Kintore Hydrogen Facility

Appendix 13.2: Flood Risk Assessment

Kintore Hydrogen Ltd

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Table of Contents

Basis of Report i
Acronyms and Abbreviations v
1.0 Background 1
1.1 Introduction 1
1.2 Site location 1
1.3 Flood risk terminology 2
2.0 Sources of information 3
2.1 National floodplain mapping 3
2.1.1 Electrolysis plant 3
2.1.2 Gas injection site 4
2.1.3 Water abstraction, treatment and discharge site 4
2.2 Flood history and records 5
2.3 Planning context and regulatory guidance 5
2.3.1 National Planning Framework 4 (NPF4) 5
2.3.2 Aberdeenshire Local Development Plan January 2023 7
2.3.3 SEPA flood risk and land use vulnerability guidance 8
2.3.4 SEPA climate change guidance 8
3.0 Flood risk screening 9
4.0 Detailed flood risk review 15
4.1 Baseline conditions 15
4.1.1 Existing site and surrounding terrain 15
4.1.2 Site topography 16
4.1.3 Proposed development 17
4.1.4 Local hydrology 18
4.1.5 Historical land use 18
4.2 Hydrological assessment 18
4.3 Hydraulic model 19
4.3.1 Model build 19
4.3.2 Model results 22
4.3.3 Model quality assurance 27
4.3.4 Model stability 28
4.3.5 Model sensitivity testing 28
5.0 Summary and recommendations 31

Tables in Text

Table 3-1 : Flood risk screening - electrolysis plant site 10
Table 3-2 : Flood risk screening – gas injection site 11
Table 3-3 : Flood risk screening – water abstraction, treatment and discharge site 12
Table 4-1: Summary of Peak Fluvial Inflows for the 0.5% AEP plus CC event 19
Table 4-2: Modelled material Properties 21
Table 4-3: Floodplain loss and compensatory storage volume available 23
Table 4-4: Sensitivity Analysis Variables 29

Figures in Text

Figure 1-1 – Site location 2
Figure 2-1 – SEPA Surface Water Flood Mapping at the electrolysis plant site 3
Figure 2-2 – SEPA river and surface water flood mapping at the gas injection site 4
Figure 2-3 – SEPA River and Surface Water Flood Mapping at the water abstraction and treatment plant 5
Figure 4-1 – Elevation data 17
Figure 4-2 – Hydraulic model domain (extent) 20
Figure 4-3 – Baseline 1:200+CC modelled flood depths 22
Figure 4-4 – Proposed Development 23
Figure 4-5 – Proposed Compensatory Storage Area 24
Figure 4-6 – 1:200+CC event with the inclusion of compensatory storage comparison (proposed vs baseline) 24
Figure 4-7 – Potential Dewsford Burn realignment 25
Figure 4-8 – Flood risk in realigned Dewsford Burn 26
Figure 4-9 – Access and egress route (electrolyser area) 27
Figure 4-10 – TUFLOW HPC Checks 28
Figure 4-11 – 1:200+CC sensitivity testing of Mannings n roughness 29
Figure 4-12 – 1:200+CC sensitivity testing of flows 30

Photos in Text

Photograph 1 : Electrolysis plant site location (facing north from a central point within the site) 15
Photograph 2 : Electrolysis plant site (facing south, from the north edge of the site from the Dewsford Burn) 16

Annexes

Annex A Illustrative Development Plan

Annex B Topographic Survey

Annex C SEPA Checklist

Annex D Hydrology Report

Acronyms and Abbreviations

AEP	Annual Exceedance Probability
AOD	Above Ordnance Datum
BREEAM	Building Research Establishment Environmental Assessment Method
CC	Climate Change
CFB	Coastal Flood Boundary
DTM & DSM	Digital Terrain Model, Digital Surface Model
FFL	Finished Floor Level
FRA	Flood Risk Assessment
HPC (TUFLOW)	Heavily Parallelised Compute
HT	Head-Time
LiDAR	Light Detection and Ranging
NPF4, NPF3	National Planning Framework 4, 3
NGR	National Grid Reference
PVA	Potentially Vulnerable Area
OS	Ordnance Survey
QA	Quality Assurance
RCP	Representative Concentration Pathway
SEPA	Scottish Environment Protection Agency
SGS	Sub-grid sampling
SPP	Scottish Planning Policy
UKCP18	United Kingdom Climate Projections – 2018 dataset
2D	Two-Dimensional

1.0 Background

1.1 Introduction

SLR Consulting Limited (SLR) was commissioned by Kintore Hydrogen Ltd (the “Client”) to undertake a Flood Risk Assessment (FRA) at the proposed Kintore electrolysis plant, water abstraction and treatment plant and the gas injection location (the “Sites”).

This FRA report has been prepared to assess flood risk to the Sites and flood risk resulting from the Proposed Development. It has been informed by hydraulic modelling and has been completed in accordance with best practice and legislation including National Planning Framework 4 (NPF4) and the Aberdeenshire Local Development Plan.

An outline Drainage Impact Assessment is reported separately and shows how incident rainfall-runoff form the proposed development will be collected and attenuated prior to discharge.

1.2 Site location

The electrolysis plant site is located on land to the west of the existing Kintore Substation, approximately 2.8 km to the southwest of Kintore, Aberdeenshire, 0.3 km northwest of Leylodge and 0.5 km to the west of the B977.

The existing National Grid Gas high-pressure natural gas pipelines runs from north to south, 1.3 km to the west of the A96 and close to Broomhill Plantation. The proposed connection point would be within farmland around 1 km southwest of the A96 and Kinellar.

The consented water abstraction point is located on the south bank of the River Don off Rushlach Road, approximately 1.5 km southeast of the edge of Kintore.

The location of the Sites is presented on Figure 1-1 and illustrative development plans of the Sites is included in Annex A.

Figure 1-1 – Site location

1.3 Flood risk terminology

Flood risks are typically expressed by the probability of the occurrence of a flood event (maximum flood height or other such indicator) of stated magnitude or greater in any one year – termed the Annual Exceedance Probability (AEP). This may be expressed as a percentage (such as 1%, 0.5%, etc.) or by the equivalent chance of occurrence (1:100, 1:200, etc.). For convenience, the latter approach is used in this report.

Where flood events have a climate change factor included, the flood event is denoted in this report by "+CC". For example, the 1:200 AEP flood event with climate change included is denoted "1:200+CC".

2.0 Sources of information

2.1 National floodplain mapping

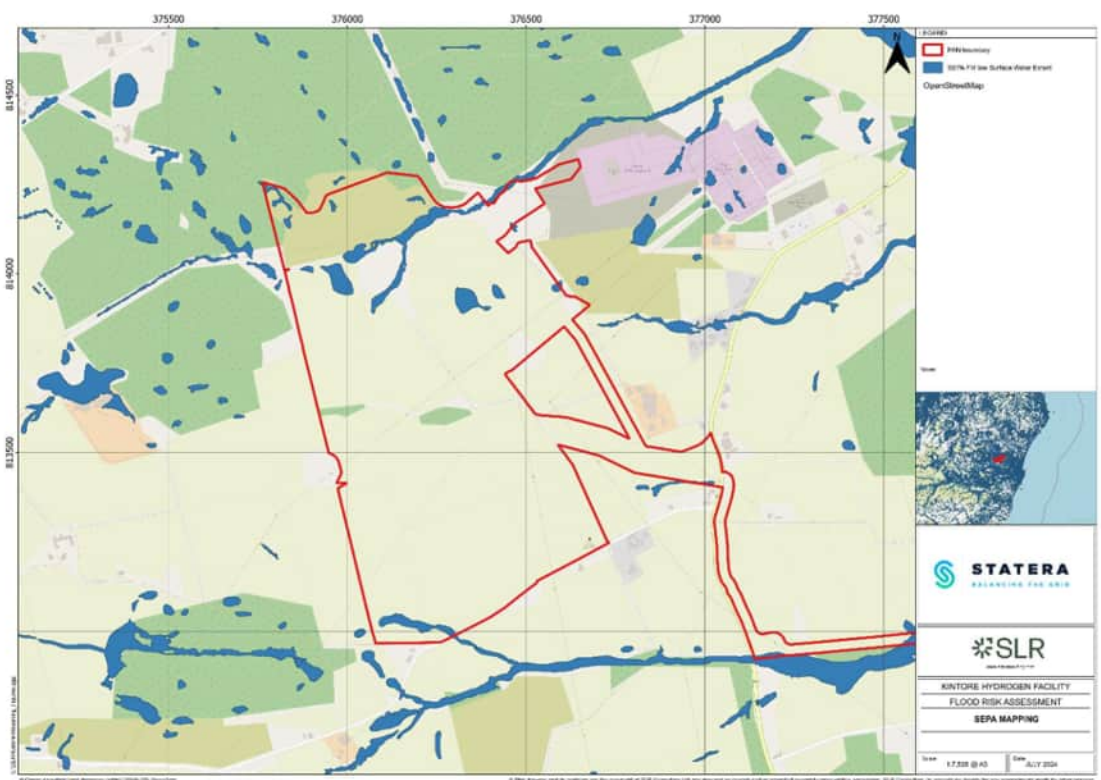
Strategic level information regarding the tidal, fluvial and surface water flood risk at the Sites have been obtained from SEPA via the online SEPA Flood Maps[1]. Information on potential groundwater flood risk has been obtained from the SEPA Flood Risk Management Maps[2].

The Sites are not shown to be at risk of coastal flooding for any of the modelled events mapped by SEPA and therefore the risk of coastal flooding is not discussed in the following sections.

2.1.1 Electrolysis plant

The SEPA surface water flood risk mapping (low likelihood scenario) for the electrolysis plant area is shown on Figure 2-1, part of which is shown to be at risk of surface water flooding, although there is an element of the surface water flood mapping that may be representative of fluvial flooding from the Dewsford Burn. As the Dewsford Burn catchment area is less than 3 km^2 at this location, it is not included in the SEPA fluvial flood mapping.

Figure 2-1 – SEPA Surface Water Flood Mapping at the electrolysis plant site



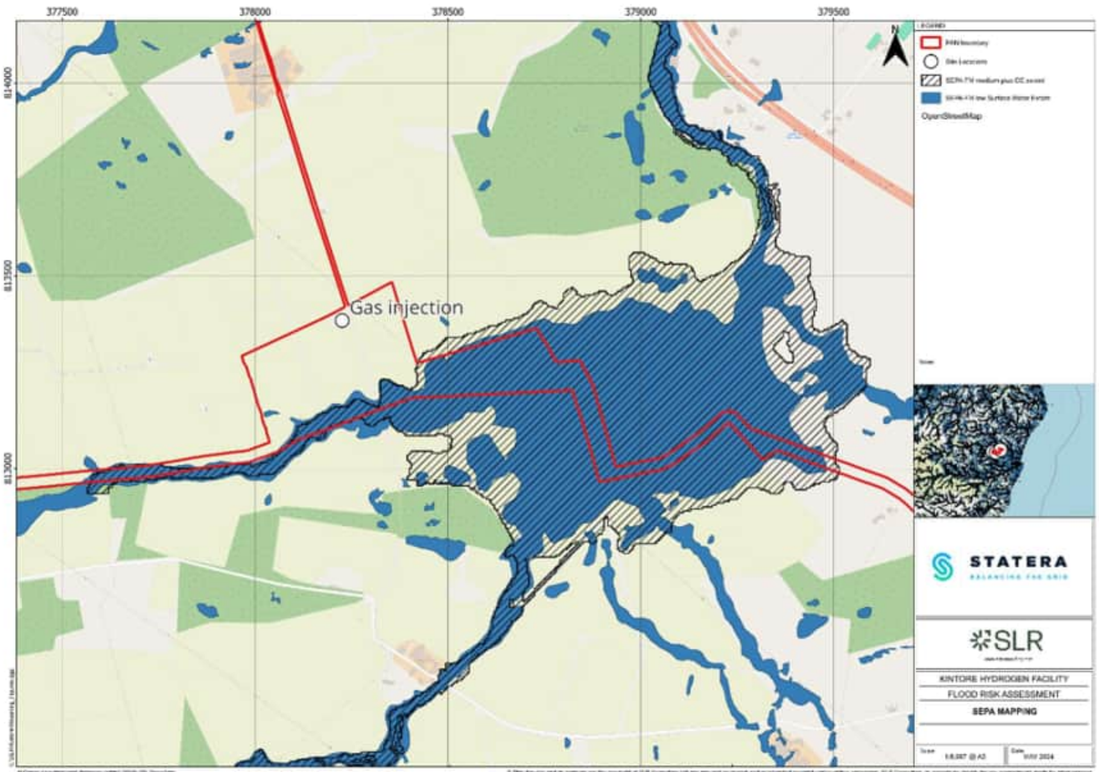
[1] Scottish Environment Protection Agency (2022) SEPA Flood Maps, available online at https://map.sepa.org.uk/floodmaps, [Last Accessed July 2024]

[2] Scottish Environment Protection Agency (2016) Online Flood Risk Management Maps, available at: http://map.sepa.org.uk/floodmap/map.htm, [Last Accessed July 2024]

2.1.2 Gas injection site

The SEPA fluvial (medium plus CC scenario) and surface water (low likelihood scenario) flood risk mapping for the gas injection site is given on Figure 2-2 and shows that part of the southern extent of the gas injection site is at risk from both fluvial and surface water flooding, however, no overground infrastructure is proposed within these areas denoted to be at risk.

Figure 2-2 – SEPA river and surface water flood mapping at the gas injection site

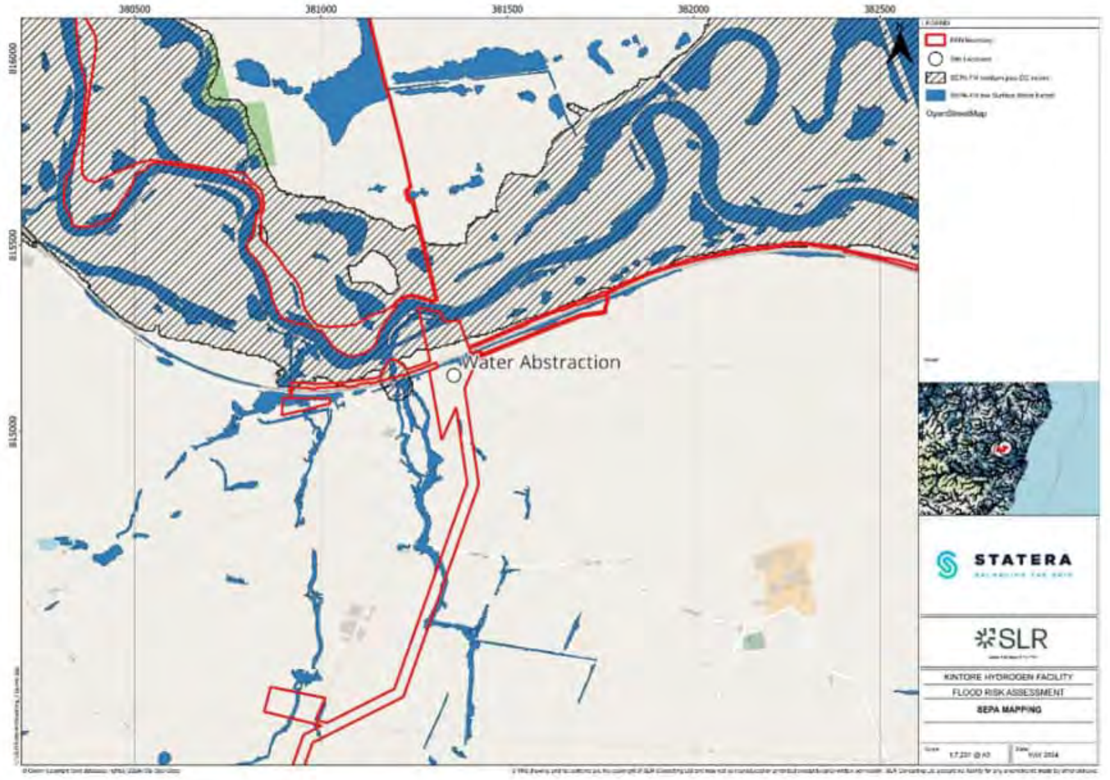


2.1.3 Water abstraction, treatment and discharge site

SEPA mapping demonstrates that part of the northern extent of the water abstraction, treatment and discharge site is at risk from surface water flooding (see Figure 2-3). It is noted, however, that similar to the gas injection site, no overground infrastructure is proposed in these areas (see Annex 01).

As part of the Proposed Development, there will be a need to house the abstraction offtake and the discharge effluent point for return flows on the south bank of the River Don, which is located within the mapped floodplain. These activities are considered water compatible use and will be regulated under by the Controlled Activity Regulations (CAR) and PPC legislation. These will ensure that the abstraction offtake and discharge point will have negligible impact on flood risk nor impede the conveyance of the River Don.

Figure 2-3 – SEPA River and Surface Water Flood Mapping at the water abstraction and treatment plant



2.2 Flood history and records

Within the Scottish Flood Risk Management Strategies, the Sites are located within the 2018 Inverurie and Kintore Potentially Vulnerable Area (PVA) (02/06/13)[3]. This area is designated as a PVA due to flooding in Inverurie and Kintore, most recently in January 2016. Past floods were caused by fluvial flooding of the River Don, the Urie and other smaller watercourses as well as flooding from surface water. The assessment confirms a significant flood risk from river and surface water flooding to homes and businesses. Aberdeenshire Council is working on a flood study on the River Don and Urie in Inverurie with a future study planned in Kintore.

2.3 Planning context and regulatory guidance

2.3.1 National Planning Framework 4 (NPF4)

National Planning Framework 4 (NPF4)[4] was introduced in February 2023 and supersedes National Planning Framework 3 (NPF3) and Scottish Planning Policy (SPP) 2014. Flood risk is addressed in Policy 22 of NPF4, which states the following:-

a) Development proposals at risk of flooding or in a flood risk area will only be supported if they are for:

[3] Scottish Environment Protection Agency (2018) Potentially Vulnerable Areas (2018), accessible at: https://www.sepa.org.uk/data-visualisation/nfra2018/ [Last Accessed July 2024]

[4] Scottish Government (2023) National Planning Framework 4 (NPF4)

i. essential infrastructure where the location is required for operational reasons;

ii. water compatible uses;

iii. redevelopment of an existing building or site for an equal or less vulnerable use; or,

iv. iv. redevelopment of previously used sites in built up areas where the LDP has identified a need to bring these into positive use and where proposals demonstrate that long term safety and resilience can be secured in accordance with relevant SEPA advice.

The protection offered by an existing formal flood protection scheme or one under construction can be taken into account when determining flood risk. In such cases, it will be demonstrated by the applicant that:

- all risks of flooding are understood and addressed;
- there is no reduction in floodplain capacity, increased risk for others, or a need for future flood protection schemes;
- the development remains safe and operational during floods;
- flood resistant and resilient materials and construction methods are used; and
- future adaptations can be made to accommodate the effects of climate change.

Additionally, for development proposals meeting criteria part iv), where flood risk is managed at the site rather than avoided these will also require:

- the first occupied/utilised floor, and the underside of the development if relevant, to be above the flood risk level and have an additional allowance for freeboard; and
- that the proposal does not create an island of development and that safe access/ egress can be achieved.

b) Small scale extensions and alterations to existing buildings will only be supported where they will not significantly increase flood risk.

c) Development proposals will:

i. not increase the risk of surface water flooding to others, or itself be at risk.

ii. manage all rain and surface water through sustainable urban drainage systems (SUDS), which should form part of and integrate with proposed and existing blue green infrastructure. All proposals should presume no surface water connection to the combined sewer; and

iii. seek to minimise the area of impermeable surface.

d) Development proposals will be supported if they can be connected to the public water mains. If connection is not feasible, the applicant will need to demonstrate that water for drinking water purposes will be sourced from a sustainable water source that is resilient to periods of water scarcity.

e) Development proposals which create, expand or enhance opportunities for natural flood risk management, including blue and green infrastructure, will be supported.

NPF4 defines an area at risk of flooding as follows:

For planning purposes, at risk of flooding or in a flood risk area means land or built form with an annual probability of being flooded of greater than 0.5% (1:200 AEP) which must include an appropriate allowance for future climate change.

This risk of flooding is indicated on SEPA's future flood maps or may need to be assessed in a flood risk assessment. An appropriate allowance for climate change should be taken from the latest available guidance and evidence available for application in Scotland. The calculated risk of flooding can take account of any existing, formal flood protection schemes in determining the risk to the site.

Where the risk of flooding is less than this threshold, areas will not be considered 'at risk of flooding' for planning purposes, but this does not mean there is no risk at all, just that the risk is sufficiently low to be acceptable for the purpose of planning. This includes areas where the risk of flooding is reduced below this threshold due to a formal flood protection scheme.

2.3.2 Aberdeenshire Local Development Plan January 2023[5]

2.3.2.1 Policy C4: Flooding

C4.1 Flood Risk Assessments should be undertaken in accordance with SEPA Technical Flood Risk Guidance and will be required for development in the indicative medium to high category of flood risk of 0.5% or greater annual probability (1 in 200 years or more frequent).

Assessments may also be required in areas of lower annual probability (0.1%- 0.5% annual probability) in circumstances where other factors indicate a potentially heightened risk or there are multiple sources of potential flooding. Assessments should include an allowance for freeboard and climate change. Development should not increase flood risk vulnerability and should avoid areas of medium to high risk, functional floodplain or other areas where the risks are otherwise assessed as heightened or unacceptable except where:

- It is a development to alleviate flooding or erosion of riverbanks or the coast;
- It is consistent with the flood storage and conveyance function of a floodplain;
- It would otherwise be less affected by flooding (such as a play area or car park);
- It is essential infrastructure. The location is essential for operational reasons for example for water-based navigation, agriculture, transport or utilities infrastructure and an alternative lower risk location is not available.

C4.2 If development is to be permitted on land assessed as at a medium to high risk of flooding it should be designed to be flood resilient for the lifetime of the development (this is normally a minimum of 100 years for residential development) and use construction methods to assist in the evacuation of people and minimise damage. It must not result in increased severity of flood risk elsewhere through altering flood storage capacity or the pattern and flow of flood waters.

C4.3 Buffer strips, for enhancement of the watercourse and necessary maintenance, must also be provided for any water body.

C4.4 These measures may also be required in areas of potentially lower risk of flooding (annual probability of more than 1:1000 years) or in coastal areas below the 10 metre contour should evidence demonstrate a heightened risk14.

C4.5 In such areas land raising and/or excavations will only be permitted if it is for a flood alleviation measure, it is linked to the provision and maintenance of direct or indirect compensatory flood water storage to replace the lost capacity of the functional floodplain, and it will not create any inaccessible islands of development during flood events or result in the need for flood prevention measures elsewhere.

[5] Aberdeenshire Council (2023) Aberdeenshire Local Development Plan

C4.6 We will not approve development that may contribute to flooding issues elsewhere. Sustainable Urban Drainage principles apply to all sites. C4.7 We are opposed to the enclosed culverting of watercourses for land gain and will actively seek to discourage such proposals. We encourage the daylighting (or de-culverting) of existing culverted watercourses.

2.3.3 SEPA flood risk and land use vulnerability guidance

This guidance[6] outlines how SEPA assess vulnerability of flooding of different land uses with the following Categories:

- Most Vulnerable Uses;
- Highly Vulnerable Uses;
- Least Vulnerable Uses;
- Essential Infrastructure; and
- Water Compatible Uses.

With reference to Table 1 of the guidance, the Proposed Development is considered to be **Essential Infrastructure** as it is *'essential utility infrastructure that has to be located in a flood risk area for operational reasons (this includes electricity generating power stations and grid and primary sub-stations, sewage treatment plants and water treatment works, wind turbines and other energy generating technologies)'.* It should be noted that the guidance available at time of writing has not been updated to reflect NPF4 although, the classification is still relevant.

2.3.4 SEPA climate change guidance

The SEPA climate change allowances[7] for flood risk assessment in land use planning version 3, April 2023 was used to inform the appropriate climate change allowances. SEPA allowances are based on the climate predictions (UKCP18). The SEPA guidance is based upon UKCP18 data, using Representative Concentration Pathway 8.5 (RCP 8.5), which assumes limited efforts to mitigate climate change, so that greenhouse gas levels in the atmosphere will continue to increase.

The allowances used for this FRA are as follows:

- Peak river flow, +34%
- Cumulative sea level rise 2017 to 2100, +0.87m
- Peak rainfall intensity allowance, +37%

[6] SEPA (2024) Flood Risk and Land Use Vulnerability Guidance

[7] SEPA (2023) Climate change allowance for flood risk assessments in land use planning, available online at https://www.sepa.org.uk/media/gq3c2xyb/climate-change-allowances-guidance-v4-final_nov23.pdf , Version 4 [Last Accessed July 2024]

3.0 Flood risk screening

A screening review has been completed as below to identify whether there are any potential sources of flooding at the Sites which warrant detailed assessment and /or mitigation.

A summary of the potential sources of flooding and a review of the potential risk posed by each source to the Sites is presented in Table 3-1, Table 3-2 and Table 3-3.

Potential sources of flooding include:

- Flooding from the sea or tidal flooding;
- Flooding from rivers or fluvial flooding;
- Flooding from surface water and overland flow;
- Flooding from groundwater;
- Flooding from sewers;
- Flooding from reservoirs, canals, and other artificial sources; and,
- Flooding from infrastructure failure.

Flood 'risk' definitions within the screening assessment are based on a qualitative technical assessment considering the information reviewed, risk to site users and the development itself.

Reviewing Table 3-1, Table 3-2 and Table 3-3, it is shown:

- the gas injection infrastructure is outwith the SEPA flood mapping extents and there is a difference in elevation between the site and the nearest flood extents of approximately 4m;
- the water abstraction and discharge site has some minor surface water identified but this is not in an area of proposed infrastructure. The surface water flooding is caused by the presence of the Network Rail embankment. The difference in elevation of the site and the flood extent from the River Don is around 5m.
- the main electrolysis plant site location was identified as at risk of flooding from surface water as noted in the SEPA mapping. This surface water flood extent may also be representative of fluvial flooding. Due to the small size of the Dewsford Burn catchment, it is not included in the SEPA fluvial flood mapping.

Therefore, only the electrolysis plant site requires a detailed assessment for fluvial flooding. This is assessed in Section 4.0.

Table 3-1 : Flood risk screening - electrolysis plant site

Source of Flood Risk	Description	Flood Risk Assessment
Tidal	• The minimum elevation at the electrolysis plant site is approximately 100 m AOD and the site is located approximately 20 km inland from the North Sea. There is, therefore, a negligible risk of tidal flooding.	**Negligible Risk**
Fluvial	• The Dewsford Burn lies within the northern extent of the electrolysis plant site. • The watercourse is not included in the SEPA flood mapping (Figure 2-1), due to the size of the catchment being less than 3 km^2 although, the surface water flood mapping is indicating potential for fluvial flooding. • It is therefore considered that fluvial flooding associated with the Dewsford Burn requires additional assessment to determine the flood extent.	**Further Review Required**
Pluvial (i.e., direct rainfall)	• Site elevations across the electrolysis plant site decrease north and southwards from a high within the centre of the site, with some natural undulations and depressions. Any excess flows resulting from direct rainfall would be expected to migrate primarily north towards the Dewsford Burn or southward towards the Park Burn. • SEPA surface water mapping indicates that there is also some smaller isolated areas of surface water ponding within northern extent of the electrolysis plant site and a small flow path within the southern extent of the electrolysis plant site. No overground development is proposed near the flow path within the southern extent of the electrolysis plant site (see Annex 01). • The ponding within the northern extent of the electrolysis plant site corresponds to a natural depression as observed during the site visit and on review of the topographic survey and LIDAR. As the site elevation is due to be re-graded as part of the development, surface water flooding will be managed and mitigated by the drainage design. • It is therefore considered that the electrolysis plant site is not at significant pluvial flood risk.	**Negligible Risk**
Surface Water Flows	• Inspection of local topography and surrounds indicates that the electrolysis plant site generally slopes northwards or southwards from a topographic high with some natural undulation and depressions. The topography is such that flows would be expected to travel uninhibited overland, towards either the Dewsford Burn or Park Burn. There may be some ponding in natural depressions across the electrolysis plant site, however, given that the site will be re-graded and managed by on site drainage, surface water flooding is considered of negligible risk to the electrolysis plant site.	**Negligible Risk**
Groundwater	• SEPA flood mapping indicates that the electrolysis plant site is not at risk from groundwater flooding. This is consistent with the low permeability underlying geology. There is a negligible risk of flooding from groundwater flooding at the electrolysis plant site.	**Negligible Risk**

Source of Flood Risk	Description	Flood Risk Assessment
Sewers and Artificial Drainage Systems, and Water Supply	• The electrolysis plant site is in an agriculture setting and there was no indication of any existing drainage system on site. • Based on these considerations, there is a negligible risk of flooding from this source.	**Negligible Risk**
Infrastructure Failure (i.e. reservoirs, canals, culvert blockage, etc.)	• SEPA Reservoirs Mapping[8] indicates that the electrolysis plant site is outwith any mapped reservoir flood extents. • Reservoirs in Scotland are regulated under the Reservoirs (Scotland) Act 2011 and there has been no loss of life in the UK as a result of reservoir flooding since 1925. • Therefore, infrastructure failure is considered of negligible risk to the electrolysis plant site.	**Negligible Risk**

Table 3-2 : Flood risk screening – gas injection site

Source of Flood Risk	Description	Flood Risk Assessment
Tidal	• The gas injection site has a minimum elevation of approximately 75 m AOD and is 18 km inland from the North Sea. • There is, therefore, a negligible risk of tidal flooding.	**Negligible Risk**
Fluvial	• The gas injection site lies north of the Park Burn. • The watercourse is included in the SEPA flood mapping (Figure 2-2), and it demonstrates the proposed overground infrastructure is outwith the 1:200+CC floodplain mapping extent. A review of local topography indicates that there is approximately 4 m difference in ground elevations between the 1:200+CC floodplain and the location of the proposed overground infrastructure. • It is therefore considered that the gas injection site is of negligible risk from fluvial flooding	**Negligible Risk**
Pluvial (i.e., direct rainfall)	• The gas injection site elevations generally decrease south eastwards towards the Park Burn, and any excess flows resulting from direct rainfall would be expected to migrate towards the Park Burn. The SEPA surface water mapping indicates that there is no surface water ponding at the injection the gas injection site. • It is therefore considered that the gas injection site is not at significant pluvial flood risk.	**Negligible Risk**

[8] Scottish Environment Protection Agency (2022) Reservoirs. Available at: Reservoirs | Scottish Environment Protection Agency (SEPA), last accessed 29/08/2023

Source of Flood Risk	Description	Flood Risk Assessment
Surface Water Flows	• Inspection of local topography and surrounds indicates that the gas injection site generally decreases south eastwards towards the Park Burn. The local topography is such that flows would be expected to travel uninhibited overland, towards the Park Burn. • It is therefore considered of negligible risk to the gas injection site.	**Negligible Risk**
Groundwater	• SEPA flood mapping indicates that the gas injection site is not at risk from groundwater flooding.	**Negligible Risk**
Sewers and Artificial Drainage Systems, and Water Supply	• The gas injection site is located in an agriculture setting and there is no indication of any existing drainage system on site. • Based on these considerations, there is a negligible risk of flooding from this source.	**Negligible Risk**
Infrastructure Failure (i.e. reservoirs, canals, culvert blockage, etc.)	• SEPA Reservoirs Mapping indicates that the gas injection site is outwith any mapped reservoir flood extent. • Reservoirs in Scotland are regulated under the Reservoirs (Scotland) Act 2011 and there has been no loss of life in the UK as a result of reservoir flooding since 1925. • Therefore, infrastructure failure is considered of negligible risk to the gas injection site.	**Negligible Risk**

Table 3-3 : Flood risk screening – water abstraction, treatment and discharge site

Source of Flood Risk	Description	Flood Risk Assessment
Tidal	• The water abstraction, treatment and discharge site has a minimum elevation of approximately 53 m AOD and is 15 km inland from the North Sea. • There is, therefore, a negligible risk of tidal flooding.	**Negligible Risk**
Fluvial	• The main water abstraction, treatment and discharge site lies south of the River Don, however, part of the works will include creating a structure within the River Don bed and underground pipeline connection through the river bank. • The watercourse is included in the SEPA flood mapping (Figure 2-3), and it demonstrates the planned overground infrastructure (pumping station and potential water treatment works) is outwith the 1:200+CC mapping. A review of local topography indicates that there is a 5 m difference in ground elevations between the 1:200+CC floodplain and the location of the water treatment infrastructure.	**Negligible Risk**

Source of Flood Risk	Description	Flood Risk Assessment
	• As part of the water supply infrastructure there will be a water intake and discharge structure adjacent to the right bank of the River Don. This is considered a water compatible use that will have no impact on flood events nor impede flood flows with appropriate design at the detailed design stage of the project. • It is therefore considered that there is a negligible risk from fluvial flooding.	
Pluvial (i.e., direct rainfall)	• Elevations at the water abstraction, treatment and discharge site generally fall northwards towards the River Don. Near the existing Network Rail infrastructure elevations decrease north westwards towards the Silver Burn. Any excess flows resulting from direct rainfall to the south of the Aberdeen to Inverness rail line would be expected to migrate towards the Silver Burn that passes under the rail line before discharging into the River Don. • The SEPA surface water mapping indicates that there are some areas of surface water ponding within the pumping station and water treatment plant site although the proposed infrastructure is located outwith this extent. • It is therefore considered that the water abstraction, treatment and discharge site is not at significant pluvial flood risk.	**Negligible Risk**
Surface Water Flows	• Inspection of local topography and surrounds indicates that the water abstraction, treatment and discharge site generally slopes north westwards near the existing Network Rail infrastructure. The local topography is such that flows would be expected to travel north westwards, towards the Silver Burn that passes under the Aberdeen to Inverness rail line before discharging into the River Don. To the north of the existing Network Rail infrastructure elevations decrease northwards towards the River Don. • It is therefore considered of negligible risk to the water abstraction, treatment and discharge site.	**Negligible Risk**
Groundwater	• SEPA flood mapping indicates that the water abstraction, treatment and discharge site is not at risk from any wider area groundwater flood risk influences. • Based on these considerations, there is a negligible risk of flooding from groundwater	**Negligible Risk**
Sewers and Artificial Drainage Systems, and Water Supply	• The water abstraction, treatment and discharge site is in an agriculture environment and there was no indication of any existing drainage system on site. • Based on these considerations, there is a negligible risk of flooding from this source.	**Negligible Risk**

Source of Flood Risk	Description	Flood Risk Assessment
Infrastructure Failure (i.e. reservoirs, canals, culvert blockage, etc.)	• SEPA Reservoirs Mapping indicates that the water abstraction, treatment and discharge site is outwith any mapped reservoir flood extent. • Reservoirs in Scotland are regulated under the Reservoirs (Scotland) Act 2011 and there has been no loss of life in the UK as a result of reservoir flooding since 1925. • Therefore, infrastructure failure is considered of negligible risk to the water abstraction, treatment and discharge site.	**Negligible Risk**

4.0 Detailed flood risk review

4.1 Baseline conditions

4.1.1 Existing site and surrounding terrain

A field inspection of the electrolysis plant site and surrounding area was carried out by an experienced SLR hydrologist on 27th October 2023.

Access to the electrolysis plant site is afforded from an unclassified road off the B977 at the southeast corner of the electrolysis plant site. The Dewsford Burn is located within the northern extent of the electrolysis plant site and flows generally eastwards towards the Tuach Burn. The burn appears to have been historically straightened due to its linear alignment on a field boundary.

Photograph 1 shows the northern extent of the electrolysis plant site looking north towards the Dewsford Burn. Photograph 2 is taken from the northern (left) bank of the Dewsford Burn looking south across the electrolysis plant site .

Photograph 1 : Electrolysis plant site location (facing north from a central point within the site)

Photograph 2 : Electrolysis plant site (facing south, from the north edge of the site from the Dewsford Burn)

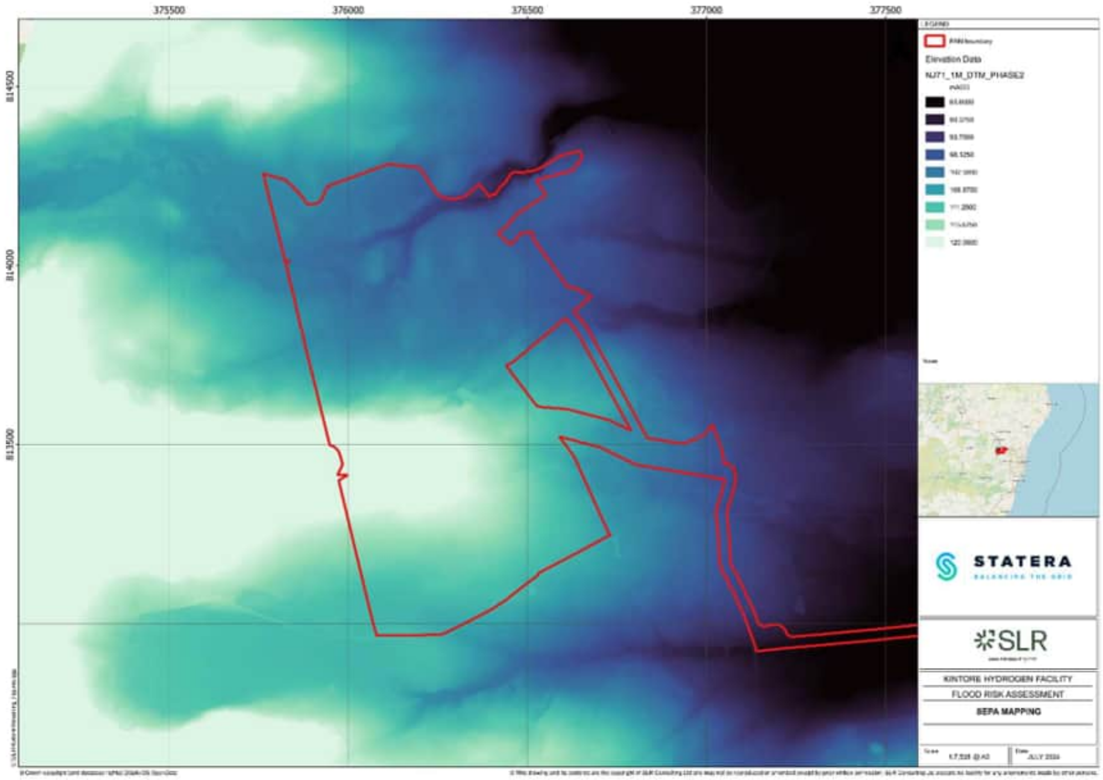
4.1.2 Site topography

Ground elevations at the electrolysis plant site decrease from a high within the centre of the site, situated at approximately 130 m AOD. Elevations decrease northwards towards the Dewsford Burn to an elevation of approximately 100m AOD and southwards to an elevation of approximately 110 m AOD towards the Park Burn.

The local topography is indicated on Figure 4-1, using 1m spatial resolution LiDAR DTM data downloaded from the Scottish Remote Sensing Portal[9].

[9] Scottish Government (2023), Scottish Remote Sensing Portal, available online at: https://remotesensingdata.gov.scot/ [Last accessed July 2023]

Figure 4-1 – Elevation data



© Contains Scottish Government SRSP LiDAR data

4.1.3 Proposed development

The proposed electrolysis plant would be a facility for production of hydrogen from water by electrolysis using renewable electricity. The electricity would be supplied from SSEN's new 400 kV bays at the nearby Kintore Substation, which provides transmission capacity for the increasing wind power generation in Scotland among other renewable sources. The raw water would be supplied from the River Don.

The location of the Proposed Development has therefore been chosen due to being adjacent to the newly expanded capacity of Kintore Substation (not requiring a new overhead transmission line), close proximity to the National Grid Gas NTS pipelines (requiring a connection pipeline of less than 3 km) and proximity to a more than sufficient raw water supply from the River Don.

In overview, the structures and equipment of the electrolysis plant would comprise:

- buildings housing the electrolyser cells, with gas treatment equipment inside or adjacent to the buildings, and oxygen vent stacks adjacent or on the roofs;
- electrical switchyard with 400/132 kV transformers;
- hydrogen scrubber (only applicable for alkaline technology is adopted);
- hydrogen compressors and auxiliaries for export;
- an enclosed ground flare for hydrogen;

- nitrogen generation and storage;
- compressed air generation and storage;
- external cooling system with cooling towers and pumps;
- water treatment building and tanks;
- firewater tanks;
- control room, workshop and stores buildings;
- gatehouse, internal access and circulation roads and parking;
- site drainage, runoff attenuation ponds and underground services; and
- perimeter security fencing, lighting and CCTV.

4.1.4 Local hydrology

The electrolysis plant site lies approximately 300-500 m west of the recently expanded Kintore Substation. At the time of the site inspection, there was some minor ponding of water in natural depressions within the site. The Dewsford Burn was also approximately bankfull.

The Dewsford Burn flows west, becoming the Tuach Burn which discharges into the River Don at Kintore.

The south of the electrolyser plant site falls southwards to the Park Burn.

4.1.5 Historical land use

Historical mapping[10] from 1840 indicates that the electrolysis plant site was previously undeveloped. Subsequent dated mapping also shows the site remains undeveloped and used for agricultural until present day.

4.2 Hydrological assessment

Flood estimates have been developed using the latest Flood Estimation Handbook (FEH) Statistical and Rainfall Runoff methods. All catchments in this study are classed as small (<25km^2) and are ungauged.

The WINFAP v5.1 software has been used to apply the Statistical method using the NRFA Peak Flow Dataset v12.13 to the lumped catchment. This method requires the estimation of the median annual flood (QMED) and a normalised flood frequency curve, termed flood growth curve.

The Rainfall Runoff methods are those first published by Kjeldsen, which were subsequently updated in 2015 and implemented within the ReFH2 software. The latest ReFH2.3 model was released in 2023 and calibrated for the FEH22 depth duration frequency (DDF) rainfall model. This has been applied to all sub and lumped catchments.

The 1999 re-statement of the FSR 'unit hydrograph' rainfall runoff method, as outlined in FEH Volume 4 has been applied to the catchments of this study due to advice outlined in Section 4.3 of SEPA technical flood risk guidance.

[10] National Library of Scotland, Map Finder, available at: https://maps.nls.uk/geo/find/marker/#zoom=15&lat=55.7119&lon=-4.7163&f=0&z=1&marker=55.7132,-4.7175&from=1450&to=1972 [Last Accessed July 2024]

Full details of the hydrology assessment and analysis is documented in Annex D and the design flows for the 0.5% AEP plus climate change event is summarised in Table 4-1.

Table 4-1: Summary of Peak Fluvial Inflows for the 0.5% AEP plus CC event

AEP%	Flow (m3/s)
Statistical	3.06
FEH R-R	2.81
REFH2	3.33

4.3 Hydraulic model

4.3.1 Model build

This section of the report summarises the construction of the 1D-2D hydraulic model using ESTRY TUFLOW HPC software to simulate the fluvial flooding impacts for 1:200+CC event.

The construction of the hydraulic model requires:

- Model extent;
- Model cell size;
- Topography;
- Hydraulic features;
- Hydraulic boundaries; and,
- Ground roughness (Manning's n).

4.3.1.1 Model Extent

The hydraulic model domain (extent) is shown in Figure 4-2.

Figure 4-2 – Hydraulic model domain (extent)

Contains OS data © Crown copyright 2024

4.3.1.2 Topography

The underlying base of the topography comes from two sources:

- Phase 2 – DTM data obtained from the Scottish Remote Sensing Portal; and
- topographic survey, supplied by the client (0).

4.3.1.3 Topography Alterations

The following were also added to the base DTM to refine the detail to the 2D domain of the flood model:

- the elevations of the top of bank of the watercourse as a ZSH layer;
- reinforcement of the embankment west of the site; and
- the inclusion of the development platform raised above the flood level;

4.3.1.4 Model Cell Size

A 2 m model grid cell size was utilised. This cell size has also been determined to be sufficient for incorporating important topographic details such as simulating flow paths and representing of the general topography in the modelled area. These factors were carefully considered to provide an accurate evaluation of the flood risk model grid cell size, ensuring a thorough and robust assessment of potential flood impacts.

4.3.1.5 Hydraulic Boundary

The boundary condition applied to the TUFLOW model was three Flow-Time (QT) boundary placed to the north and east of the electrolysis plant site and one to laterally distribute flow along the watercourse. This boundary is used to assign the fluvial flows for the 1:200+CC event.

The downstream boundary is a normal depth boundary.

4.3.1.6 Manning's n

The definition of the extent of each of the roughness values in the 2D domain was determined using the OS Opendata layers[11]. This information was verified by reviewing aerial imagery of the electrolysis plant site and site visit observations.

The material roughness across the model domain has been read into the hydraulic model using a TUFLOW standard Material.csv with Manning's n values derived from Chow (1959)[12].

Table 4-2: Modelled material Properties

Material ID as referenced in GIS layer	Manning's n value	Land use type
1	0.060	General Roughness
2	0.022	Roads
3	0.100	Buildings
4	0.030	Water
5	0.070	Gorse (heavy)
6	0.050	Gorse (light)
10	0.080	Trees

4.3.1.7 Software Version

In line with good modelling practice, the TUFLOW model was constructed using the latest commercially available software version at project outset: TUFLOW HPC 2023-03-AC (single precision).

4.3.1.8 Modelling Parameters

The underlying 2D digital terrain model (DTM) was generated using the base Phase 2 LiDAR grid, complemented with topographic survey. Sub-grid sampling (SGS) testing was undertaken during the initial model build. It was decided to continue using HPC with SGS functionality in 2 m grid cell size.

All modelled scenarios have been simulated for 20 hours to allow for the inflow boundaries to complete the full hydrograph and allow the watercourse to return to low levels. The computational timesteps used by HPC are adaptive over the course of the simulation, with 2D time-varying outputs generated every 15 minutes.

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[11] Ordnance Survey, OS OpenData, available online at https://osdatahub.os.uk/downloads/open [Last Accessed July 2024]

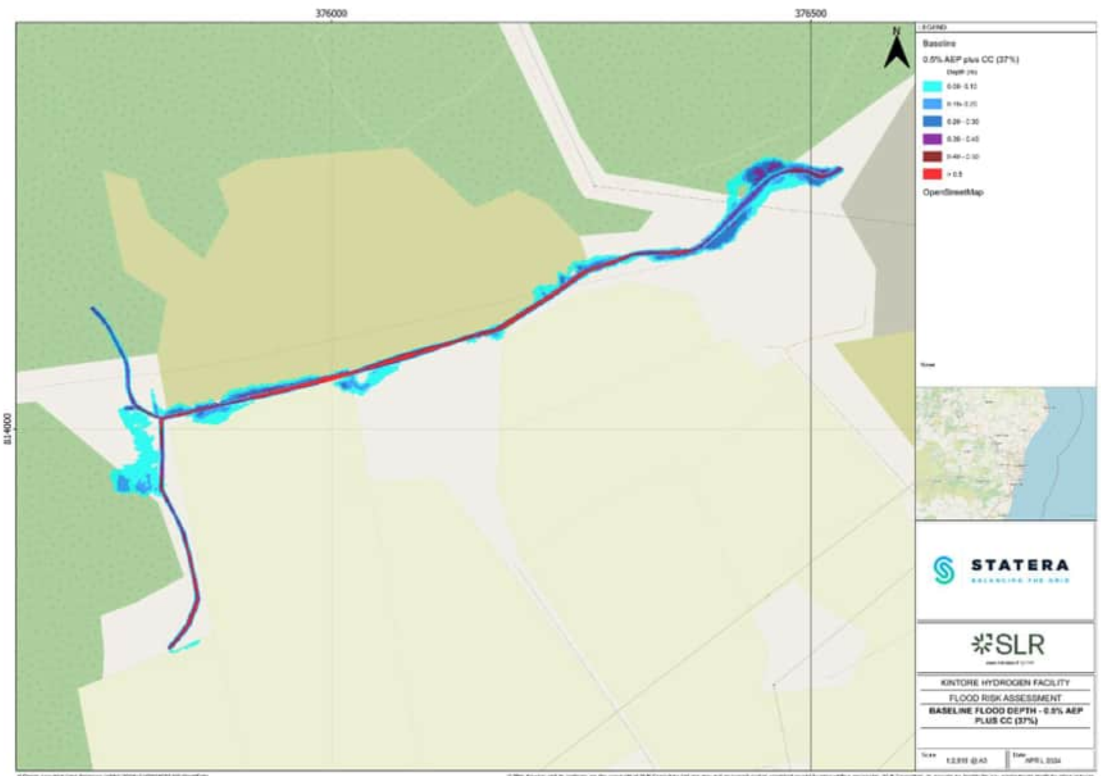
[12] Chow, V.T (1959) Open-channel hydraulics

4.3.2 Model results

4.3.2.1 Baseline

Maximum flood extent and depth results for the areas on and surrounding the electrolysis plant site are presented in Figure 4-3. The results show that the flooding is generally well contained.

Figure 4-3 – Baseline 1:200+CC modelled flood depths



4.3.2.2 Proposed development

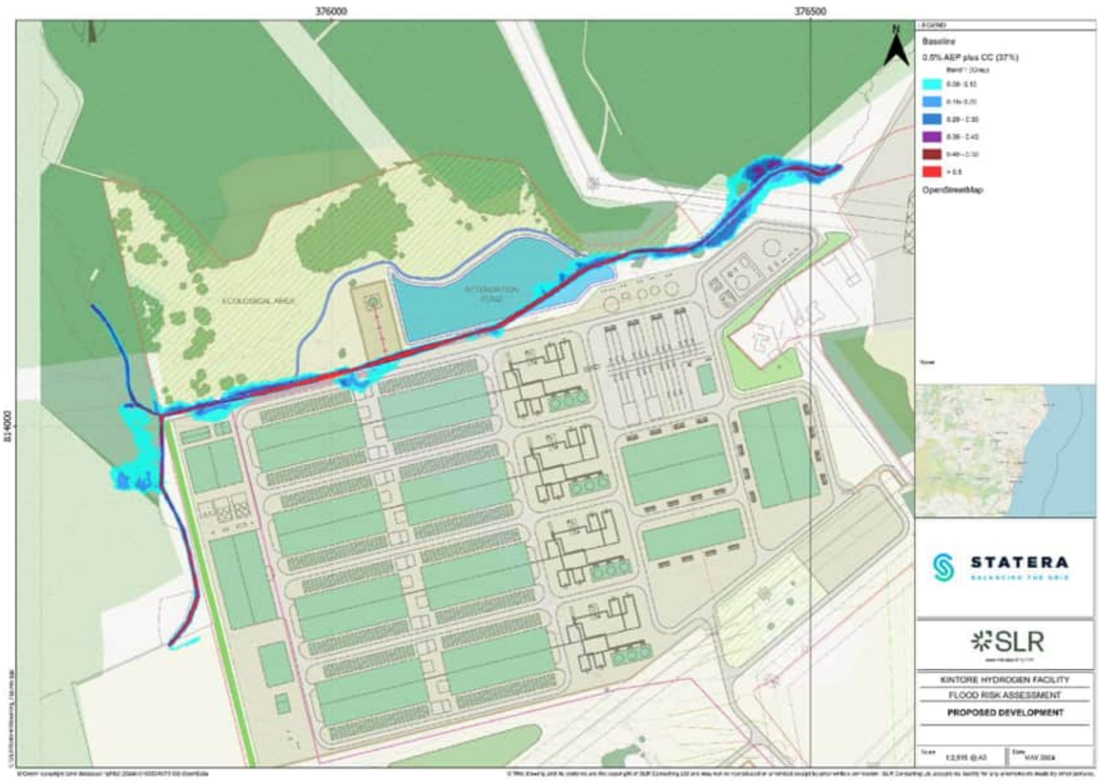
An illustrative potential layout of the electrolysis plant site overlayed with the baseline flood extent is shown in Figure 4-4.

Figure 4-4 also shows a potential realignment option of the Dewsford Burn immediately to the north of the electrolyser site which is discussed in further detail in Section 4.3.2.4.

The majority of the development is located south of the existing Dewsford Burn alignment with the only infrastructure potentially to be located north being the ground flare. Any infrastructure crossing the watercourse will be elevated above the 1:200+CC water level and not impede flows. The design details for which would be developed at the detailed design stage and agreed with SEPA and Aberdeenshire Council at that time.

The baseline model was updated to reflect the Proposed Development at the electrolysis plant site by modifying the ground topography to increase the ground elevation to prevent flooding to the development footprint.

Figure 4-4 – Proposed Development



4.3.2.3 Floodplain Loss

Based on the illustrative layout there is a loss of function floodplain of 98 m^3 for the 1:200+CC flood event as a result of establishing the platform for the electrolyser site. An area to provide compensatory flood storage has been identified, see Figure 4-5, adjacent to the loss of floodplain, that can provide like for like compensatory storage as demonstrated in Table 4-3. The compensatory storage volume is greater than required to provide the correct level for level compensation at depth.

Table 4-3: Floodplain loss and compensatory storage volume available

Band (m AOD)	Volume Lost (m^3)	Compensatory Storage provided (m^3)
100.0 – 101	59	290
101-102	39	79

The modelling results, including for the compensatory flood storage, show no change in flood levels downstream of the Proposed Development at the electrolysis plant site and only a minor change in flood levels of approximately 50 mm immediately upstream of the Proposed Development (see Figure 4-6).

Figure 4-5 – Proposed Compensatory Storage Area

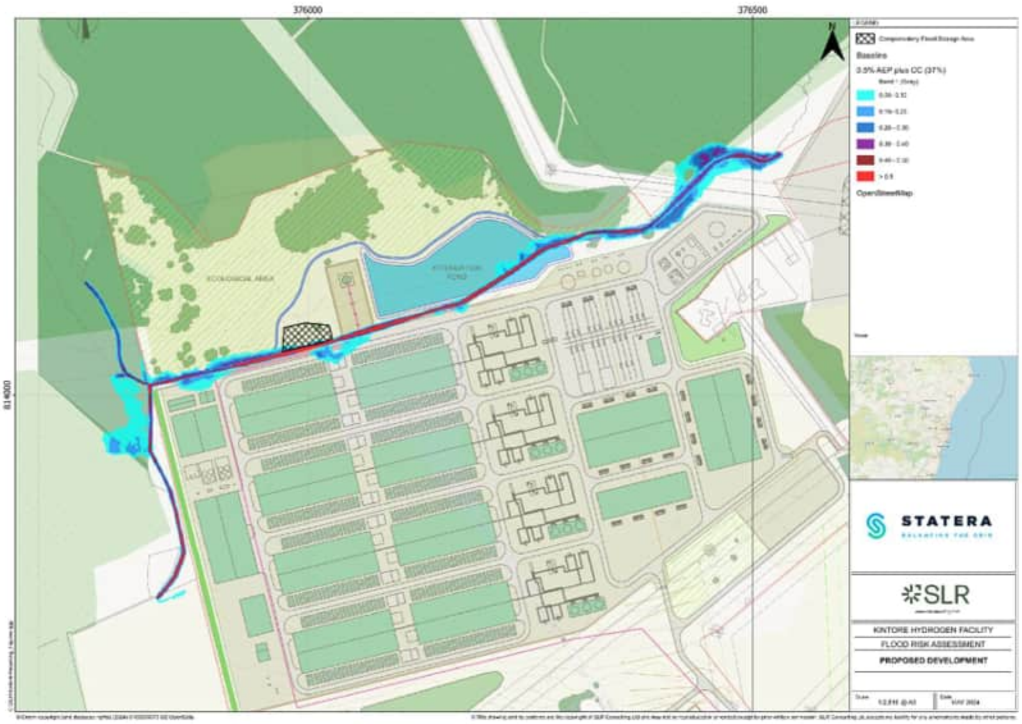


Figure 4-6 – 1:200+CC event with the inclusion of compensatory storage comparison (proposed vs baseline)

4.3.2.4 Potential Dewsford Burn realignment

An alternative to compensatory storage has been modelled to simulate an option to restore the Dewsford Burn to a more natural alignment. An indicative alignment for this is shown in Figure 4-7 and includes a typical cross section for the realigned channel which includes an inset floodplain. If a realignment was pursued, the finalised alignment, layout and design would need to be approved by SEPA under the CAR regime.

The modelling for this scenario also demonstrates that the indicative realignment of the watercourse also does not impact flood risk downstream of the proposed development. There is a localised increase in water levels, of 15 mm upstream: see Figure 4-8. This does not result in any change or onset of flooding to the proposed development and there is no change in flood levels downstream of the development or adjusted alignment.

Figure 4-7 – Potential Dewsford Burn realignment

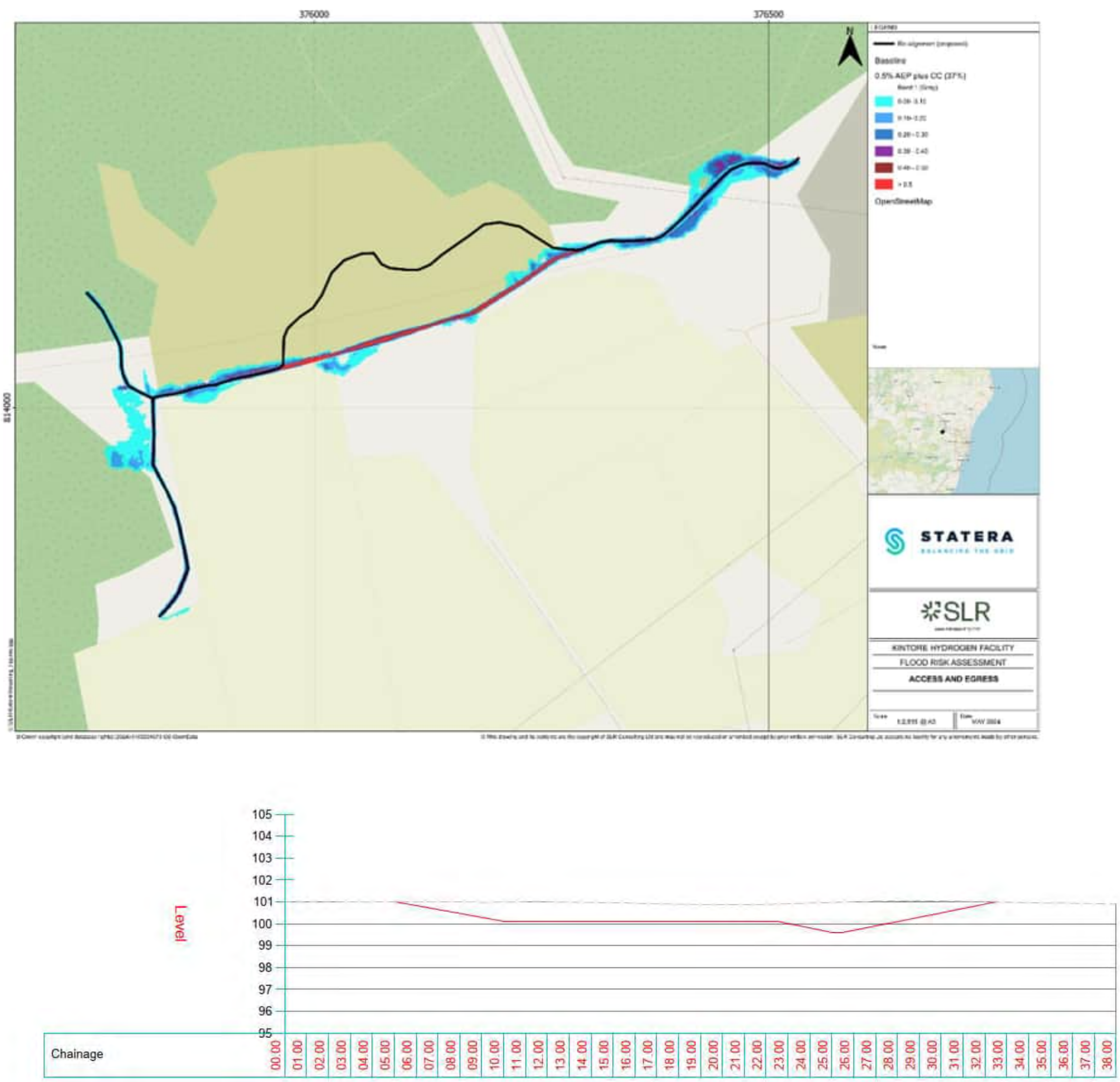


Figure 4-8 – Flood risk in realigned Dewsford Burn

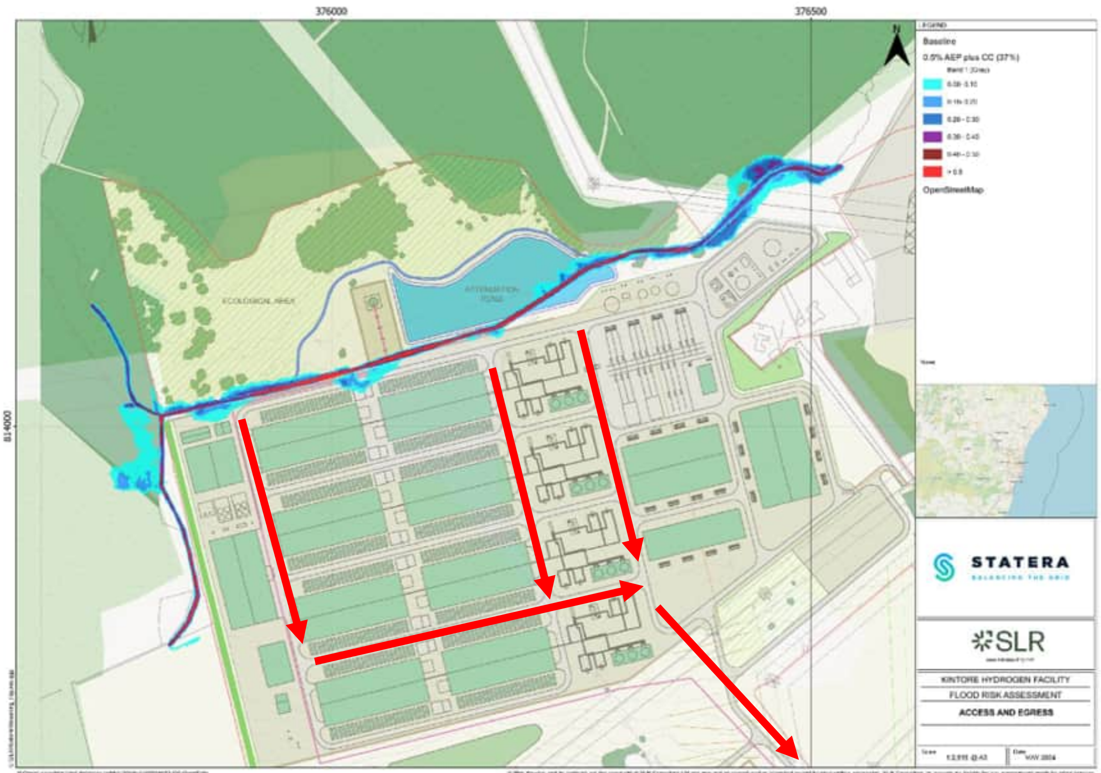
4.3.2.5 Access and Egress

The access and egress arrangements were reviewed in the context of the proposed facility within the northern extent of the electrolysis plant site (see Figure 4-9). As the building threshold is above the 1:200+CC flood level the building itself remains free from flooding. In addition, the access road to the plant in the south side of the site (outside the extent of Figure 4-9) is outwith the 1:200+CC flood extents (of the Dewsford Burn and Park Burn) and provides flood free access and egress.

The modelling results demonstrate that there is dry access and egress for pedestrians and vehicles up to and including the 1:200+CC via the proposed permanent operational access from an unclassified road off the B977.

In addition, the rest of proposed access in the southern extent of the electrolysis plant site is also shown by the modelling and SEPA flood maps to remain free from flooding during the 1:200+CC event.

Figure 4-9 – Access and egress route (electrolyser area)



4.3.3 Model quality assurance

This section outlines the Quality Assurance (QA) measures undertaken in developing the hydraulic model.

Part of the general model QA process involves reviewing the TUFLOW messages generated during the model compilation stage and resolving any issues. Warnings produced by TUFLOW during the run are also investigated. Locations causing recurring warnings were identified and a solution implemented to reduce or remove the source of the issue. Model logs have also been utilised to record the key decisions made when developing the model, allowing for traceability and aid in the transfer of the models between different users. The main components of the model build, configuration and application were recorded and have been reviewed and signed-off by a senior hydraulic modeller.

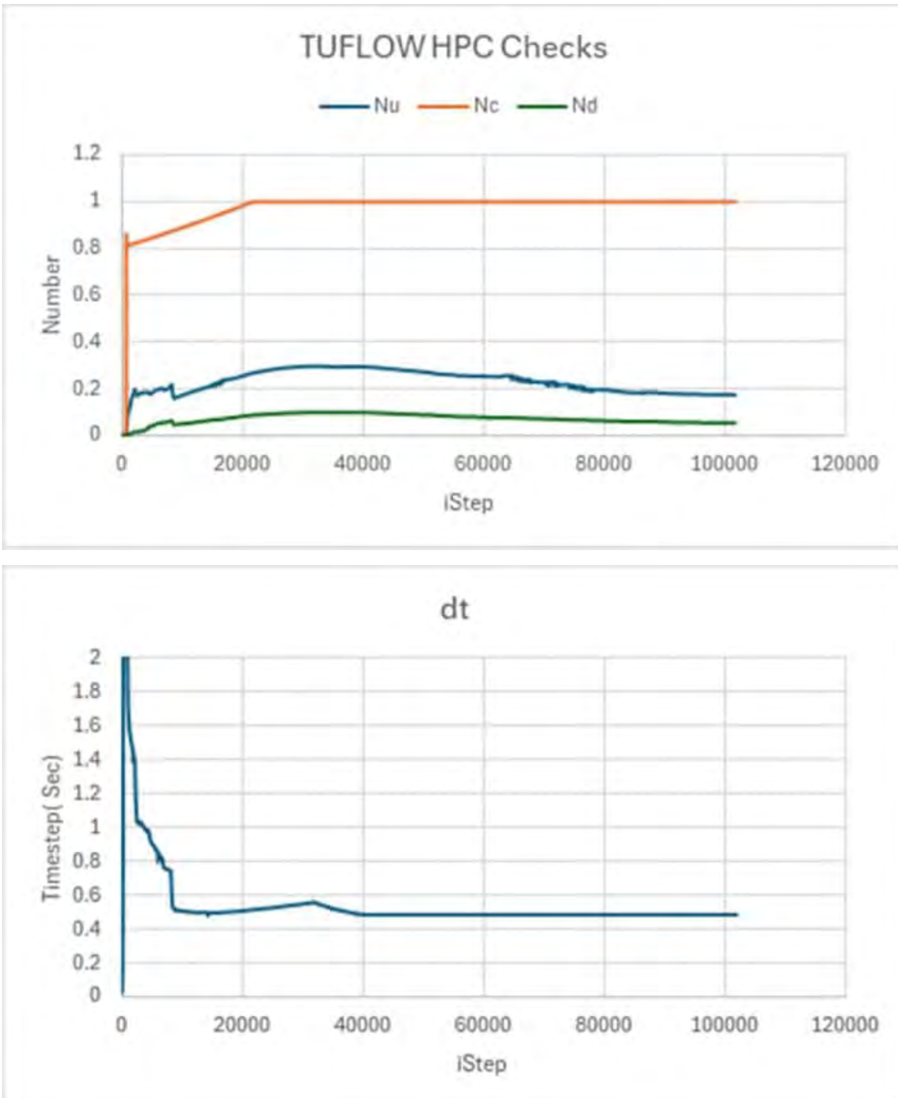
Further QA over the course of the model build was undertaken, including:

- material roughness was checked by importing and thematically mapping the grd_check file to ensure surface resistance was applied correctly with respect to aerial images;
- the extent of the 2D domain was reviewed to ensure it was not limiting flood extents in the larger flood events within the area of interest; and
- minimum dT values across the 2D domain were reviewed to highlight any troublesome areas that were slowing down overall run time.

4.3.4 Model stability

The model has been reviewed and found to be stable and suitable for its intended use. TUFLOW HPC is inherently stable by nature of the adaptive time-stepping, the time-steps (dT) are consistent, and the Nu, Nc and Nd are within acceptable limits as identified by the software developers.

Figure 4-10 – TUFLOW HPC Checks



4.3.5 Model sensitivity testing

Sensitivity analysis is the study of how the variation in the output of the model (depth) can be apportioned, qualitatively or quantitatively, to difference changes in the model inputs (model variables, boundary conditions and parameters).

Sensitivity analysis is used to identify:

- the factors that potentially have the most influence on the model outputs;
- the factors that need further investigation to improve confidence in the model; and
- regions in space where the variation in the model output is greatest.

In line with good practice, the following parameters, and variables for the hydraulic model have been varied in accordance with the % uplift / parameter change specified in Table 4-4:

Table 4-4: Sensitivity Analysis Variables

Parameter	Value change
Flow	+ 20 %
Channel and floodplain roughness	+ 40 %

A universal separate increase of 40% to the Manning's n roughness values was applied across the entirety of the model domain. The model results demonstrated a limited change in flood extent with a small increase in extent due to the local topography. The change in water levels is +/- 145 mm. Based in this analysis, it can be concluded that the adopted roughness parameters are reasonable and that the model is insensitive to changes in roughness.

Increasing the design flows by a further 20% demonstrates the same observations at the increased roughness sensitivity testing. The change in extents is limited and due to the underlying topography of the site. The change in water levels is up to +182 mm.

Figure 4-11 – 1:200+CC sensitivity testing of Mannings n roughness

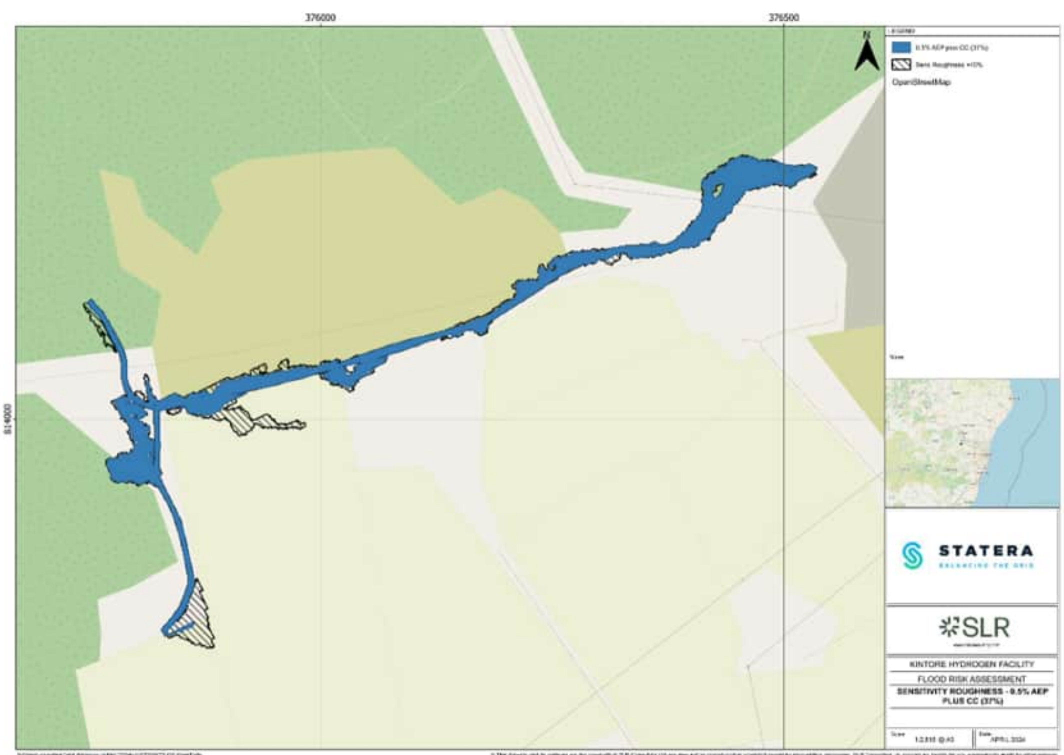


Figure 4-12 – 1:200+CC sensitivity testing of flows

5.0 Summary and recommendations

SLR Consulting Limited was appointed by Kintore Hydrogen Ltd to prepare a Flood Risk Assessment to quantify the flood risk to the proposed Kintore Hydrogen Plant.

The above-ground elements of the gas injection site and water abstraction, treatment and discharge site, through the review of the SEPA flood mapping and ground topography levels, are outwith the 1:200+CC flood extents and has flood free access and egress. The water intake and outfall structure and pipeline at the River Don are water-compatible infrastructure and would not impede flows or increase flood risk.

For the main electrolysis plant site, a 1D-2D ESTRY-TUFLOW model and hydrological assessment has been developed to quantify flood risk.

The Proposed Development at the electrolysis plant site results in a loss of functional floodplain of Dewsford Burn of 100 m^3, which is proposed to be compensated for with like-for like provision of flood compensatory storage. The compensatory storage can be provided within the application boundary.

A second scenario has been considered which includes an option to re-align a short section of Dewsford Burn (restoring it to a more natural shape and alignment, from its current canalised channel) and create inset floodplain that can demonstrate no impact on flood levels downstream. It has been shown that a new channel can also be used to provide the compensatory flood storage required. Any finalised realigned channel would need to be agreed with SEPA through the CAR licence process.

The flood risk assessment has shown that flood risk does not impede development and that development of the site does not increase flood risk to off-site third party land. An outline Drainage Impact Assessment is reported separately and shows measures that will be used to collect and attenuate incident rainfall runoff from the proposed development.

The modelling results demonstrate that there is dry access and egress for pedestrians and vehicles up to and including the 1:200+CC event from all elements of the proposed development.

Annex A Illustrative Development Plan

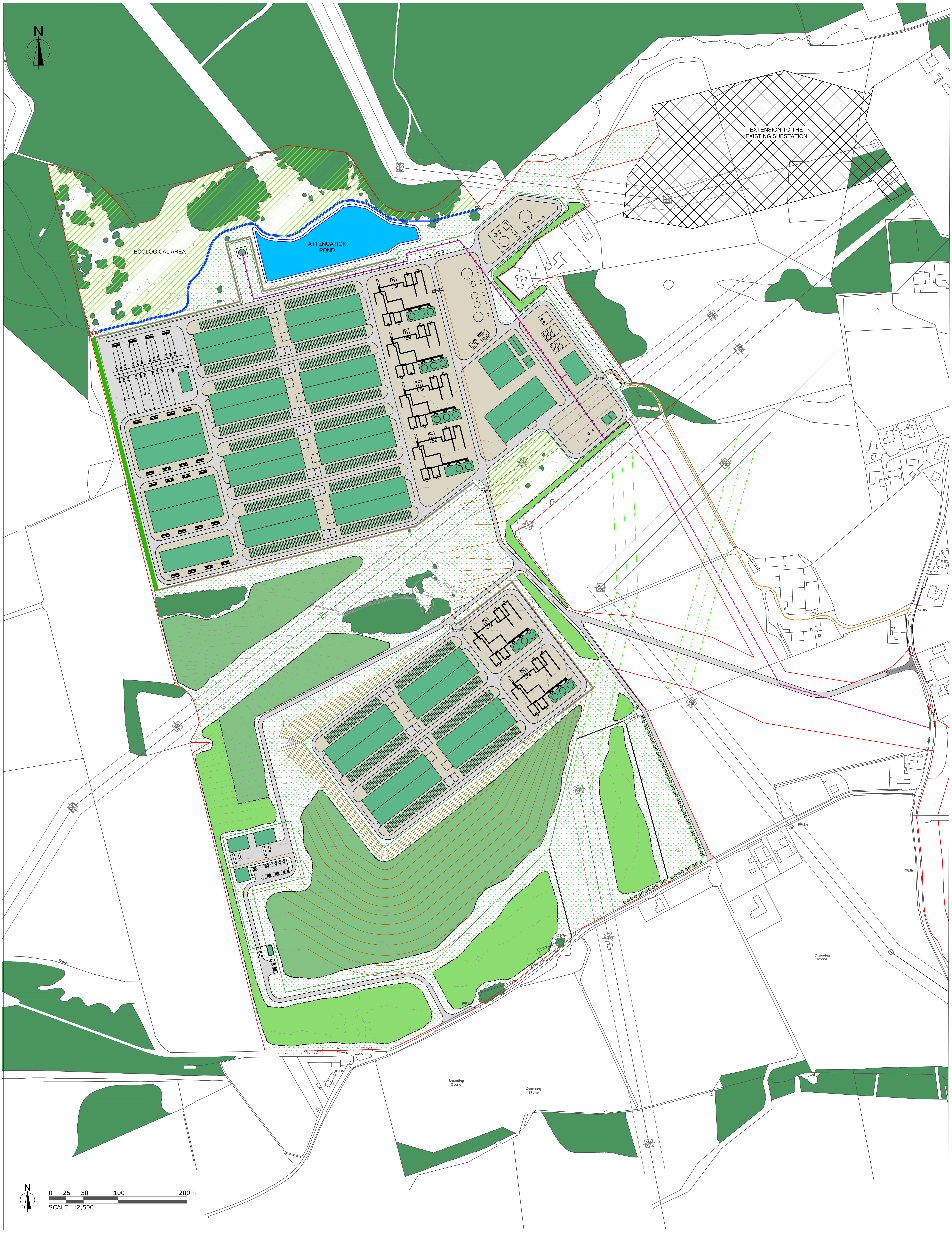
Kintore Hydrogen Facility

Appendix 13.2: Flood Risk Assessment

Kintore Hydrogen Ltd

SLR Project No.: 428.013099.00001

31 August 2024



Legend

- Site boundary
- Existing hedgerows and trees
- Extension to existing substation
- Bund
- Diverted line electricity clearance zone
- Diverted route of overhead electricity line*.
- Ecological area
- Fencing
- Stone access track
- Phase 1 planting
- Phase 2 planting
- Retaining wall
- Hydrogen pipeline
- Attenuation pond
- Watercourse reroute (if needed)
- Loose permeable gravel
- Other planting (e.g. wildflower grassland)
- Emergency access route
- Proposed 1m contours
- Specimen tree planting

*Estimated alignments - third party (Transmission Owner) works

Revision	Date	Comment
A	22.05.24	Access arrangement altered

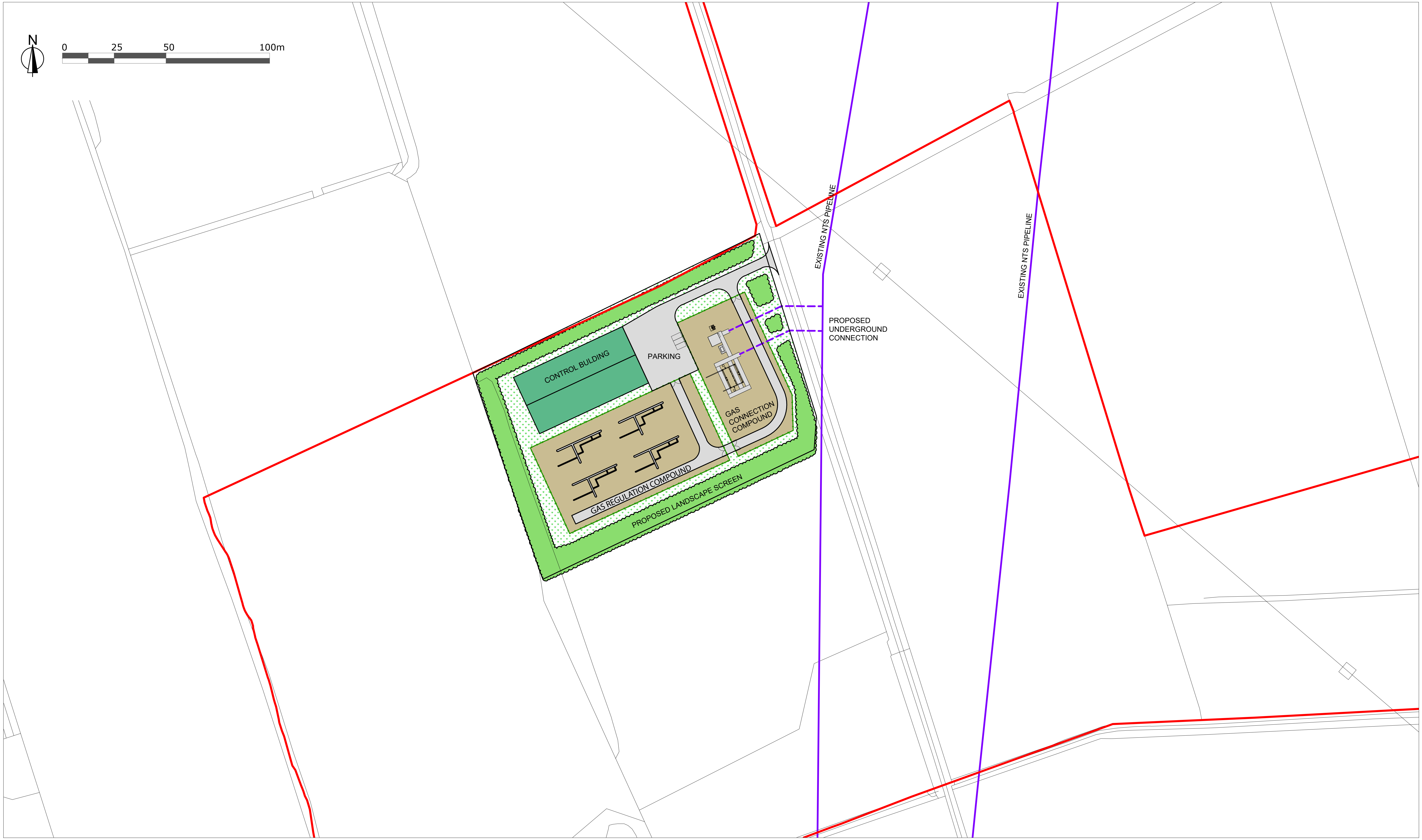
STATERA
BALANCING THE GRID

ON BEHALF
Statera Energy

PROJECT
Kintore Electrolysis

DATE 27th March 2024
SCALE 1 : 2,500 @ A1
DWG No SL260_L_X_MP_2
APPROVED CMcD

TITLE
Masterplan
Option 1



STATERA
BALANCING THE GRID

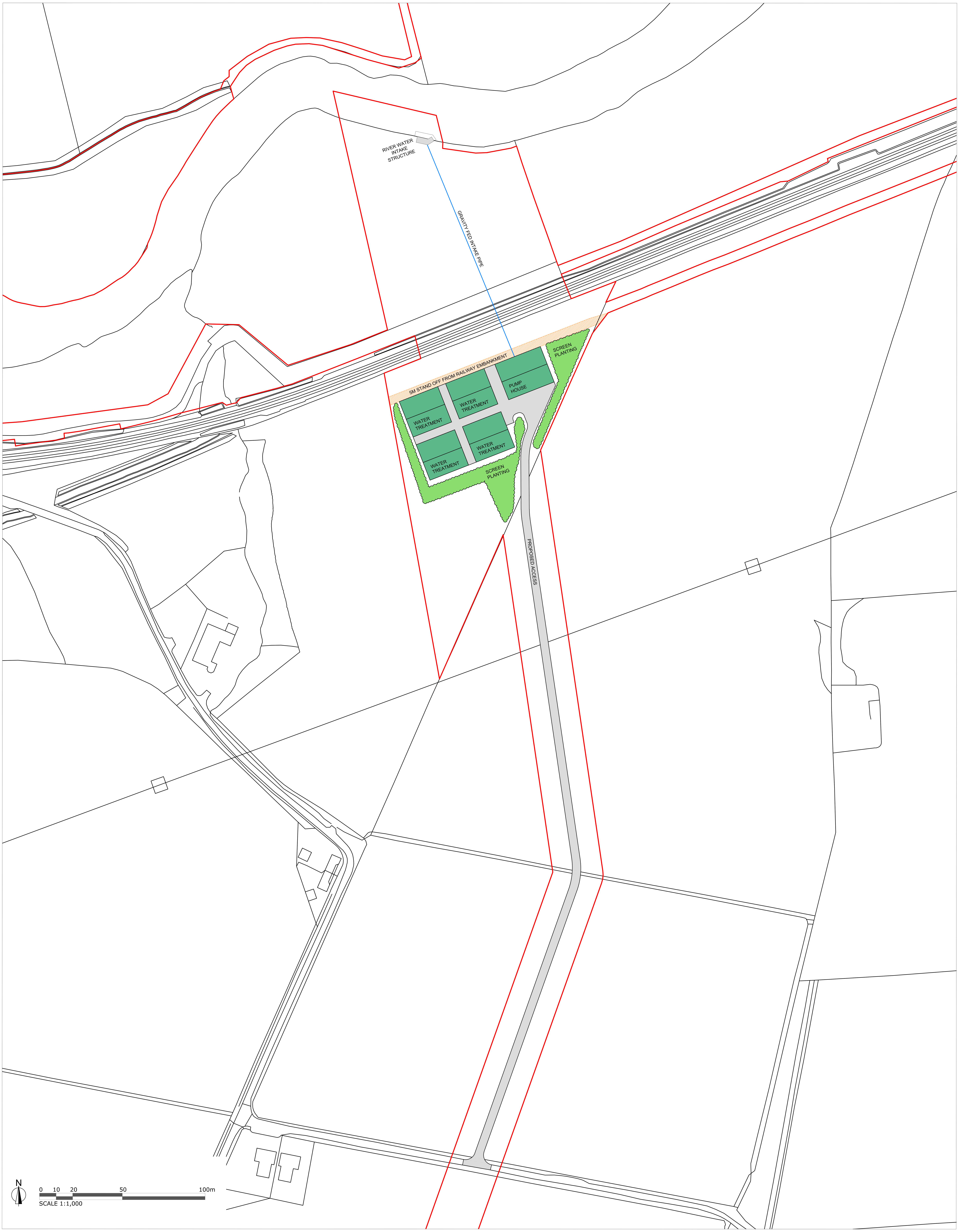
Revision	Date	Comment
-	-	-

ON BEHALF
Statera Energy

PROJECT
Kintore Electrolysis

DATE 27th March 2024
SCALE See scale bar @ A3
DWG No SL_L_X_WG_1
APPROVED CMcD

TITLE
Gas Connection Compound



STATERA
BALANCING THE GRID

Revision	Date	Comment
-	-	-

ON BEHALF
Statera Energy

PROJECT
Kintore Electrolysis

DATE	27th March 2024
SCALE	1 : 1,0000 @ A1
DWG No	SL260__L__X__WG__2
APPROVED	CMcD

TITLE
Water Treatment Works

Making Sustainability Happen