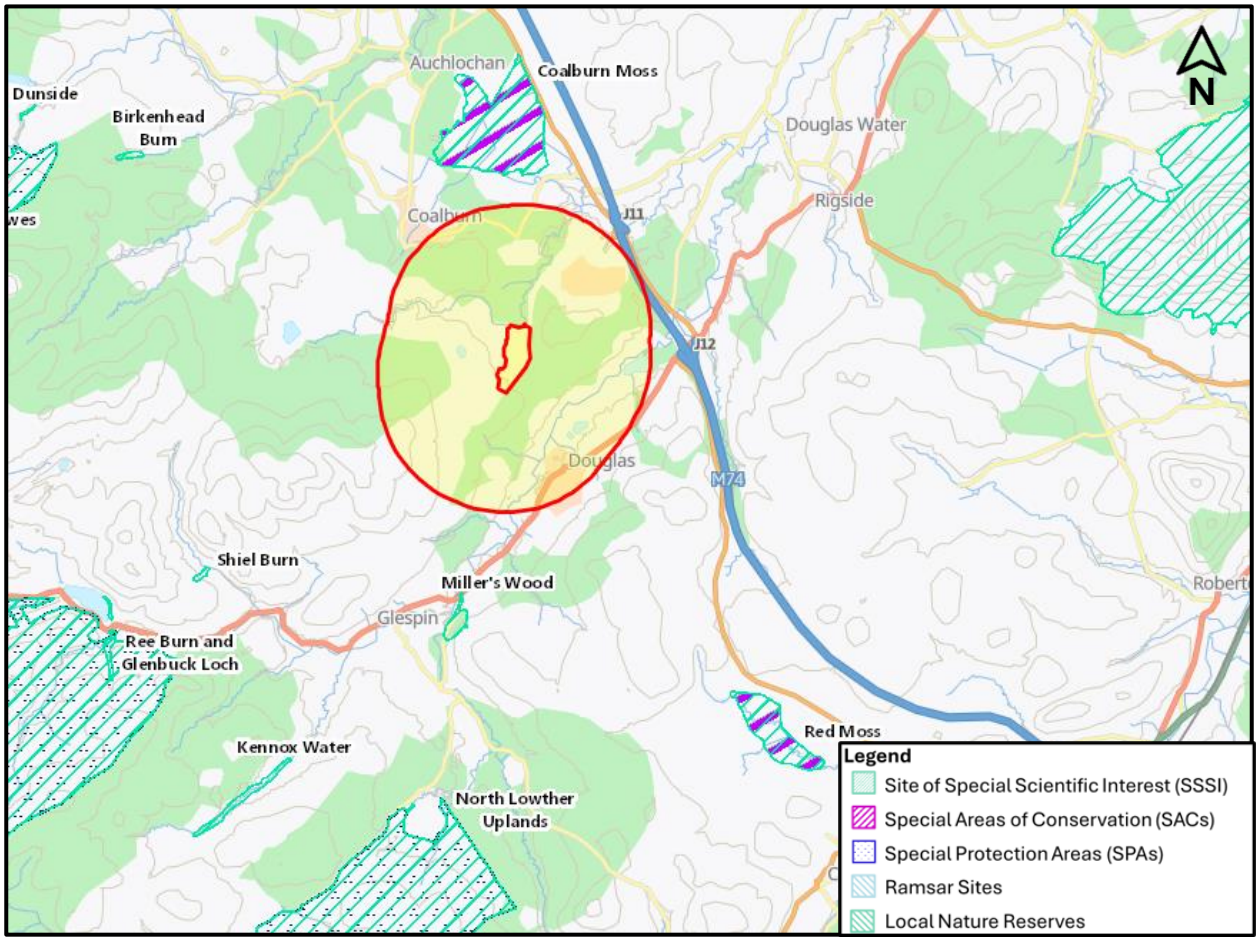

Figure 3: Nearby Ecological Receptors

2.3 Hydrological receptors

The nearest watercourse is Alder Water which borders the Site to the north and flows into the Poniel Water. The Poniel Water then flows east to join the Douglas Water, which in turn flows north-east to join the River Clyde.

The Site is located within the Poniel Water Baseline Waterbody Inter Catchment, located within the Poniel Water and Confluence with Douglas Water Baseline Confluence Inter Catchment, located within the River Clyde Main River and Coastal Catchment.

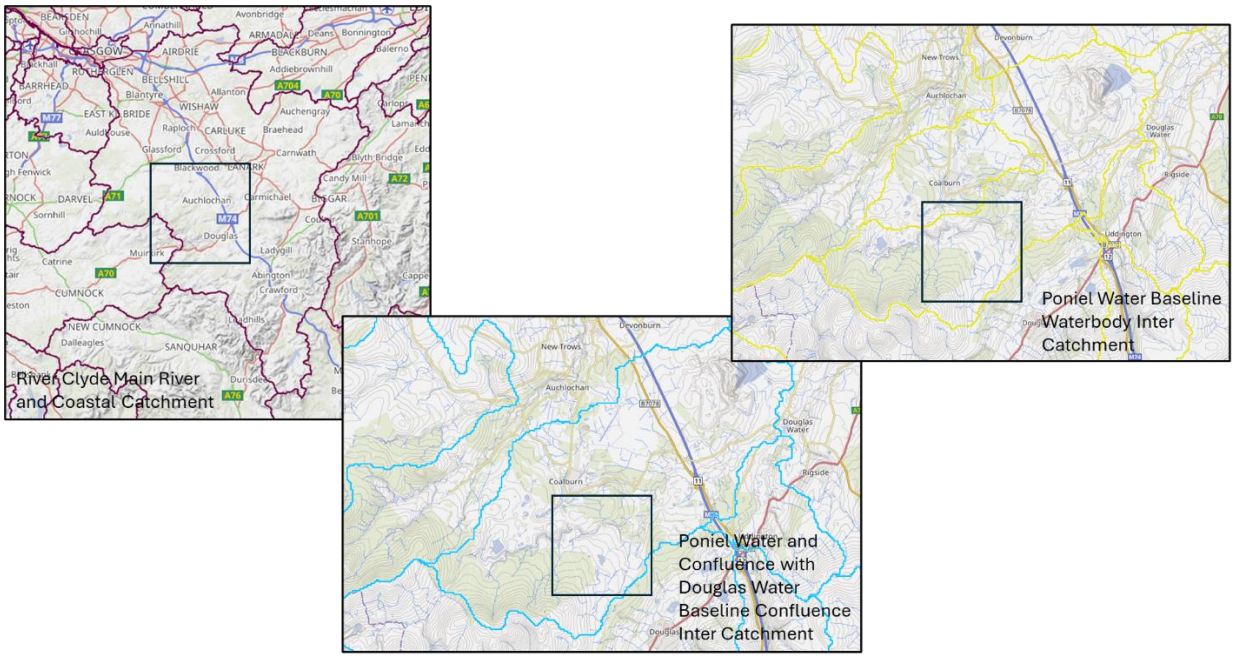

Figure 4: River Catchment Data

2.4 Weather Conditions

2.4.1 Temperature

Optimum operational temperature for the battery modules is between 10°C and 30°C, units are containerised to ensure the batteries are kept within this range. The batteries have a storage range of between -25°C and 50°C which the batteries must be kept between to ensure they are not damaged.

Figure 5 below shows the average temperatures and precipitation in Douglas. The maximum mean daily temperature is 17°C in the month of July and the minimum daily mean temperature in is 1°C between December and February. The average hottest day reaches a temperature of approximately 23°C in July and the average coldest day in December at approximately -5°C.

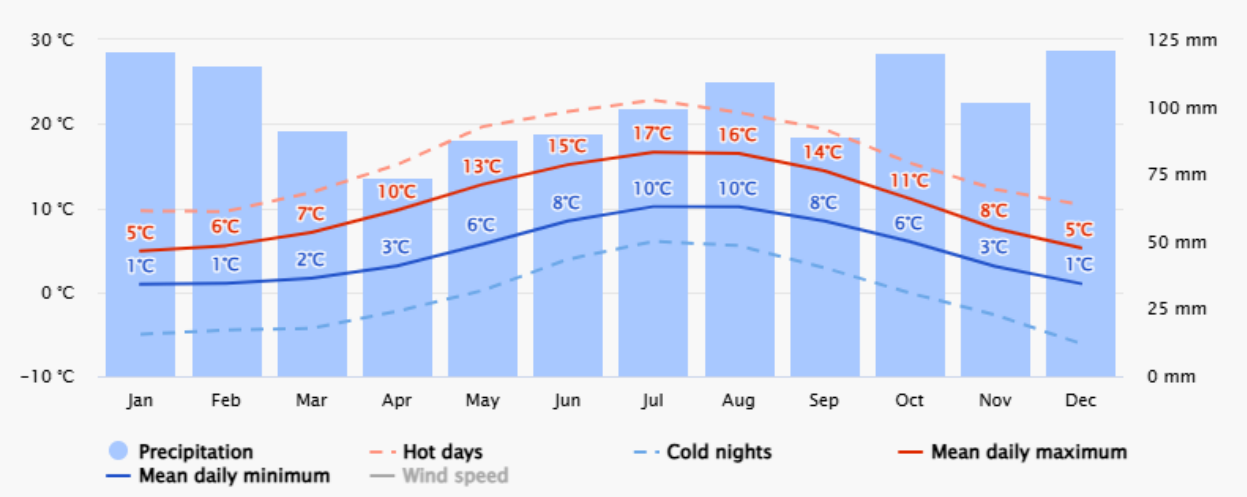

Figure 5: Douglas Average Temperatures and Precipitation

2.4.2 Flooding

Please see the Drainage Strategy produced for this application (ref. R008).

The following provisions have been put in place to ensure flooding does not impact the battery systems:

- The Site will be designed to ensure battery units will not sit in water and standing water flows away from the battery units and Site infrastructure,
- If it is determined that flooding may be likely at the Site provisions will be put in place to ensure that flood water does not reach higher than 150mm as per the manufacturer's guidance,
- If it is determined that flood water has damaged any equipment, cabling ducts etc. the affected systems will be inspected to ensure they are safe.

2.4.3 Lightning

A lightning protection assessment will be undertaken to determine whether lightening protection is required. Lightning/surge protection equipment will be installed by a qualified professional and comply with the relevant regulations.

2.4.4 Snow and ice

The likelihood of snow and ice at the Site is moderate. Figure 6 below shows the months of January, February, March, April, November and December on average to have at least 2 snow days per year. The highest average number of snow days is shown in January, recording approximately 10 snow days on average, followed by February with 9 days on average.

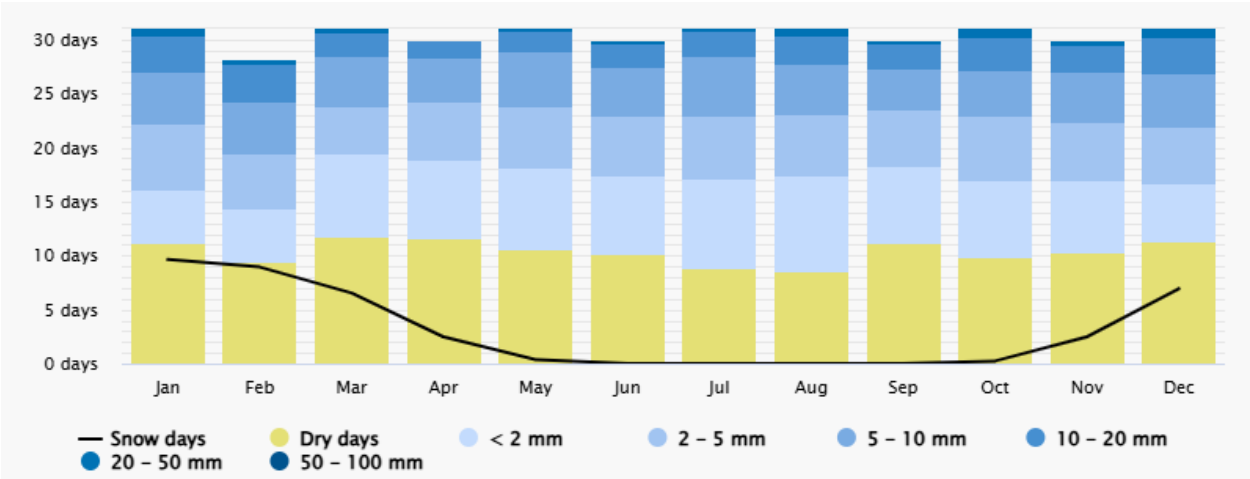

Figure 6: Douglas Average Precipitation Amounts

In the event of severe snow and ice at the Site, operatives will ensure ventilation panels are clear and functional, and any snow cleared off the rooves of the containers to avoid snow falling and ice buildup.

2.4.5 Wind Conditions

The prevailing wind direction at the Site is westerly, with wind direction from west-north-west to south frequently occurring. Therefore, areas to the north and east of the Site would be most likely to be impacted by airborne emissions from any fire event.

In a fire incident any local sensitive receptors that may be impacted by windblown smoke from a fire would be contacted.

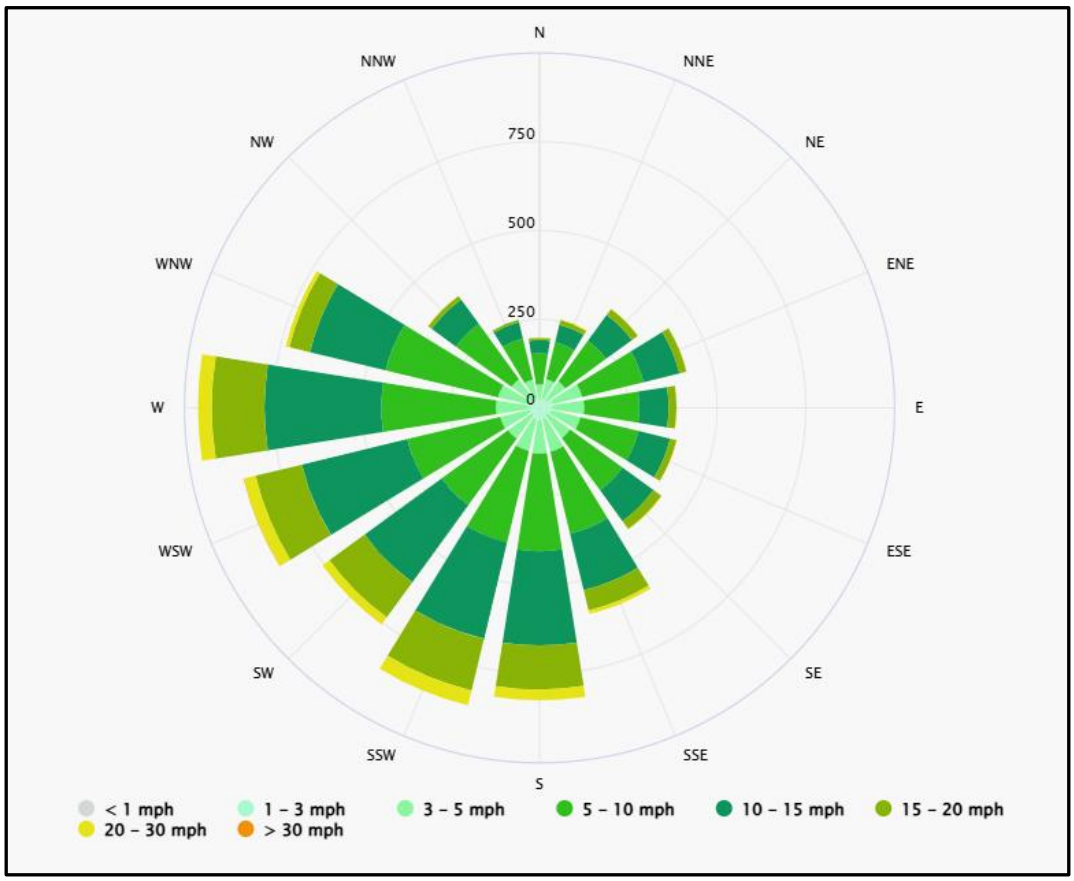

Figure 7: Douglas Wind Rose Diagram

3 System Design, Construction, Testing and Commissioning

3.1 System Design and Construction

The Site will be comprised of:

- 400kV substation Compound 92m X 139m X 12.9m (at highest point).
- Customer Switchgear Containers which are 10m X 3.7 m X 3.2m (H).
- 2 40 ft Spare Parts Containers which are 12.2m X 2.5m X 2.7m (H).
- 2 40ft Welfare Containers which are 12.2m X 2.5m X 2.7m (H).
- A 20ft Energy Management System which is 2.4m X 6.1m X 2.6M (H).
- 13, 608 LDES Triple Stacked Containers which are 6.0m X 2.4m X 7.8m (H).
- 162 PCS Inverters Single/Double which are 11.8m X 2.1m X 2.6m (H).
- 1,141 String Control Units which are 1.1m X 1.1m X 2.4m (H).
- 350 DC Combiner's which are 1m X 0.4m X 1.8m (H).
- 175 AC Distribution Panels which are 1m X 0.4m X 1.8m (H).
- Two Water Tanks (120,000L and 240,000L).

Please see the below simplified site Layout Plan, the site's detailed Layout Plan has been submitted as part of this Planning Application, please see document ref. R001 PL 01 10 Indicative Site Layout Plan.

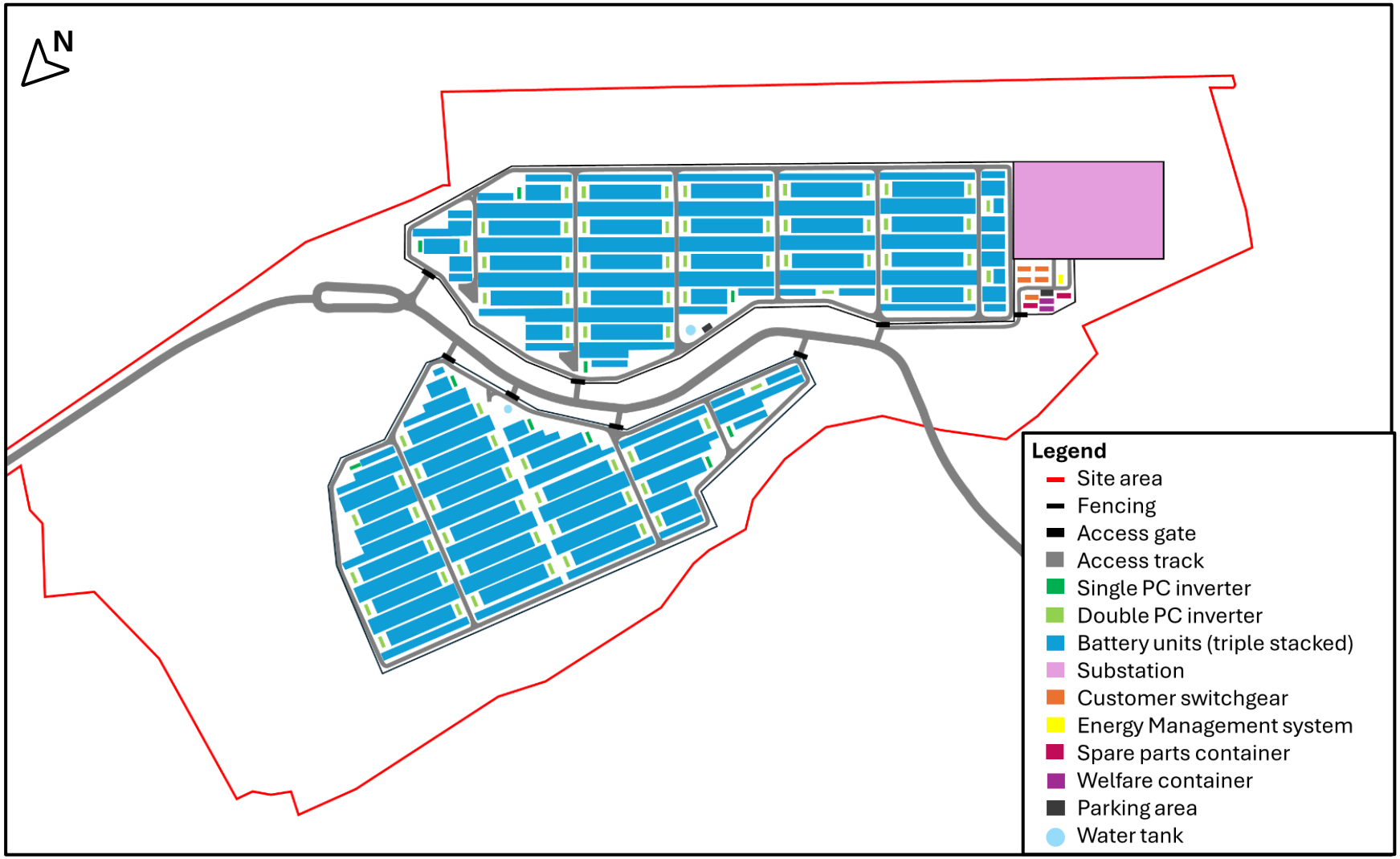

Figure 8: Site Layout Plan

LDES Summary	
Type of Battery unit	LDES Triple Stacked Flow Battery Containers
Container dimensions	height x width x depth 7.8m x 6.1m x 2.4m
LDES units separations distance	2.4-3.3m
Number of LDES containers	13,608 container set-up
Capacity of each unit	300KWh
Substation	400 kV separately fenced network operator substation plus separate containerised developer substation equipment
Number of Power Conversion System (PCS) units	162 PCS inverter unit set-up (single and double stacked)
Number of Control units	1,141 string control units
Additional infrastructure	• Perimeter fencing, • CCTV cameras, • Two water tanks (120,000L and 240,000L) • Associated infrastructure including, pipework, power cabling and access tracks.

Table 1: LDES Summary Table

3.1.1 Staffing

The site will employ around 20 maintenance engineers, a Dayshift Manager and an Admin Officer. There will be 5 shifts per day, with 3 to 4 operatives working per shift.

There is a welfare office located at the existing CHP plant which will be available for staff use.

3.1.2 Battery Module

The proposed battery module is a self-contained Vanadium Flow Battery (VFB) encased within a standard 20ft shipping container. The battery module has the following:

- Openings for cabling, plumbing and ventilation,
- Openings for access for service and maintenance (font face doors providing maintenance access and rear face doors for access to cooling fans and air filter),
- Powered by AC auxiliary supply,
- Electrochemical subsystems and components allowing charge and discharge of DC power,
- Components allowing for communication with external control and monitoring systems,
- Thermal management systems (heat exchangers, ducting blower),
- Electrolyte storage (tanks, leak detection and secondary containment providing 130% storage capacity, drip tray and spray shields).

3.2 Testing

3.2.1 Factory Acceptance Testing

- Routine tests are undertaken on all Invinity manufactured equipment in accordance with applicable UL and IEC standards,
- All Invinity production sites are ISO 9001, ISO 14001 and ISO 45001 certified,
- The following routine tests are typically undertaken:
  - Dielectric withstand (hi-pot) test,
  - Grounding system continuity test,
  - Functional checks,
  - Leak checks.

3.2.2 Site Acceptance Testing

Site acceptance tests are undertaken by Invinity engineers shortly after installation on Site.

This includes;

- Wiring inspections,
- Lockout, E-stop and safety equipment verification,
- Dielectric withstand (hi-pot) test,
- Grounding system continuity testing,
- Functional test of ladders, railings, climbing apparatus, spill containment etc.,
- Internet connection speed test.

3.2.3 Factory Acceptance Testing

- Routine tests are undertaken on all Invinity manufactured equipment in accordance with applicable UL and IEC standards,
- All Invinity production sites are ISO 9001, ISO 14001 and ISO 45001 certified,
- The following routine tests are typically undertaken:
  - Dielectric withstand (hi-pot) test,
  - Grounding system continuity test,
  - Functional checks,
  - Leak checks.

3.3 Certification

The Endurium VFB (proposed for use at the Site) is not yet certified, however this will be undertaken before installation is undertaken at the Site. The following certifications are proposed:

- CE marked to the applicable CE directives, specifically the machinery directive 2006/42/EC (MD), Low Voltage Directive 2014/35/EU (LVD), and Electromagnetic Compatibility (EMC) directive 2014/30/EU.
- Able to provide a CE confirmation of conformity, a document which confirms that the product complies with all relevant EU legislation and standards.
- The following list is key UL standards that apply to Invinity Energy Systems (IES) Products:
  - UL 9540 – Standard for Energy Storage Systems and Equipment – this certification requires assessment of both the battery units and PCS which can be achieved through field evaluation of the product post installation,
  - UL 1973 – Standard for Batteries for use in Stationary, Vehicle Auxiliary power and Light Electric Rail (LER) Applications,
  - UL 9540A – Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems.
- NFPA 855 is a US standard applicable to the installation of BESS systems. NFPA 855 has been reviewed and IES products can be installed in line with this guidance.
- The manufacturing processes and facilities comply with and are certified to the following standards:
  - ISO 9001 Quality Management System (QMS),
  - ISO 14001 Environmental Management System (EMS),
  - ISO 45001 Occupational health and Safety (OH&S).

3.4 Design

The design plans submitted as part of this application are subject to change as the detailed design is finalised post Site Investigation and procurement phases post consent. Any updated final design would need to be approved through planning conditions prior to commencement. The current design version should therefore be viewed as a concept design, the final design iteration will be based upon:

- The final selection of technology and components to be utilised alongside the LDES system,
- Procurement of items for the construction of the LDES system,
- Outcome of the Site Investigation works,
- Review and mitigation of risk undertaken during the design process,
- Review by a fire safety engineer and relevant authorities prior to finalisation of the design.

3.5 Detection and Monitoring

The following can be monitored through the Site's battery system controller:

- Average state of charge,
- Max/min/standard deviation of charge,
- Discharge energy remaining,
- Theoretical maximum power available in charge and discharge,
- Any warnings,

- Any alarms,
- The battery modules operating mode,
- DC power readiness requests, active power setpoint, and
- Reactive power setpoint.

3.5.1 LDES Battery Module System Monitoring and Faults

The battery modules can be connected to form battery strings, with multiple strings forming an array and multiple arrays forming a battery system. The battery system can be controlled remotely by the battery system controller connected via ethernet or optical fibre. The battery controller provides an interface which can be integrated with third party software linking to SCADA, EMS and to allow for data logging. The battery system controller allows for remote access to communicate with the battery system, relaying faults, remote shut down of the system and allowing technical support from the equipment provider. For on-site maintenance and monitoring a laptop can be connected to control the system in situ.

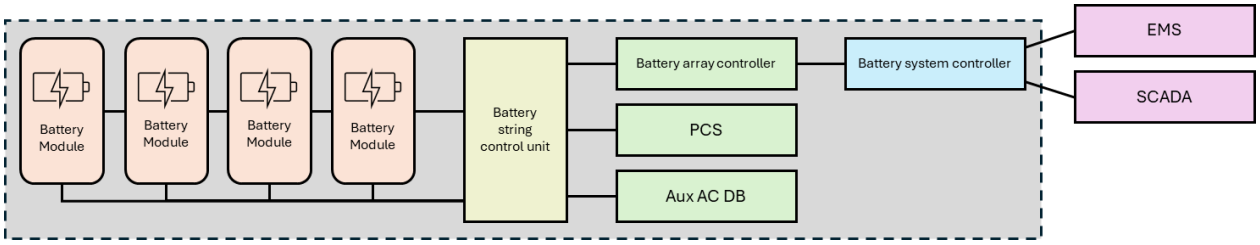

Figure 9: Battery System Setup

Faults with the battery modules are reported in three ways:

- **Warning –** Indicates a module will operate but is impaired. An alert is given that there is an abnormal condition that could lead to an issue if left unresolved.
- **Fault –** A condition that prevents the unit from charging or discharging or causing it to stop entirely. If the fault goes away the module will resume as normal.
- **Latching fault –** A condition that stops the module from working, it will not resume automatically, the unit must be fixed and the faults cleared manually.

3.6 Maintenance

Scheduled maintenance will be undertaken on a rolling annual basis and will likely include:

- Visual inspections for leaks, cleanliness, pest infestation,
- Visual inspection of system components including; tanks, stacks, pumps, hoses, cooling fans, sensors, electrical wiring and connections,
- Software updates, system upgrades and modifications.

In addition to this there will be a Site Maintenance Schedule detailing when parts are likely to require replacement to allow for maintenance planning, avoiding unscheduled maintenance.

The annual service involves the following:

- Remote inspection and maintenance planning,
- Fan-end service (maintenance which can be undertaken whilst the string is operating),

- Door-end service (maintenance which is undertaken whilst the system is in maintenance mode).

3.6.1 Maintenance Operatives

The following will be insured by Site operatives:

- Operatives undertaking maintenance activities must read and be familiar with the safety instructions discussed within the Site's Operating Manual,
- Users must not access the internal components of the battery module units without receiving training, certification or written consent from Invinity.

3.7 Deflagration Prevention and Venting

Deflagration prevention and venting systems will be installed within the battery containers. In the full Battery Safety Management Plan information will be provided to demonstrate the design suitability of the system, determining the best place for these systems to be installed to avoid further propagation of fire or risk to human safety. The emergency response plan will consider the likely path of vented gases to reduce the risk to emergency responders and local population.

Ventilation of gases from inside the modules is achieved with perforations and small vents at each end of the module. A minimum of two air changes must be undertaken per hour, in line with requirements for buildings intended for human occupancy.

3.8 Battery Module Stacking

Modules are stackable like ISO shipping containers, held together with container clamps. Stacking limits are determined based on the seismic conditions of the Site which factors in the location, foundation, soil and enclosure stacking rating. Installation undertaken in this way ensures compliance with Eurocode requirements and seismic requirements, including IEEE 693 and ASCE 7-22.

All stacked modules will be installed with suitable clamps, work platforms, ladders and stairs to ensure units are accessible and maintenance can be undertaken as required.

Units will be stacked in such a way that ventilation is not restricted, allowing air flow throughout the system.

3.9 Site Profile

A geotechnical study must be undertaken by an independent specialist to confirm that the foundations have been built in a way that is fit for purpose.

A concrete pad will be constructed for the siting of the units, anchor bolts will be sized and torqued to the value specified by a professional engineer.

3.10 Security

There are a number of security measures to be utilised at the Site, this includes:

- 2.4m high palisade fencing, installed in 2.7m stretches, with concrete foundations,
- There will be 4m high CCTV cameras located with a minimum of 50m spacing along the perimeter fencing,

- There are a number of double gates (with a width of 6m) in the perimeter fence., Gates will be kept locked except when access is required to the Site.

Please see the Site security measures labelled on the below figure.

Figure 10: Site Security Measures

4 Access

4.1 Site Access

The Site is accessed via the M74 motorway which joins the B7078 (Carlisle Road) roundabout at Junction 11 (Poniel). Access to the Site is gained directly from the junction 11 roundabout via an existing circa 2km long private road.

Please see the figure below:

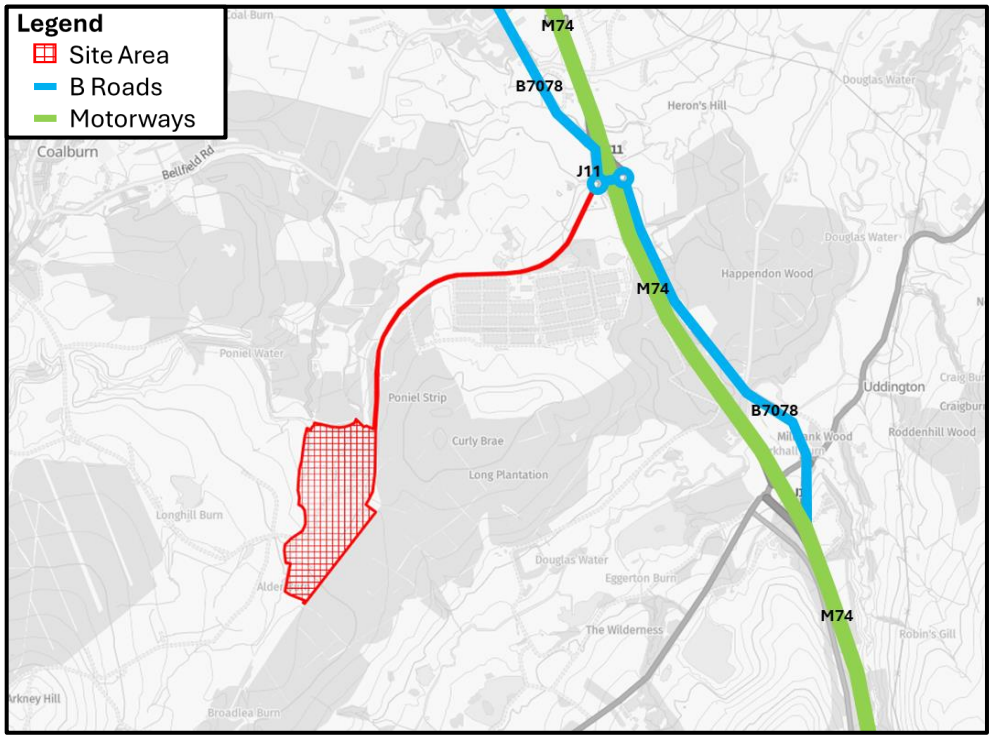

Figure 11: Site Access

The Site, including its access, has been designed to ensure appropriate fire incident response procedures can be undertaken. The new internal roadways will be built to ensure access for the fire service. The roads within the LDES compounds will be underlain by a 350mm layer of 6F2 aggregate, atop this will be a 150mm type 1 well compacted surface layer. (please see drawing No. AEM047 SD-17). The roadway width will be at least 4500mm.

The roadways on site which provide access to the LDES compounds are partially comprised of existing access roads, these existing roadways are currently used for HGVs and abnormal loads and are adequate for use by the fire service.

The LDES compound is separated into two sections by an internal roadway. The southern LDES compound can be entered from three separate entrances all located along the north and north-west boundary of the southern LDES compound. The northern LDES compound can be entered from four separate entrances all located along the southern boundary of the northern LDES compound, allowing the fire service to enter the Site safely depending on the location of any incident. Once inside the LDES compound internal roadways loop around the LDES and inverter units.

The substation is located to the south-west of the Site with access roads to the north of the substation. There are a number of locations for vehicles to turn located on the Site access roads.

4.2 Access Between LDES Units and Unit Spacing

Spacing has been provided between groups of LDES units for servicing and maintenance purposes. This spacing also reduces the likelihood of fire spread between units and allows adequate space between the units for the fire service to lay hoses etc.

Consideration has been given for forklift access to both the front and rear service openings of each module.

A clear space of 3.3m will be provided in front of each module to allow for the servicing of the units (forklift and scaffolding access). At least 0.5m will be provided at the rear of each unit (which, where 2 units are placed back-to-back, provides at least 1m) to allow for the servicing of the unit's fan and air filters via a ladder.

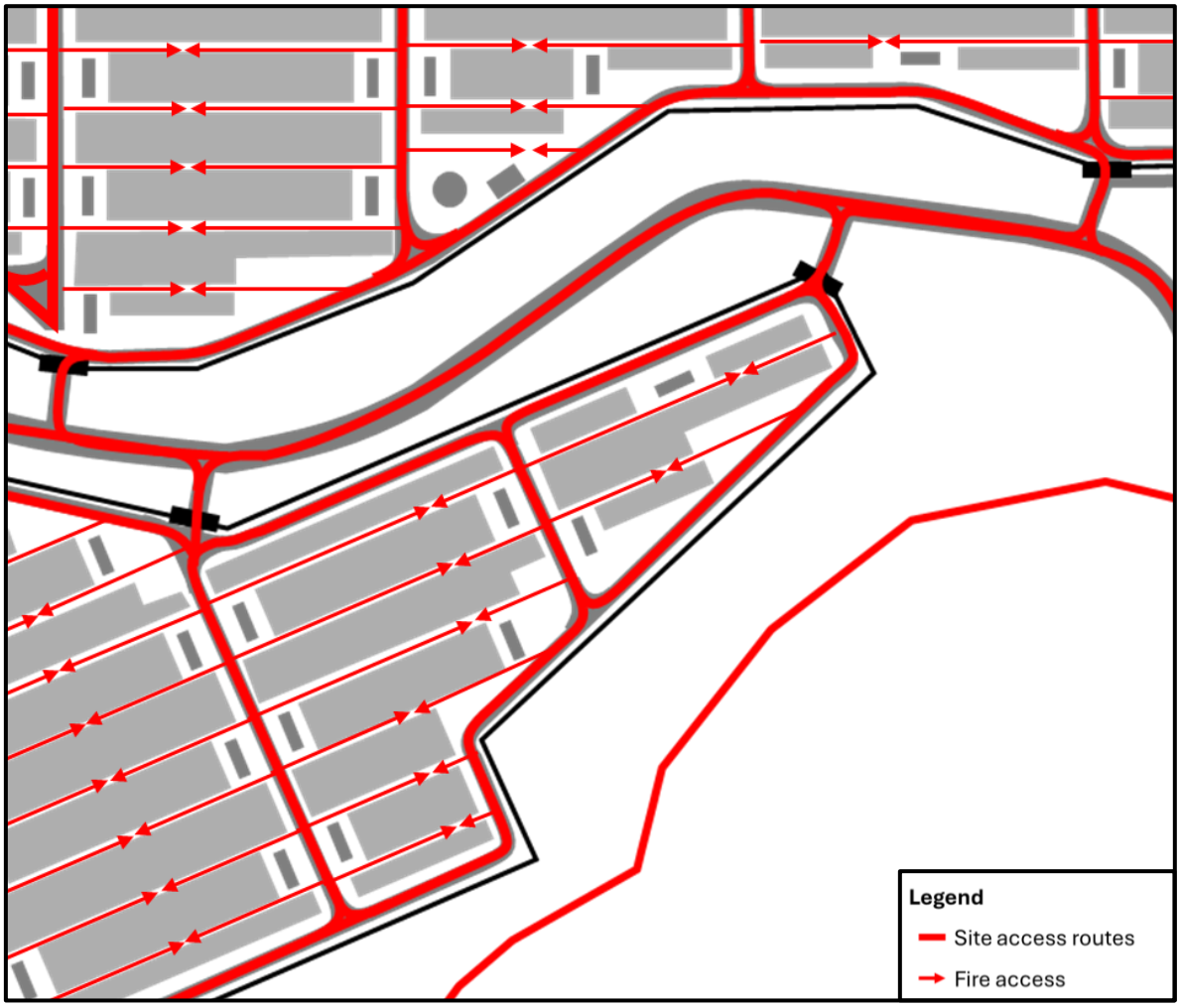

Figure 12: Access to LDES Units

The final BSMP will detail any High Voltage DC electrical systems which may present a risk to firefighters during incident response. Their location will be marked on a plan and stored within the Site information box, ensuring the emergency services are aware of their location.

4.3 Distance from LDES Units to Occupied Buildings and Site Boundaries

The Site setting is rural, with no occupied buildings within 450m of site infrastructure.

4.4 Site Design Considerations

The following features have been included in the Site's design:

- LDES equipment has been spaced to ensure the risk of propagation is reduced relative to the reduced risk of the technology proposed,
- Vehicle parking has been provided on Site to ensure access routes are kept clear,
- There is adequate space available for turning vehicles,
- Barriers, guard rails or bollards will be placed along areas off the access track where required to reduce the likelihood of vehicle collision with Site equipment,
- A spare parts container has been included to ensure there is safe storage for any spare parts and items,
- Areas of vegetation have been kept a safe distance from any LDES units.

The following will be ensured at the Site:

- All areas of vegetation will be kept well maintained and any waste taken off-site to a suitably permitted facility to avoid risk of fire,
- All spare parts and equipment will be stored within the spare parts container (please see Site plan) or located off-site until required,
- Vehicles visiting the Site will utilise the Site's parking facilities and will not park on the Site's access routes,
- All vehicle manoeuvres will be undertaken when and where safe to do so.

5 Water Supplies

The water supply provided for a fire incident at the Site is approximately 360,000 litres, stored within two water storage tanks, both located centrally to the Site. One tank has a capacity of 240,000 litres and is located to the north-west of the southern portion of the Site, the other tank is 120,000 litres and is located to the south of the northern most portion of the Site. Both water tanks are located over 10m away from the nearest battery unit and are located near to the access roads within each compound closest to the central Site access route.

Fire equipment will be stored at each of the entrances, including hoses and pumps to ensure the Fire Service have the equipment required to reach all areas of the Site. The water supply and fire equipment storage will be signposted at the Site entrances to ensure the Fire Service can easily locate it in a fire incident. Fire equipment will be protected from incident with vehicles through the use of barriers, guard rails or bollards. Equipment will have connections compatible with the local fire service equipment.

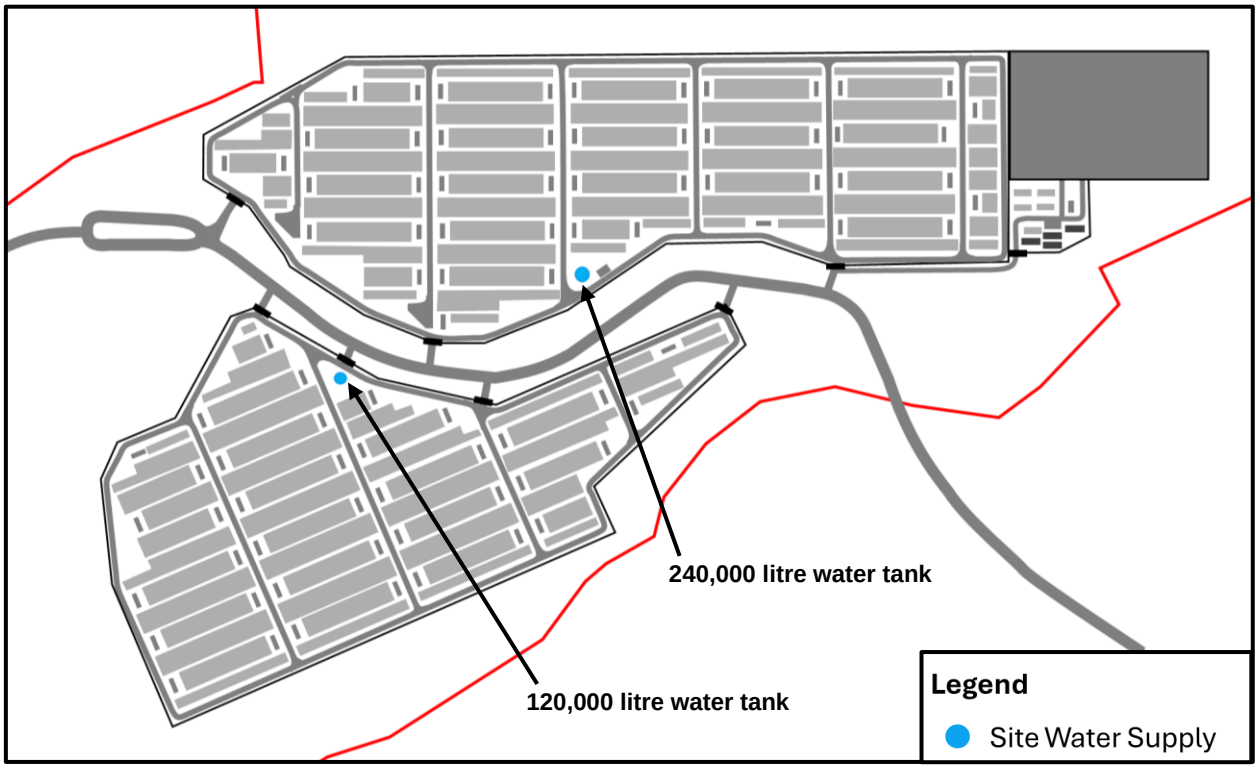

Figure 13: Location of Water Supply

6 Signage

Signage will be installed on the fencing of the LDES compound and the Substation identifying the presence of the equipment and systems located on Site. The signage must be sized so that it is visible from either 30m away or from the Site boundary. To ensure this the sign will be placed on the fence located next to the compounds gated entrances and a light will be fitted to ensure it is visible at all times.

The signage will contain the following details:

- Relevant hazards posed,
- The type of technology associated with the LDES,
- Any suppression system fitted,
- 24/7 Emergency Contact Information.

Where required the signage will be placed on the individual LDES units and where required will be ISO compliant.

There will be signage showing the location of the Site's water supply. In a fire incident this will ensure the fire service can locate the water supply and determine the best access route through the Site.

7 Emergency plans

7.1 Risk Assessment and Management Plan

A Risk Management Plan will be developed by the operator providing advice in relation to:

- The hazards and risks at and to the facility and their proposed management,
- Any safety issues for firefighters responding to emergencies at the facility,
- Safe access to and within the facility for emergency vehicles and responders, including to key Site infrastructure and fire protection systems,
- The adequacy of proposed fire detection and suppression systems (e.g. water supply) on-site,
- Natural and built infrastructure on-Site and processes that may impact or delay effective emergency response.

The following table has been summarised from information provided by the proposed manufacturer of the battery modules in the product manual:

Symbol / Risk	Risk	Mitigation
Electrocution / shock hazard present 	High voltages and other and other electrical related risks present.	• Common connection points for protective earth conductors, • Fuses for power block short circuit protection to protect equipment in the call stack from being overloaded, • Fuses for high voltage over current protection to protect external equipment from being overloaded, • Over-charge hardware protections in the battery module controller, • Current limiting hardware protection to protect from shorts and overloading, • Lightning surge protections for DC links and communications cables.
Corrosive / toxic substance present 	Electrolyte is corrosive and toxic.	• Secondary containment tank, nested within the lower enclosure, drains by gravity (130% of electrolyte volume), • Passive leak detection using detection systems from the pump, tank level will drop below the pump and alert generated, • If leak occurs outside the unit, battery system should be shut down and electrolyte leak plan implemented.
Flammable material present 	Battery module flammability	• Vanadium Flow as opposed to lithium-ion, which is flammable with the risk of thermal runaway, • All-aqueous technology which can operate over a wider temperature range than other battery chemistries, • Electrolyte is not flammable and less susceptible to heat damage, • Housed in a weatherproof enclosure, protecting components and providing thermal management.
	Flammable gases can be generated.	Hydrogen – • Ventilation system used within the units, • Minimum of 2 air exchanges undertaken per hour, • Personal gas meters will be worn when undertaking maintenance near to these areas. Arsine – • Arsine may be detected near open tank ports, operatives to take care and observe local exposure limits,

Symbol / Risk	Risk	Mitigation
Warning / caution 	Incorrect installation, maintenance or operation of system.	• Isolating VFB from external energy sources and allowing stack to discharge to safe levels before undertaking any maintenance, • VFB should not be operated with any external enclosure panels removed, • All wiring connections to battery completed in accordance with the applicable local code, • Electrical grounding completed in accordance with the applicable local code, • External electrical system operated in accordance with product specifications, • The battery shall only be connected to electrical equipment stated within the operations manual, • The battery shall only be operated in line with the environmental conditions for which it was designed, • Air flow path shall be unrestricted, ensuring air flow, • Operators will not service or modify units unless in accordance with the operations manual, • Personnel working on the battery should be familiar with product documentation and appropriate PPE, • No modifications will be made to the connections (electrical and plumbing), • Use extreme care when installing or servicing the battery (insulated tools), • In the event of an electrolyte leak the battery must be disconnected and response should be in accordance with electrolyte leak plan.

Table 2: Invinity Energy Systems Risk Summary

The following risk management table displays a selection of risks and related management techniques related to fire which may be included in the Site's Risk Management Plan:

Hazard	Risk Management
All required areas of the Site will be accessible	• Cars on Site will utilise Site parking areas and will not block any roadways, • Any and all equipment and kit will not be placed in the roadways or in areas which may need to be accessible, • The Site has multiple access points to enable safe access to required areas of the Site in fire incident, • All people who require access to the Site will be provided access codes etc, • Site roadways will be constructed to ensure safe access for site visitors.
No access to water in a fire incident	• Equipment will be provided on Site to ensure the fire service can reach the Site's water supply, all connections will be compatible with the local fire services equipment, • All fire safety equipment will be serviced and maintained as per the product specification or fire service guidance. • Signage will be placed to direct the fire service to the correct locations to access the Site, water supply and fire equipment stored on Site.
Release of polluting material in a fire event	• Venting and deflagration will be placed within the units in line with the relevant guidance, • An emergency response plan will be prepared to reduce the risk of polluting material impact on nearby sensitive receptors, • The fire will be tackled as quickly as possible in a safe manner, • The Environment Agency and any additional relevant authorities will be notified, • The local population will be contacted if thought that the air pollution will impact them.
Release of polluting material in a fire event	• The Scottish Environment Protection Agency (SEPA) and any additional relevant authorities will be notified, • Any fire water will be contained in line with the Site's Drainage Plan, • The fire water will be assessed to see if it can be disposed of within the foul water sewer in line with the Site's wastewater consents, • If the fire water cannot be disposed of within the foul water sewer it will be tankered off to a suitably permitted facility.
Damage to equipment and infrastructure	• Equipment and infrastructure will be kept well maintained, according to a regular maintenance schedule, • If any equipment or infrastructure experiences a fault, it will be checked quickly by a suitably qualified person and mended or replaced as required.

Table 3: Example Risk Management Table

7.2 Emergency Response Plan

Before the Site is operational an Emergency Response Plan will be produced. This will cover emergency procedures for all credible hazards and risks, including building, infrastructure and vehicle fire and grass fire.

7.2.1 Alerting the Fire Service

In the event of a fire incident occurring on Site, the on-site detection systems should alert Site operatives (on-site or remote) of the incident. Site operatives will then alert the fire service, Site key-holder and any additional relevant authorities of the fire incident.

The Site keyholder will be waiting at the Site until the fire service arrive. The Fire Service will then be provided access to the Site, provided information surrounding the incident and provided the documents contained within the information box provided at the Site entrance.

The following table contains details of fire stations within 20 kilometres of the Site:

Fire Station	Postcode	Approximate distance	Approximate time to Site	Fire service
Douglas Community Fire Station	ML11 0NS	8.9km	10 min	Scotland Fire and Rescue Service
Lesmahagow Community Fire Station	ML11 0DG	10.4km	11 min	Scotland Fire and Rescue Service
Abington Fire Station	ML12 6RZ	19.1km	16 min	Scotland Fire and Rescue Service
Lanark Fire Station	ML11 7QT	17.4km	22 min	Scotland Fire and Rescue Service

Table 4: Nearby Fire and Rescue Services

7.2.2 Site Evacuation Procedure

The site will be staffed 24/7.

In the event that an operator is alerted to an incident on Site the following will be undertaken:

- The operator will alert any other operators of the incident on-site,
- The operator will ensure the Site is clear,
- The operator will make their way to the fire evacuation point,
- The operator will contact the fire service and any other relevant authorities,
- When the fire service arrives on Site the operator will provide them with the information provided within the Site's information box and relay any known information of the incident on Site.

7.2.3 Site Contacts

Before operations begin at the Site the following table will be filled in and displayed within the Site's control and welfare container.

The Site contacts record will be kept up-to-date and will contain details for facility personnel and off-Site personnel that may be required to provide technical support during an emergency.

Position	Name	Contact Type	Contact

Table 5: Example Site Contacts Table

7.2.4 Facility Description

A facility description will be provided including infrastructure details, operations, number of personnel, and operating hours of the Site.

A copy will be stored in the control container and can be accessed by Site operatives.

7.2.5 Emergency Resources

The Site Emergency Response Plan will be accessible to all Site operatives and provided at the Site's entrances for use by the emergency services.

Equipment which may be required by the fire service in a fire incident will be stored by the Site access points to ensure it can be easily accessed in a fire incident.

Additional emergency resources will be stored either within the Site's control container or spare parts container. The equipment housed at the Site will include first aid, spill kits, emergency eye-wash facilities, emergency warning systems, communication systems and personal protective equipment (PPE) and key spare parts which may be required in an emergency.

The following lists the spare parts key to reducing costs and equipment downtime as well as generally keeping the system in good working order:

Item number	Description	Item number.	Description
100944	Clamp, pinch, for 11.5 to 14 mm tubing, 304 SS	104286	Assembly, AC breaker, pump motor VFD
100946	Tubing 25in IDx 5in OD, EPDM PP, rated 20psi	104287	Assembly, AC circuit breaker, fan
100951	O-ring #235, Viton	104288	Circuit breaker, AC, 3 pole, 1A curve C, 480V, 10kAIC, UL, CE, CSA
100958	Pipe thread sealer, PTFE based	104293	Module controller assembly

Item number	Description	Item number.	Description
101051	Assembly, air temperature sensor, with intermediate connector plug	104307	Fan box plenum with air intake filter housing assembly
103878	Pump-motor assembly mounted onto bracket with inlet and outlet electrolyte couplers	104313	Gas management assembly
103904	Blower, 380-480VAC, 3P, 50/60Hz. Built in VFD.	104787	Module harness package (almost every electrical harness included)
104194	Module controller	104901	Fuse assembly, DC balancer, module
104195	Assembly, Motor 4HP	104903	Contactor, AC 3 phase 3 pole, 50A, 690V (max), 24VDC coil
104197	VFD, 4hp, 380-480VAC 3P in, 6.5A 3P out, UL and CE	104904	Contactor, accessory, aux contact (1NO+1NC) for J7KN contactor
104218	PSU, 24VDC (fixed) 100w out. 108-305VAC in. UL and CE	104905	Circuit breaker, AC, 3 pole, 6A Curve C, 480V, 10kAIC, UL, CE, CSA
104231	Power block assembly	104906	Circuit breaker, AC, 3 pole, 10A Curve C, 480V, 10kAIC, UL, CE, CSA
104274	Fuse assembly, power block	104909	Assembly, PSU, 24VDC control power
104277	DC current sensor assembly	104911	Switch, door interlock, 2NC, roller actuator UL and CE
104278	Fuse, DC, 1500V, 200A, 30kAIC, Bolted Blade, UL and CE	104916	Inflatable Duct
104283	Assembly, contactor, main AC – module	104951	Assembly, DC Disconnect 1500V, 400A

Table 6: Spare Parts Log

Spare parts will only be fitted if it is safe to do so.

7.2.6 Dangerous Goods Stored On-Site

Before operations begin at the Site the following table will be filled in and displayed within the Site's control container, in addition to copies located within the Site information boxes, stored with any fire related equipment, located at the Site entrances:

Item	Description	Location	Grid reference

Table 7: Example Dangerous Goods Storage Table

7.2.7 Site Information Box

An information box will be installed at the Site entrances to ensure there is safe access to any Site information for the first responders. The information box will contain but is not limited to the following details:

- The Emergency Response Plan,
- Facility description which includes key infrastructure details, operation details, operating hours etc.,
- Site plans highlighting; key infrastructure, Site access points, internal facilities,
- Information surrounding the Site's firefighting facilities; water supply, pumps, nearby hydrants, fire hose reels etc.,
- Drainage plans that highlight any pollution control measures to be put in place,
- Sensitive neighbouring properties.

8 Recovery

Post fire incident the following recovery steps will be followed:

- The Site will be temporarily shut down and the remaining LDES de-energised to remove the potential for reignition.
- All relevant authorities will be contacted, for example this may include the SEPA surrounding any potential pollution incident.
- A post incident investigation will be conducted to determine the cause and response to the incident. A report will be produced by the Site operator covering the findings of the investigation and any changes to the Site operation and infrastructure to reduce the likelihood of a repeat incident.
- The Site will be cleared, and any damaged equipment will be removed from Site and taken to a suitably permitted facility for disposal.
- Once the Site is deemed safe and the required mitigation put in place, the system may be re-energised.

A full site Recovery Plan will be prepared and details provided within the Emergency Response Plan prior to the commencement of operations.