
Technical Appendix 10.1: Groundwater Dependent Terrestrial Ecosystems (GWDTE) Assessment

10.1 Executive Summary

- 10.1.1 Excavation of soil and bedrock during the construction phase of the Proposed Development has the potential to cause localised disruption and interruption to groundwater flow. Interruption of groundwater flow could potentially reduce the supply of water to Groundwater Dependent Terrestrial Ecosystems (GWDTE), thereby causing an alteration/change in the quality or quantity of and/or in the physical or biological characteristics of the GWDTE. Contamination of groundwater may also cause physical or chemical contamination of the GWDTE.
- 10.1.2 This Technical Appendix provides a summary of the GWDTE matters concerning the Proposed Development. It provides a description of the bedrock and superficial geology and takes into account the National Vegetation Classification (NVC) and habitat surveys, conducted by Ramboll in May and July 2019. It then presents a hydrogeological assessment of the identified potential GWDTEs.
- 10.1.3 Following the identification of potential GWDTEs from NVC mapping data, the hydrological and hydrogeological desktop study information has been used to qualitatively determine the sensitivity of each potential GWDTE.
- 10.1.4 The hydrogeological assessment of potential GWDTEs concludes that all of the areas identified by the ecological assessment as potential GWDTEs are considered to have a low likelihood of groundwater dependency and therefore are of low sensitivity with respect to the Proposed Development.
- 10.1.5 As the potential GWDTE areas assessed are not considered likely to be groundwater dependent, specific mitigation with respect to groundwater supplies is not considered to be applicable. However, it is noted that the locations assessed are in connectivity with wider peat bog and mire habitats present across the site. As such, it is considered that the maintenance of quality and quantity in surface water distribution across these areas will be important. Further assessment of appropriate mitigation measures to prevent deleterious impacts on surface water distribution are addressed within Chapter 10 (Hydrology and Hydrogeology) of this Environmental Impact Assessment (EIA) Report.

10.2 Introduction

- 10.2.1 This Technical Appendix provides a summary of the GWDTE within the context of the Proposed Development. It provides a description of the bedrock and superficial geology and takes into account the National Vegetation Classification (NVC) and habitat surveys, conducted by Ramboll in May and July 2019. A further, hydrogeological assessment of the identified potential GWDTEs is then described.
- 10.2.2 The study area comprised the Proposed Development area inclusive of a 250m buffer.

10.3 Baseline

Bedrock Geology

- 10.3.1 The underlying bedrock is mapped as two geological groups (see Figure 1), comprising an Unnamed Igneous Intrusion that primarily underlies the eastern section of the proposed development, and the Grampian Group that primarily underlies the western and central sections. The Unnamed Igneous Intrusion is formed of several discrete igneous formations, whilst the Grampian Group is formed of a number of metamorphic geological formations.

Superficial Geology

- 10.3.2 According to 'Geology of Britain Viewer' website (1:50,000)¹ superficial geology data (Figure 2) indicates that the north of the site is underlain by peat deposits. Quaternary Till Diamicton is present directly underlying the south western and north eastern areas of the site. Very small areas of alluvium deposits are present on the south west of the site along the course of the River Tarff and the Caochan Uilleim.
- 10.3.3 Peat soils are recorded on the National Soil Map of Scotland Carbon and Peatland Map (2016)² on the north west, south west and east of the site. Peat soils in these areas are classified as being Class 1 Peatland Soil (dystrophic blanket peat). Small areas of peat on the east of the site are classified as Class 5 Peatland Soil (areas in which soils are carbon rich deep peat with no peatland vegetation) and small areas of peat on the south east of the site are classified as Class 2 peatland Soil (sub alpine podzols with dystrophic blanket peat) with the potential to be restored to peatland. A very limited area of peat projecting onto the south east corner of the site is classified as Class 3 Peatland Soil (sub alpine podzols with dystrophic blanket peat).

Hydrogeology

- 10.3.4 According to the BGS and the Hydrogeological and Groundwater Vulnerability Maps of Scotland (1:625,000), both the underlying igneous and metamorphic bedrock formations are recognised as low productivity aquifers (see Figure 3). Such aquifers are characterised as having limited groundwater potential, with small amounts of groundwater limited to near surface weathered zones and secondary fractures (e.g. rare springs). Low productivity aquifers do not widely contain groundwater in exploitable quantities; however, some bedrock formations can locally yield water supplies in sufficient quantities for private/domestic use. The overlying superficial deposits are considered to

¹ British Geological Survey 1:50,000 Digital Map. Available online: <https://www.bgs.ac.uk/data/mapViewers/home.html>

² National Soil Map of Scotland. Available online: <https://soils.environment.gov.scot/maps/>

be generally of low permeability; however, groundwater may be present in sand and gravel lenses, hence locally important aquifers may be present, although are unlikely to be continuous over a wide area.

10.4 Groundwater Dependent Terrestrial Ecosystems

- 10.4.1 A small number of potential Moderately GWDTE and one potential Highly GWDTE habitats were identified during National Vegetation Classification (NVC) surveys conducted by Ramboll in 2019. Further details with regard to each GWDTE identified are provided below and illustrated on Figure 4.
- 10.4.2 Following identification of habitats with a potential to be GWDTEs from NVC mapping data, the hydrological and hydrogeological desktop study information has been used to help qualitatively determine the potential sensitivity of each potential GWDTE.
- 10.4.3 Where a mosaic of NVC classifications was observed, only the community occupying the largest proportion of the mosaic has been considered as representative of the potential for the mosaic to be a GWDTE.
- 10.4.4 The sensitivity of each of the GWDTE receptors has been classed based upon classifications provided within Scottish Environment Protection Agency (SEPA) guidance LUPS – GN31. The SEPA classification is modified from the UKTAG (2004) list of NVC communities, which provides the full list for all communities; therefore, the relevant UKTAG classification is also provided.
- 10.4.5 Table 1 sets out the predominant NVC communities encountered across the site and confirms which are considered to have the potential to be a GWDTE and which have therefore been assessed further (see Figure 5).

Table 1: NVC Communities Present within the Study Area and Their Potential Groundwater Dependency, According to SEPA and UKTAG

NVC Code	NVC	Groundwater Dependency (SEPA)	Groundwater Dependency (UKTAG/Scotland)
M6	<i>Carex echinata - Sphagnum recurvum</i> mire	High	High
M15	<i>Scirpus cespitosus - Erica tetralix</i> wet heath	Moderate	Moderate

M6 – Carex echinata - Sphagnum recurvum mire

- 10.4.6 The M6 community is present in a very limited area close to the north west boundary of the site on level ground, but in very close proximity to the Allt na Feithe Gobhlaich watercourse and an unnamed dammed lochan. The presence of M6 communities in this hydrological setting suggests that it is most likely reliant upon the coalescence of surface drainage pathways.
- 10.4.7 As a result of these observations, it is considered that the M6 communities recorded in this one small area are of moderate groundwater dependency.

M15 - Scirpus cespitosus - Erica tetralix wet heath

- 10.4.8 Four areas of M15 wet heath communities were recorded on the south west area of the site. The largest of these is present on the north slopes of Carn na Cloiche adjacent to the west of Caochan Uilleim watercourse. A second area of M15 vegetation is present in

close proximity to the south west boundary of the site on an area of gently sloping land. The Allt Lochain Iain is adjacent to the east of this area. Two further small areas of M15 vegetation communities are present on the slopes of Meall Caca in the east of the site.

- 10.4.9 According to site specific ecological conditions, Table 2 describes the NVC communities present within the study area and their potential groundwater dependency.

Table 2: NVC Communities Present within the Study Area and Their Groundwater Dependency, According to the Site-specific, Ecological Conditions

NVC Code	NVC Community	Potential Groundwater Dependency
M6	<i>Carex echinata - Sphagnum recurvum mire</i>	Moderate
M15	<i>Scirpus cespitosus - Erica tetralix wet heath</i>	Moderate

10.5 Groundwater Dependency

- 10.5.1 UKTAG guidance (2004) recognises that most “*water dependent terrestrial ecosystems lie along a continuum between always only groundwater dependent and always only surface water dependent [...]. The source of water supply for some wetlands does not appear to be critical, therefore the task of identifying dependence upon groundwater is sometimes complex*”.
- 10.5.2 The SNIFFER (2007) guidance³ states that the dependence of wetlands on groundwater bodies is a result of the hydrological connectivity. The degree of dependency will vary depending upon whether the wetland is underlain by a low productivity or high productivity aquifer and whether there is a hydrological linkage mechanism between groundwater and the surface wetland. Likelihood of dependency is based upon the following:
- High Likelihood: characterised by intergranular, high productivity drift aquifer and dominantly intergranular, highly productive aquifer;
 - Moderate Likelihood: characterised by intergranular, moderate productivity drift aquifer and fractured, very low productivity aquifer; and
 - Low Likelihood: characterised by intergranular, low productivity drift aquifer and fractured, very low productivity aquifer.
- 10.5.3 As mentioned in section 10.3, the site is underlain by bedrock aquifers with low productivity where the flow is virtually all through fractures and other discontinuities. Where drift deposits are present within the site, these would also be of low productivity. Therefore, it is assumed that there is low likelihood of groundwater dependency for all the GWDTEs within the site.
- 10.5.4 The UKTAG (2004) guidance provides criteria for identification and inclusion of GWDTEs in the risk assessment process, based on the complementary ecological and hydrogeological assessments. These criteria have been used to produce the matrix given in Table 3, which provides an identification of the sensitive and potentially sensitive

³ Wetland Hydrogeomorphic Classification for Scotland [available at: https://www.sniffer.org.uk/wfd66-final-report-pdf_WFD66_Final_Report.pdf, accessed 21/09/2019]

GWDTEs that will require a qualitative assessment to ascertain the significance of the risks the Proposed Development poses to them⁴.

Table 3: Matrix for Identification of Sensitive GWDTEs from Ecological and Hydrogeological Assessments

		Hydrogeological Assessment Groundwater Dependency Level		
		High Likelihood	Moderate Likelihood	Low Likelihood
Ecological Assessment of NVC Communities	Highly groundwater dependent	Sensitive GWDTE	Potentially sensitive GWDTE	Potentially sensitive GWDTE
	Moderately groundwater dependent	Potentially sensitive GWDTE	Potentially sensitive GWDTE	Not sensitive
	Not groundwater dependent	Potentially sensitive GWDTE	Not sensitive	Not sensitive

10.5.5 Since the likelihood of groundwater dependency is considered to be Low for all of the potential GWDTEs across the site, in line with underlying hydrogeological conditions (as specified in SNIFFER (2007) guidance) all the areas identified in the ecological assessment of NVC communities as potentially Moderately GWDTEs are considered not sensitive (Tables 3) and have therefore been excluded from further assessment (Figure 6).

10.5.6 As the only potential Highly GWDTE identified (M15) is directly associated with surface water features, this area is also considered not to be sensitive with respect to groundwater supplies (Table 4).

Table 4: GWDTE Sensitivity Assessment

NVC Code	NVC Community	Groundwater Dependency (Ecological Assessment)	GWDTE
M6	<i>Carex echinata</i> - <i>Sphagnum recurvum</i> mire	Moderate	Not sensitive
M15	<i>Scirpus cespitosus</i> - <i>Erica tetralix</i> wet heath	Moderate	Not sensitive

10.6 Mitigation and Further Assessment

10.6.1 As the potential GWDTE areas assessed are not considered likely to be groundwater dependent, specific mitigation with respect to groundwater supplies are not considered to be applicable.

⁴ Helen Culshaw and Andrew Halcro-Johnston, Golder Associates (UK) Ltd, "An integrated hydro-ecological approach to the identification of sensitive groundwater dependent terrestrial ecosystems within wind farm Environmental Impact Assessment" [Available at: https://www.geolsoc.org.uk/~media/shared/documents/specialist%20and%20regional%20groups/Hydro/GDE/Posters/Poster4_GDE_Meeting_Feb13.pdf?la=en, accessed 21/03/2016]

10.6.2 It is noted that the locations assessed are in connection with wider peat bog and mire habitats present across the wider site. As such, it is considered that the maintenance of quality and quantity in surface water distribution across these areas will be important. Suitable drainage and surface water measures would be used to maintain hydrological connectivity in peatland and wetland habitats and prevent deleterious impacts on surface water distribution, as addressed in Chapter 10 (Hydrology and Hydrogeology) of the EIA Report. Mitigation measures shall include:

- Avoidance of direct impact through construction activity on such areas;
- Implementation of SuDS measures to maintain quality of water supply;
- Maintenance of flow paths/redistribution of water where diverted;
- Implementation of pollution control measures; and
- demarcation of the most sensitive areas and monitoring of works in close proximity by the EcoW.

10.7 Conclusions

10.7.1 Following the hydrogeological assessment of potential GWDTEs, it has been concluded that all of the areas identified by the ecological assessment of NVC communities as potential GWDTEs are considered to have a low likelihood of groundwater dependency, and therefore are of a low sensitivity with respect to the Proposed Development.

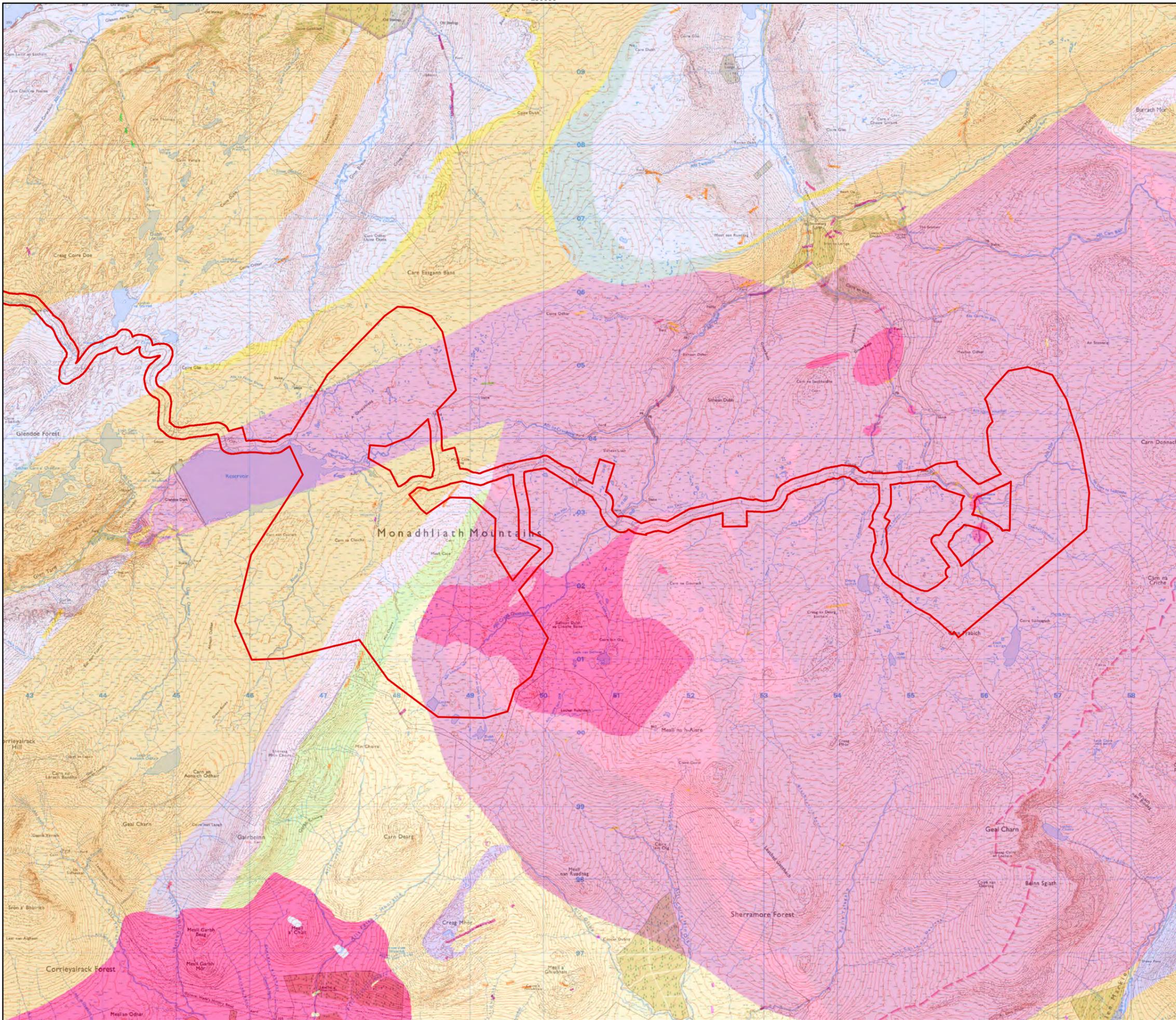
References

Scottish Environment Protection Agency (SEPA), 2014. Land Use Planning System Guidance Note 31: Guidance on Assessing the Impacts of Windfarm Development Proposals on Groundwater Abstractions and Groundwater Dependent Terrestrial Ecosystems. Available online:

https://www.sepa.org.uk/media/143868/lupsgu31_planning_guidance_on_groundwater_abstractions.pdf

UK Technical Advisory Group on the Water Framework Directive, 2004. Guidance on the identification and risk assessment of groundwater dependent terrestrial ecosystems, [available at <https://www.wfduk.org/resources%20/risk-assessment-groundwater-dependent-terrestrial-ecosystems>, accessed 21/09/2019]

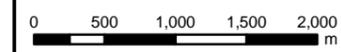
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Key

- Site Boundary
- Bedrock Geology 1:50,000
- Bedrock Formation
- Allt Crom Granodiorite, Loch Laggan Psammite Rafts
- Loch Laggan Psammite Formation
- Coire Nan Laogh Semipelite Formation
- Allt Crom Complex
- Garva Bridge Psammite Formation



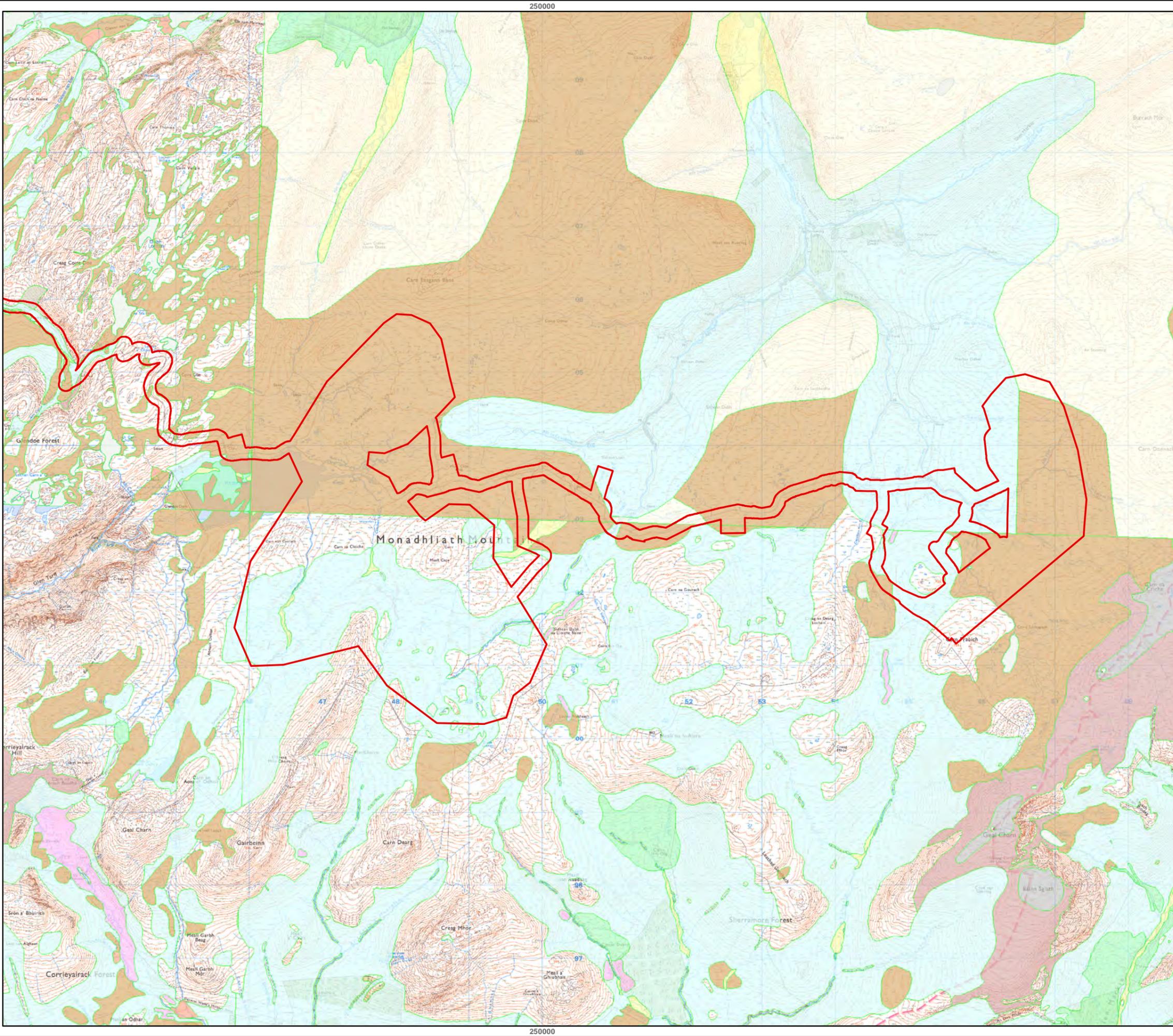
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Figure 1

Hydrology: Bedrock Geology

**Cloiche Wind Farm
Technical Appendix 10.1**



Key

- Site Boundary
- Superficial Deposits
- Peat
- Till - Diamicton
- Alluvium

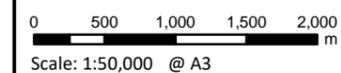
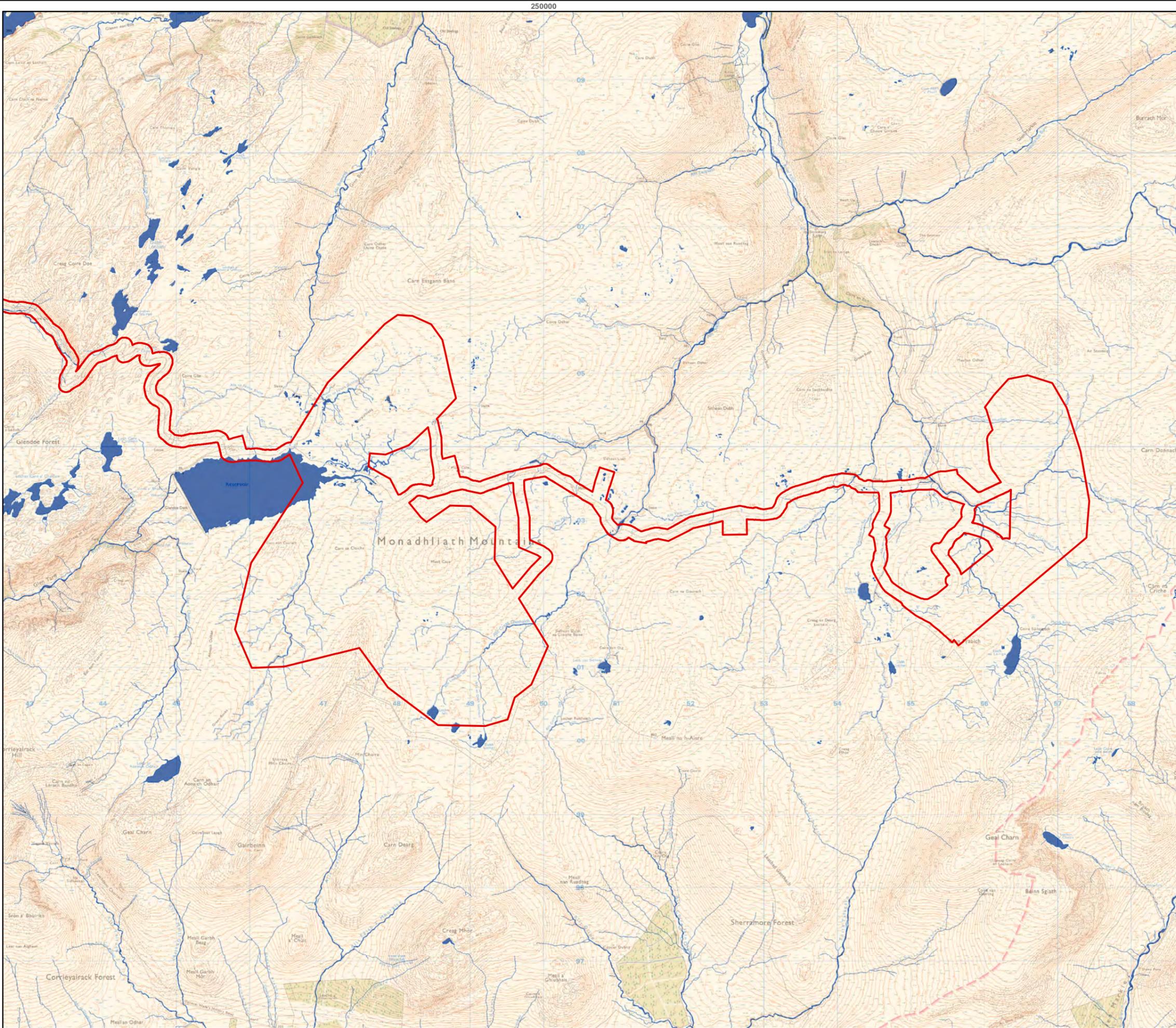


Figure 2

Hydrology: Superficial Geology

Cloiche Wind Farm
Technical Appendix 10.1

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Key

- Site Boundary
- Surface Water Features
- BGS Hydrology (1:625)
- Aquifer Classification
- Low productivity aquifer

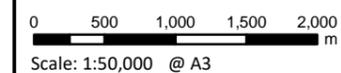
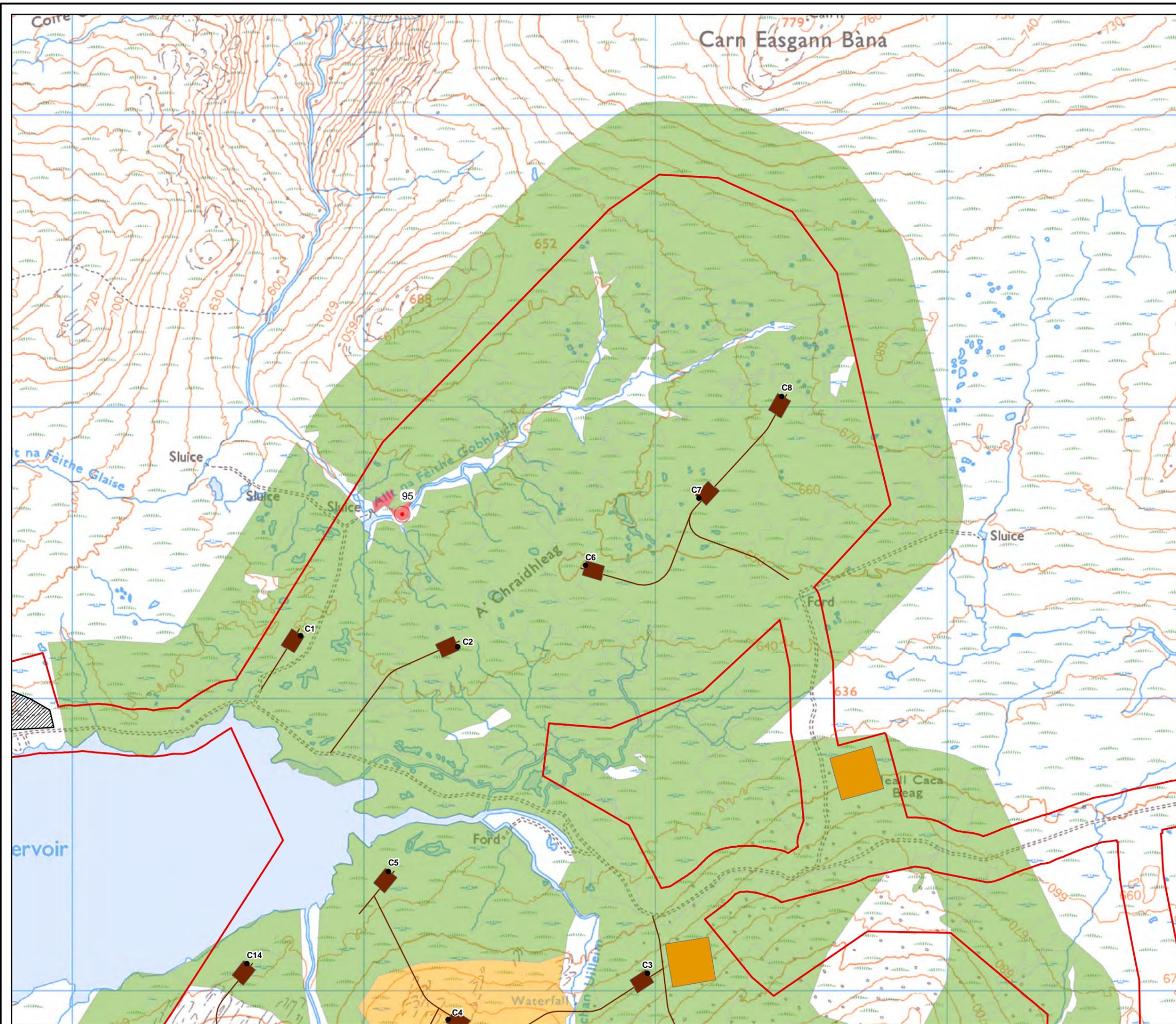


Figure 3

Hydrology: Hydrogeology

**Cloiche Wind Farm
Technical Appendix 10.1**



Key

- Site Boundary
 - Turbine
 - Track
 - Borrow Pit Search Area
 - Batching Plant
 - Compound
 - Hardstanding
 - GWDTE Target Notes
- NVC
- M15 Wet Heath
 - M19/M17/M20/bare peat mosaic
 - M6 Mire

No.	Note
92	M25 Molinia caerulea-Potentilla erecta mire (small flush)
93	M32 Philonotis fontana-Saxifraga stellaris spring
94	M10 Pinguicula-Caricetum dioicae mire (stony flush)
95	Transitional area from bog to acid grassland on edge of watercourse
97	Sedge-dominated flush. E.vaginatum, Sphagnum sp., Hylocomium, Polytrichum. Carex sp. and bryophytes such as Philonotis.
98	Flush (M6) in a wet channel grasses & E.vaginatum.
100	Flush with wet heath/acid grassland mosaic at top and marshy grassland which may be classed as M6/M25 lower downslope where peat is >0.5m

0 100 200 300 400 500 m
Scale: 1:12,500 @ A3



Figure 4 (a)
NVC Communities used to inform GWDTE Assessment

Cloiche Wind Farm
Technical Appendix 10.1

Key

- Site Boundary
- LiDAR
- Turbine
- Track
- Borrow Pit Search Area
- Hardstanding
- Substation
- GWDTE Target Notes
- NVC
- M15 Wet Heath
- M19/M17/M20/bare peat mosaic

No.	Note
92	M25 Molinia caerulea-Potentilla erecta mire (small flush)
93	M32 Philonotis fontana-Saxifraga stellaris spring
94	M10 Pinguicula-Caricetum dioicae mire (stony flush)
95	Transitional area from bog to acid grassland on edge of watercourse
97	Sedge-dominated flush. E.vaginatum, Sphagnum sp., Hylocomium, Polytrichum. Carex sp. and bryophytes such as Philonotis.
98	Flush (M6) in a wet channel grasses & E.vaginatum.
100	Flush with wet heath/acid grassland mosaic at top and marshy grassland which may be classed as M6/M25 lower downslope where peat is >0.5m

0 100 200 300 400 500 m
Scale: 1:12,500 @ A3

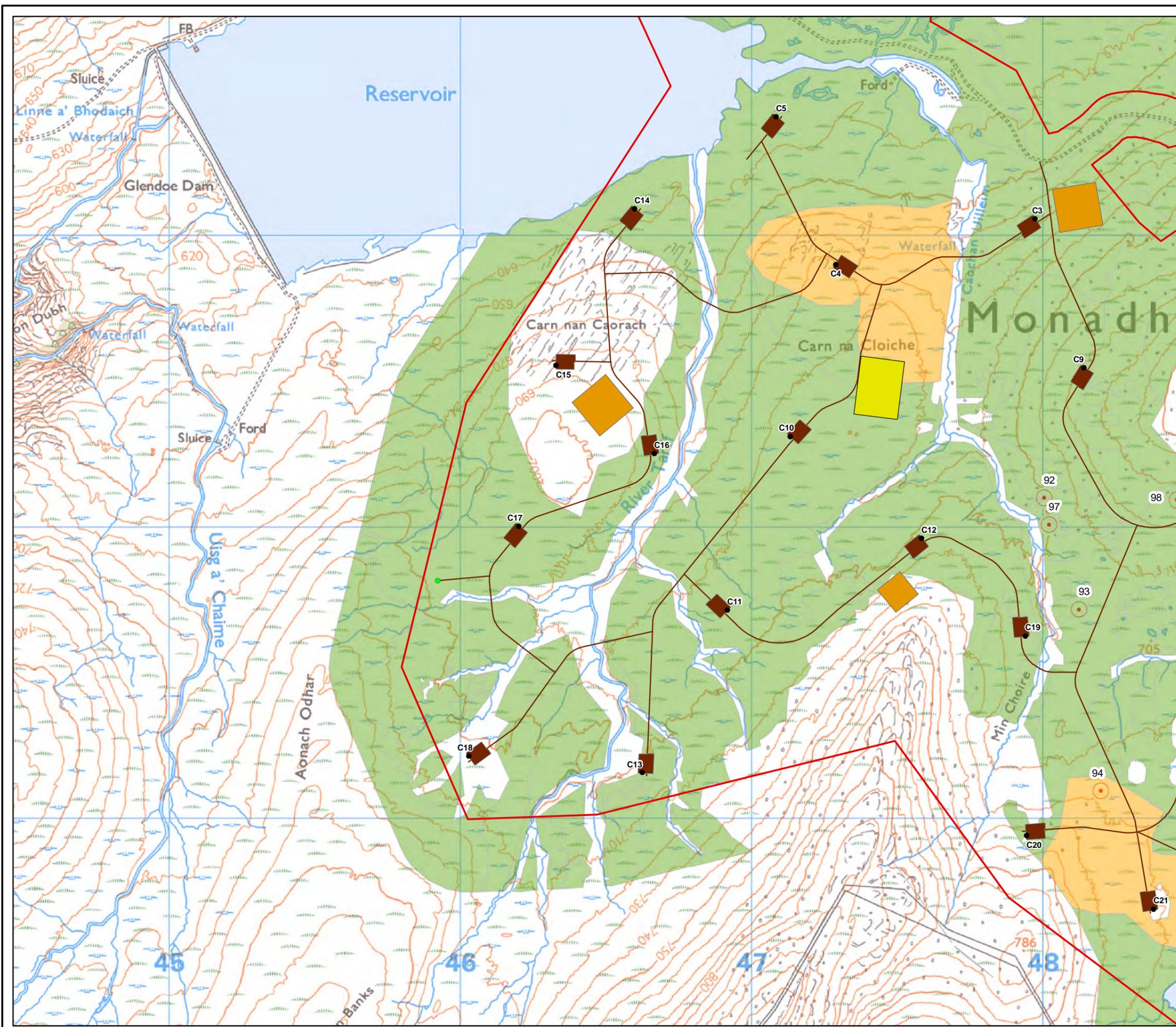
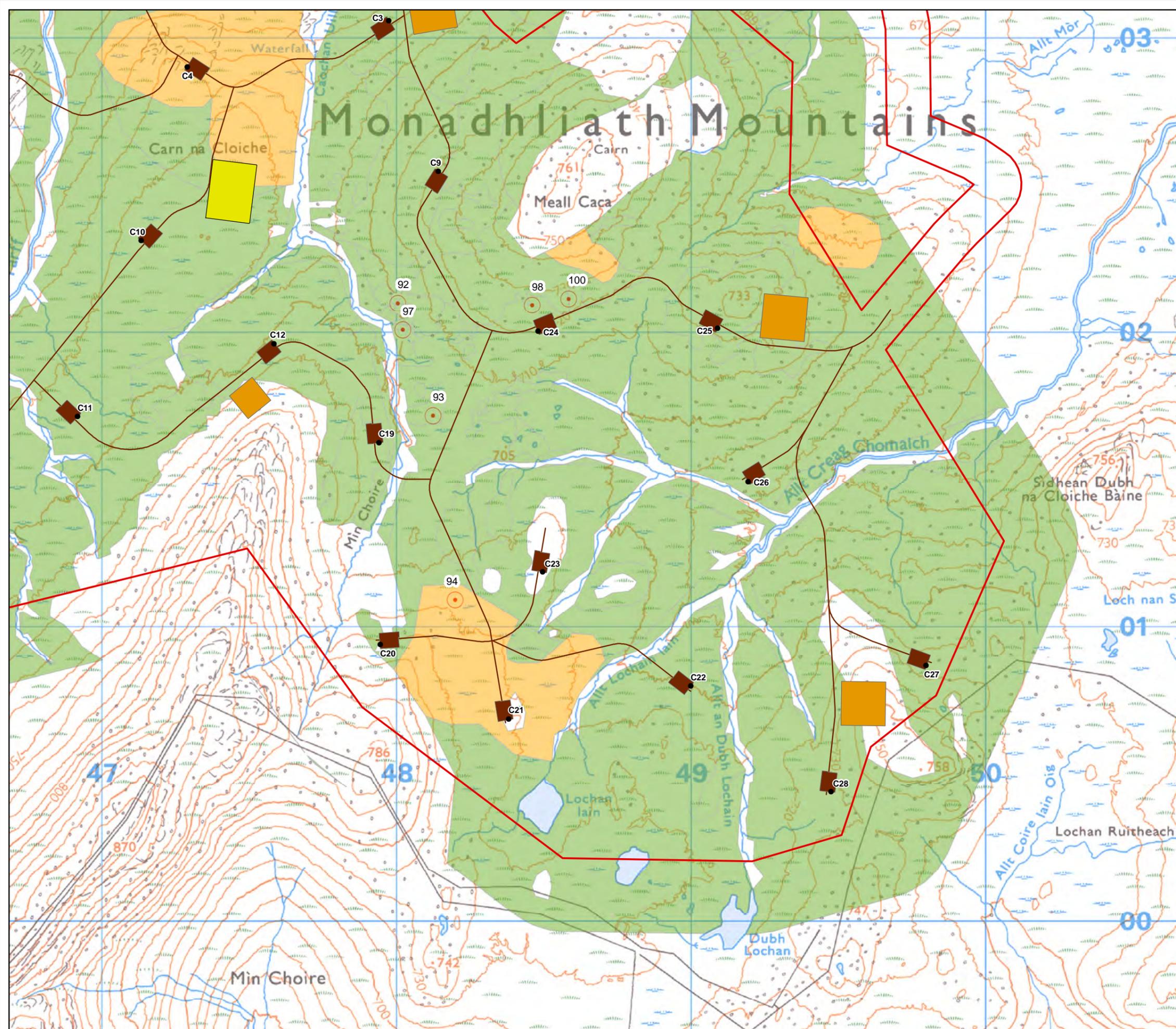


Figure 4 (b)
NVC Communities used to inform
GWDTE Assessment

Cloiche Wind Farm
Technical Appendix 10.1



Key

- Site Boundary
 - Turbine
 - Track
 - Borrow Pit Search Area
 - Hardstanding
 - Substation
 - GWDTE Target Notes
- NVC**
- M15 Wet Heath
 - M19/M17/M20/bare peat mosaic

No.	Note
92	M25 Molinia caerulea-Potentilla erecta mire (small flush)
93	M32 Philonotis fontana-Saxifraga stellaris spring
94	M10 Pinguicula-Caricetum dioicae mire (stony flush)
95	Transitional area from bog to acid grassland on edge of watercourse
97	Sedge-dominated flush. E.vaginatum, Sphagnum sp., Hylocomium, Polytrichum. Carex sp. and bryophytes such as Philonotis.
98	Flush (M6) in a wet channel grasses & E.vaginatum.
100	Flush with wet heath/acid grassland mosaic at top and marshy grassland which may be classed as M6/M25 lower downslope where peat is >0.5m

0 100 200 300 400 500
m
Scale: 1:12,500 @ A3



Figure 4 (c)
NVC Communities used to inform
GWDTE Assessment

Cloiche Wind Farm
Technical Appendix 10.1

Key

- Site Boundary
- Turbine
- Track
- Borrow Pit Search Area
- Hardstanding
- NVC
- M19/M17/M20/bare peat mosaic

No.	Note
92	M25 Molinia caerulea-Potentilla erecta mire (small flush)
93	M32 Philonotis fontana-Saxifraga stellaris spring
94	M10 Pinguicula-Caricetum dioicae mire (stony flush)
95	Transitional area from bog to acid grassland on edge of watercourse
97	Sedge-dominated flush. E.vaginatum, Sphagnum sp., Hylocomium, Polytrichum. Carex sp. and bryophytes such as Philonotis.
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Scale: 1:12,500 @ A3

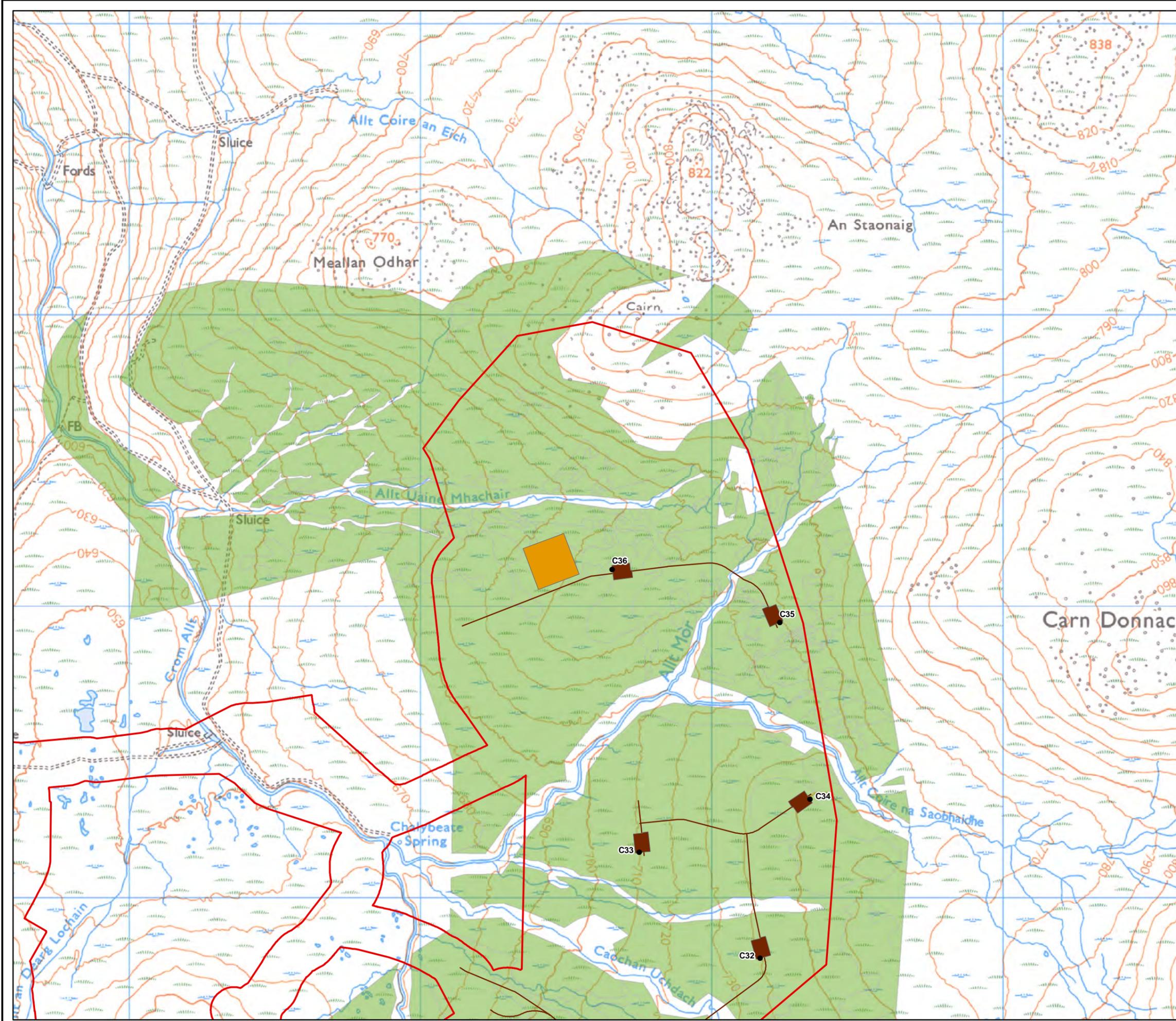


Figure 4 (d)
NVC Communities used to inform
GWDTE Assessment

Cloiche Wind Farm
Technical Appendix 10.1

Key

- Site Boundary
- LiDAR
- Turbine
- Track
- Borrow Pit Search Area
- Hardstanding
- NVC
- M19/M17/M20/bare peat mosaic

No.	Note
92	M25 Molinia caerulea-Potentilla erecta mire (small flush)
93	M32 Philonotis fontana-Saxifraga stellaris spring
94	M10 Pinguicula-Caricetum dioicae mire (stony flush)
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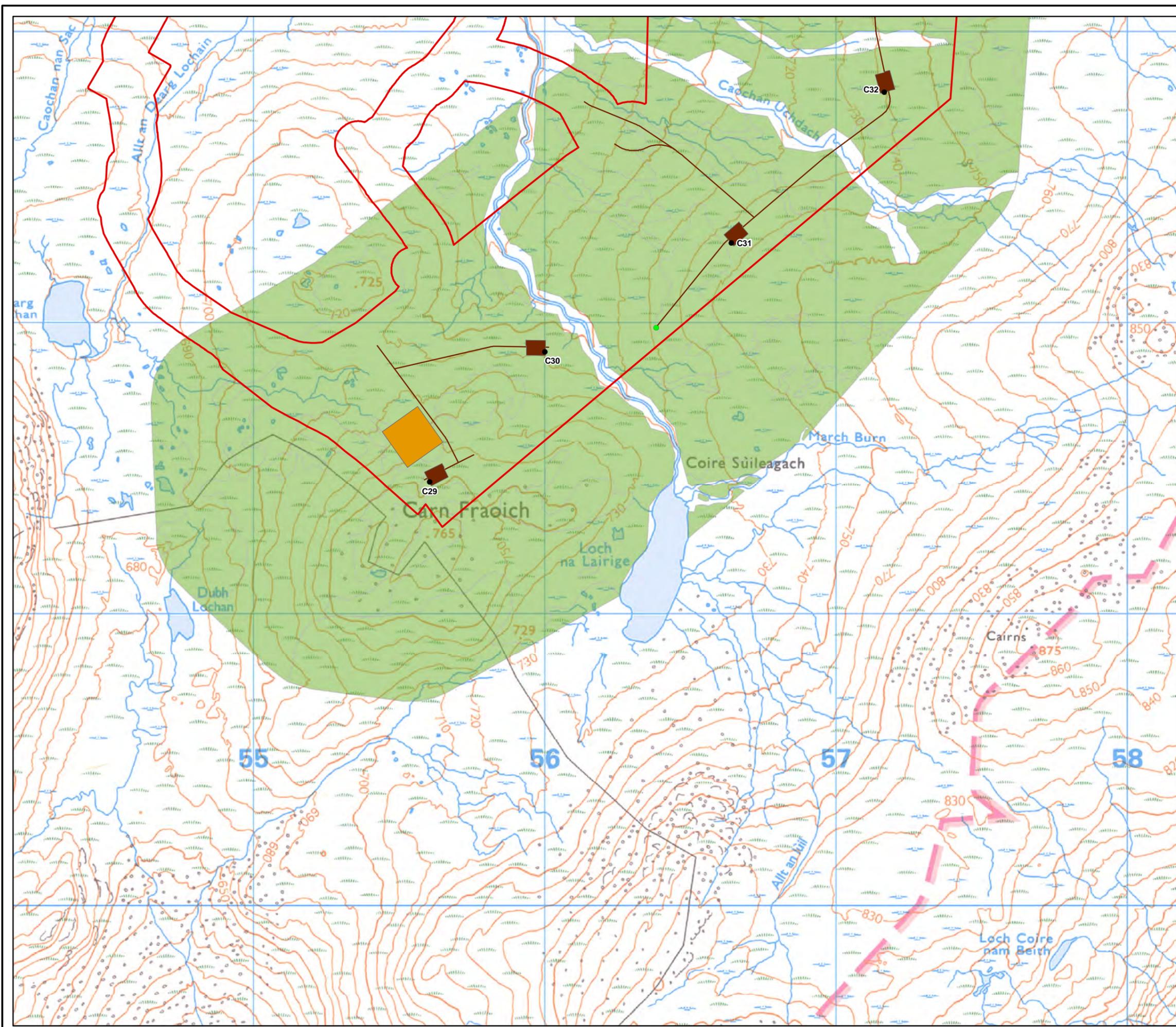
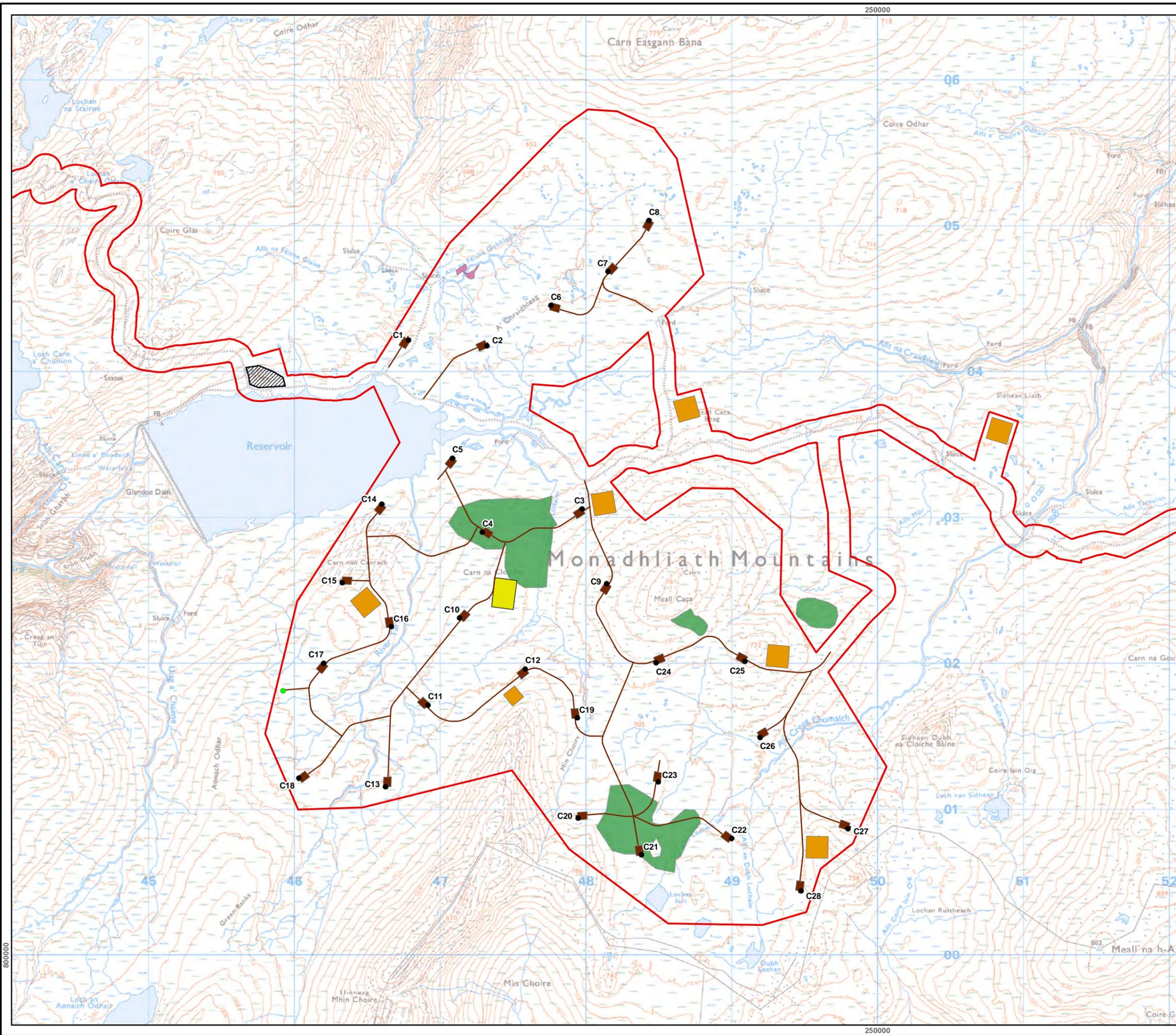


Figure 4 (e)
NVC Communities used to inform
GWDTE Assessment

Cloiche Wind Farm
Technical Appendix 10.1



Key

- Site Boundary
- LiDAR
- Turbine
- Track
- Borrow Pit Search Area
- Batching Plant
- Compound
- Hardstanding
- Substation

Potential GWDTE Areas

NVC Assessment

- Potential Moderate GWDTE
- Potential High GWDTE

This map presents habitats with a potential to be a GWDTE according to only NVC classification. Further assessment of potential groundwater sensitivity is provided within the accompanying report.

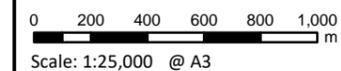


Figure 5 (a)

Hydrology: Potential GWDTE Areas

Cloiche Wind Farm
Technical Appendix 10.1

Key

- Site Boundary
 - LiDAR
 - Turbine
 - Track
 - Borrow Pit Search Area
 - Batching Plant
 - Compound
 - Hardstanding
 - Substation
- Potential GWDTE Areas
- NVC Assessment
- Potential Moderate GWDTE
 - Potential High GWDTE

This map presents habitats with a potential to be a GWDTE according to only NVC classification. Further assessment of potential groundwater sensitivity is provided within the accompanying report.

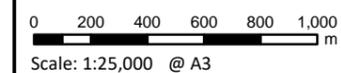
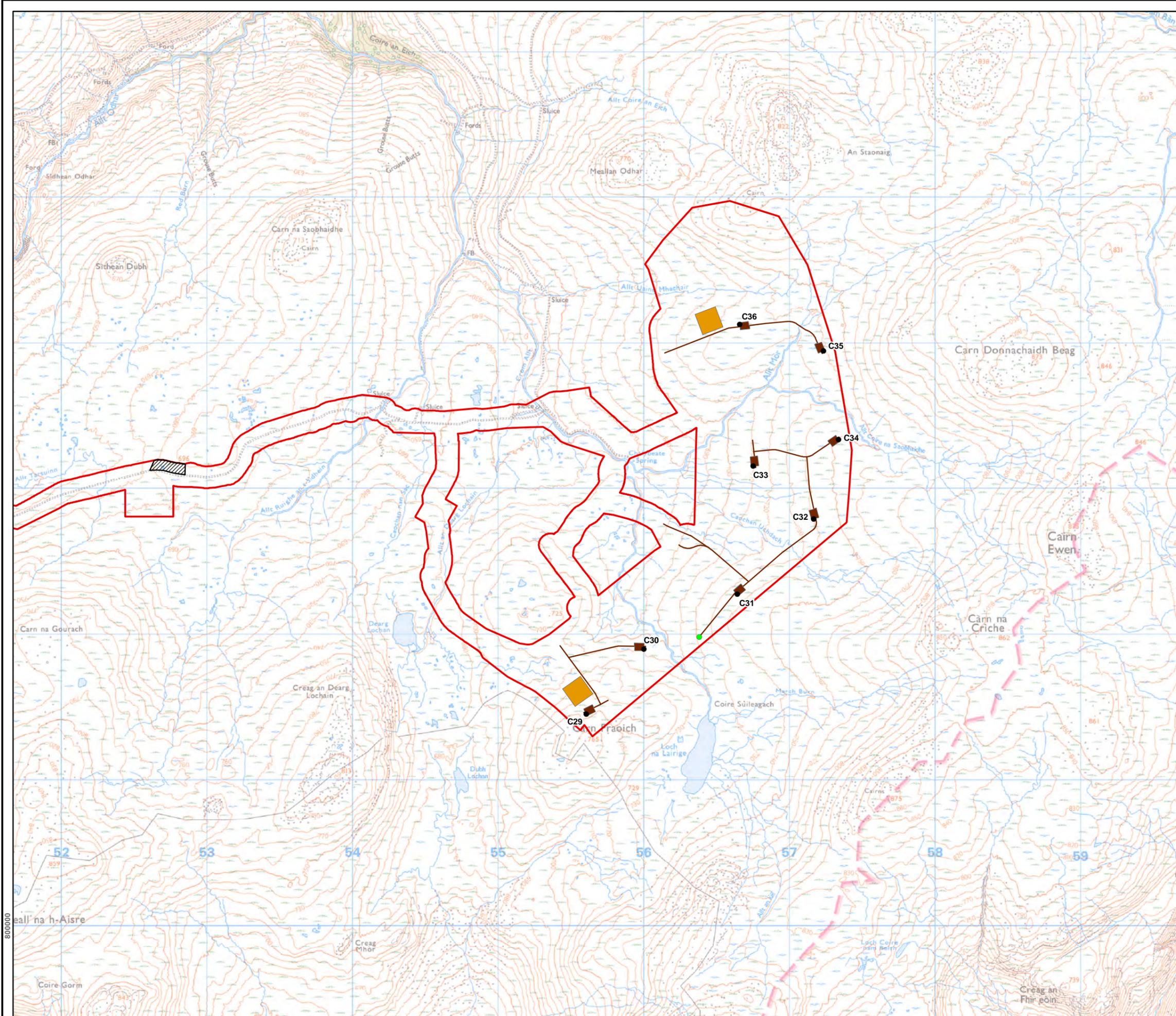


Figure 5 (b)
Hydrology: Potential GWDTE Areas



Key

- Site Boundary
 - LiDAR
 - Turbine
 - Track
 - Borrow Pit Search Area
 - Batching Plant
 - Compound
 - Hardstanding
 - Substation
- Potential GW DTE Areas
- NVC Assessment
- Potential Moderate GW DTE
 - Potential High GW DTE

This map presents habitats with a potential to be a GW DTE according to only NVC classification. Further assessment of potential groundwater sensitivity is provided within the accompanying report.

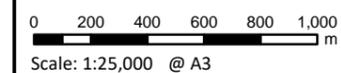
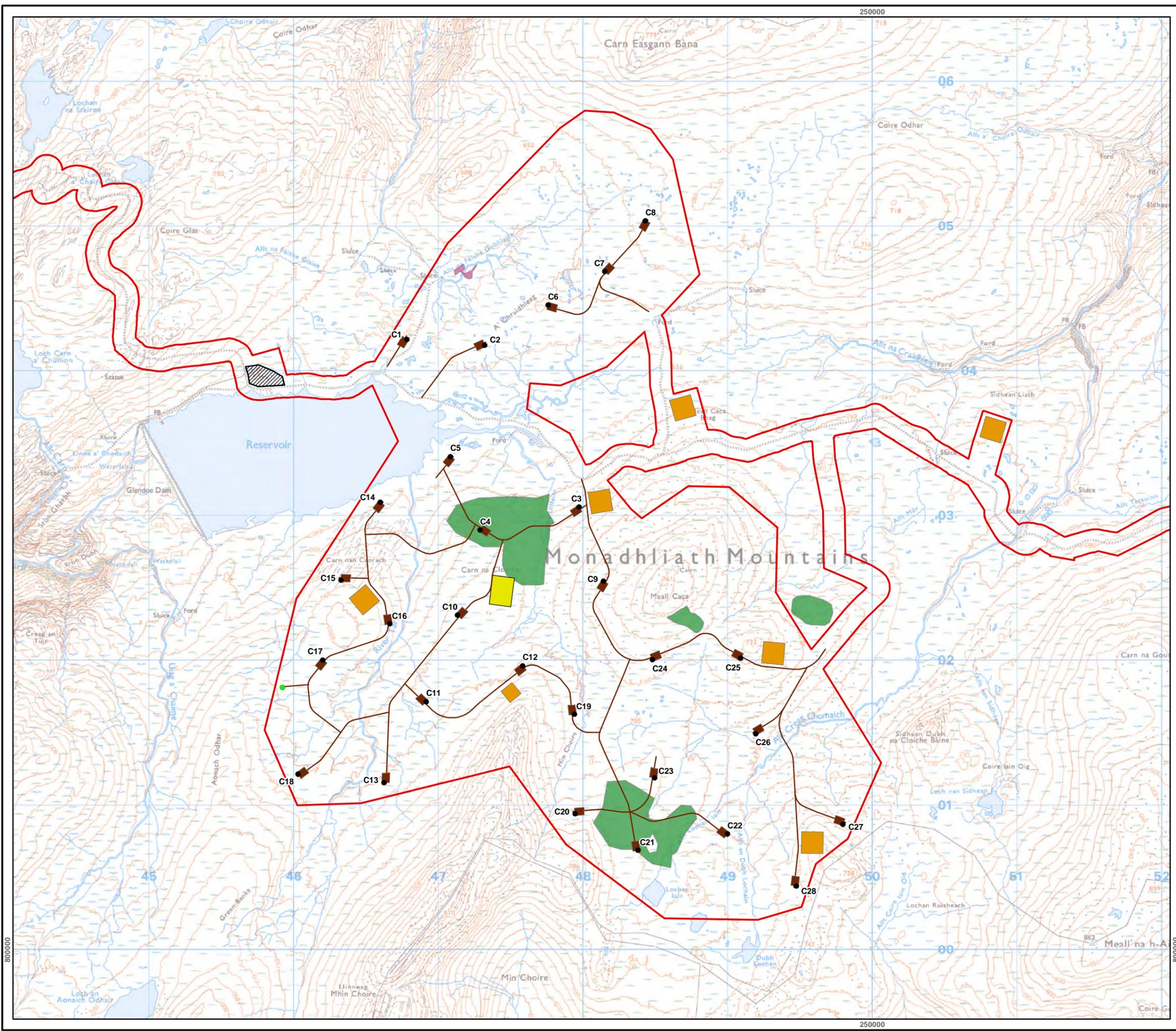


Figure 6 (a)
Hydrology: Potential GW DTE Areas Following Assessment



Key

- Site Boundary
- LiDAR
- Turbine
- Track
- Borrow Pit Search Area
- Batching Plant
- Compound
- Hardstanding
- Substation

Potential GWDTE Areas

NVC Assessment

- Potential Moderate GWDTE
- Potential High GWDTE

Identification of GWDTE areas following assessment. No areas considered likely to be groundwater dependent.

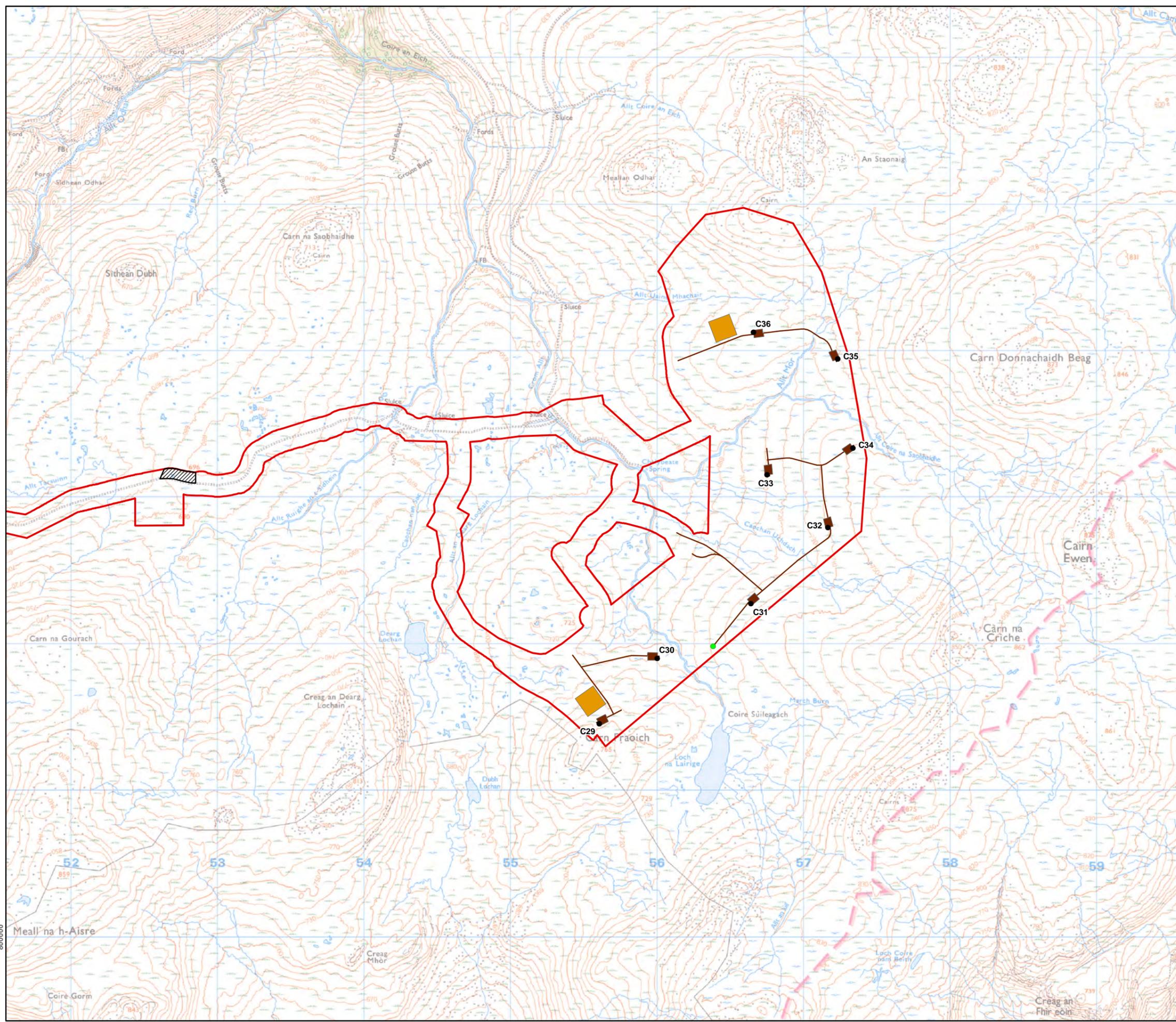
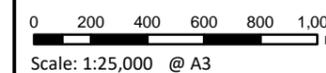


Figure 6 (b)
Hydrology: Potential GWDTE Areas Following Assessment
Cloiche Wind Farm
Technical Appendix 10.1