Houghton Main Renewable Energy Centre

Ecological assessment for Environmental Permit

Prepared for Sol Environmental Ltd.

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Unit 14 The Greenhouse Greencroft Industrial Park
Annfield Plain County Durham DH9 7XN

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Contents

1 Introduction

This document provides an ecological assessment of air quality and noise impacts for a planned Renewable Energy Centre using refuse derived fuel (RDF) at Houghton Main, Barnsley, South Yorkshire ('the Facility'), with particular reference to potential effects on Dearne Valley Wetlands SSSI. The assessment has been undertaken for Sol Environment Ltd., to inform an Environmental Permit application for GRID Powr.

The Facility is planned to be located on land centred on OS grid reference 441600, 406400 (the 'Site'). This was granted planning permission by Barnsley Metropolitan Borough Council on 29 June 2015 (ref. 2015/0137) for a Renewable Energy Park processing up to 150,000 tonnes per annum (tpa) of waste timber. This was amended on 17 April 2019 (ref. 2018/1437) to allow the use of RDF, and to increase capacity to 260,000 tpa.

Dearne Valley Wetlands was notified as a Site of Special Scientific Interest (SSSI) in 2021, and was not previously considered as a sensitive receptor in previous planning consents or subsequent amendments.

The assessment includes the following elements:

- Assessment of sensitivity of proximal ecological receptors to air quality and noise impacts, including a literature search and field survey;
- Ecological interpretation of the Air Quality Assessment (AQA) undertaken by Sol Environment Ltd[1].; and
- Ecological interpretation of the Noise Assessment undertaken by Sol Environment Ltd.

The aim of this document is to provide further ecological interpretation of the results of the AQA and noise assessment, focussing on any impacts on sensitive ecological receptors which cannot be screened out as insignificant, in accordance with Environment Agency (EA) criteria and other relevant guidance.

[1] Sol Environment (2023a). *Air Quality Assessment.*

2 Scope and methodology

2.1 Scope of assessment

Assessment of receptor sensitivity to air quality and noise impacts

The assessment of ecological receptor sensitivity to air quality impacts would normally begin with reference to the Air Pollution Information Service (APIS) website and APIS GIS app, which provides appropriate environmental quality standards (EQS) for qualifying and notified features of statutory designated sites. However, due to its recent notification, Dearne Valley Wetlands SSSI is not listed on the GIS app[2]. It was therefore necessary to derive appropriate EQSs by reference to information published by Natural England about notified features and their supporting habitats, with field verification of habitats present in the vicinity of the Facility.

With respect to the noise assessment, it was important to determine the likely distribution of notified features in the vicinity of the development, based on habitat suitability and known records.

The geographic scope of the field survey was defined by the results of air quality dispersion and deposition modelling, and the results of the noise modelling.

Ecological interpretation of air quality assessment

The scope of assessment is defined by the model results of the Air Quality Assessment (AQA) completed by Gair Consulting on behalf of Sol Environmental Ltd.

The AQA identified the following exceedances of Environment Agency screening thresholds at Dearne Valley Wetlands SSSI (see section 4 below):

- Long-term (annual mean) ammonia (NH_3) levels, where the predicted environmental concentration (PEC) exceeds 70% of the critical level for protection of ecosystems;
- Nitrogen deposition rates to acid birch woodland habitat (at 10kg N/ha/yr lower critical load), where background rates greatly exceed the critical load;
- Nitrogen deposition rates to eutrophic woodland habitats (at 15kg N/ha/yr lower critical load), where background rates greatly exceed the critical load;
- Nitrogen deposition rates to grassland habitats (at 20kg N/ha/yr critical load), where background rates slightly exceed the critical load;

[2] https://www.apis.ac.uk/app (accessed 11/04/2023)

- Acid deposition rates to woodland habitats, where the PEC is over 70% of the relevant critical load; and
- Short-term weekly hydrogen fluoride (HF) levels, where the process contribution (PC) exceeds 10% of the critical level for protection of sensitive vegetation.

Note also that there were no exceedances of screening thresholds at locally designated sites, in accordance with Environment Agency guidance for environmental permitting purposes. These are modelled in the AQA, but not considered further in this assessment.

Assessment of receptor sensitivity to noise impacts

As Dearne Valley Wetlands SSSI is notified for its ornithological interest and part of the site is predicted to experience elevated noise levels, it was necessary to assess sensitivity to noise impacts. The majority of notified bird species are associated with wetland habitats, and sensitivity could be assessed with reference to guidance published in the Institute of Estuarine and Coastal Studies' *Waterbird Disturbance Mitigation Toolkit*. For woodland species there is no equivalent guidance; a literature search was therefore necessary to assess sensitivity based on published research and attributes of the relevant notified species, with field verification of habitat suitability in the vicinity of the Facility.

2.2 Methodology

Field survey

The objectives of the field survey could be defined as follows:

- To assess habitat suitability for SSSI notified species, to determine which were likely to occur in proximity to the development;
- To identify which plant communities were present in proximal areas of the SSSI, in order to identify an appropriate critical load for nitrogen deposition;
- To identify whether any woodland or other habitats were likely to support important lower plant communities, in order to assign the correct ammonia critical level;
- To assess any factors which might increase or decrease sensitivity to noise levels in SSSI notified bird species.

The geographic scope of the field survey focussed on units 4 and 5 of the SSSI (Edderthorpe Flash (unit 4) and 3 discrete woodland / wetland areas (unit 5)).

Woodland habitats were identified if possible to the relevant National Vegetation Classification (NVC) plant community and EUNIS Level 4 habitat. Descriptions were made in the field of species composition, canopy height and structure. The epiphyte flora was assessed for the presence of nitrophilous or acidophilous indicator species, and the presence of potentially sensitive bryophyte or lichen species in the ground layer was recorded.

Grassland and wetland habitats could not be closely approached due to access restrictions, and were assessed to broad habitat / EUNIS Level 2 or 3 if possible.

Habitat suitability for notified species of wetland habitats was assessed in the field through presence of the appropriate broad habitat (e.g. wet grassland / reedbed / open water); as the SSSI is multi-part site, not all features are likely to occur in all units. Birds were also recorded and counted during the field survey, which at the time of survey included some early breeding species as well as late winter visitors. This single-visit recording did not purport to constitute a bird survey; more robust background evidence of the avifauna of the Edderthorpe Flash unit was provided by reference to the relevant eBird bar chart[3] detailing observations uploaded by visiting birders.

Habitat suitability of woodland and scrub habitats for willow tit was assessed with reference to the *Willow Tit Conservation Handbook*[4]. This was based on research conducted in the Dearne Valley, and also included data on local records. The survey also sought to record any evidence of willow tit presence, including sightings, calls or song.

Constraints

Access was limited to permissive routes along established paths (e.g. along dismantled rail routes), using the access point recommended on the RSPB website at a layby on Park Spring Road. Wetland habitats were viewed from these paths using binoculars and telescope; permission was not sought to approach closer, and would not in any case have been legally possible due to the presence of breeding species with special protection from disturbance under Schedule 1.1 of the Wildlife & Countryside Act 1981.

[3] https://ebird.org/barchart?r=L4880051&yr=all&m= (accessed 15/04/2023)
[4] Back from the Brink (undated). *Willow Tit Conservation Handbook.* https://naturebftb.co.uk/wp-content/uploads/2021/09/25221_BftB_Willow_Tit_Handbook_V6.pdf

Assessment methodology

Notified features of the SSSI were identified with reference to supporting information published by Natural England[5]. This included individual bird species, as well as component members of bird assemblage features.

Habitat affinities were derived from Natural England's supporting information document, supplemented where necessary by additional publications.

Sensitivity of notified features of designated sites was assessed with reference to the Air Pollution Information Service (APIS) website.

Background deposition rates used in the AQA were derived from the APIS website, using the Query by Location function for the OS grid reference at the point of maximum modelled impact at the SSSI boundary.

Assessment of effect magnitude and significance

There are no currently accepted thresholds for assessing the magnitude of air quality effects on ecological receptors. At the time of preparation of this report, draft CIEEM / IAQM guidance has been published, but has not yet been finalised and cannot yet be referred to; neither this draft document or the IAQM (2019) guidance provides any guidance on effect magnitude or ecological significance thresholds. In the absence of guidance for ecological receptors, Environmental Protection UK (EPUK, 2010)[6] advice can be applied with caution; although this was developed for assessment of nitrogen dioxide and particulate emissions on human health in a development control context, it provides a useful descriptor to express impact magnitude as a percentage of the relevant assessment level (see Table 2.2 below). This has now been superseded by revised advice, which is now explicitly reserved for application in a human health assessment context.

[5] Natural England (2021). *Dearne Valley Wetlands SSSI: Supporting Information*. 13 May 2021. https://consult.defra.gov.uk/natural-england/dearne-valley-wetlands-sssi/supporting_documents/Dearne%20Valley%20Wetlands%20Supporting%20Information%20notified%2013%20May%202021.pdf

[6] Environmental Protection UK (2010). *Development Control: Planning For Air Quality (2010 Update)*. EPUK, April 2010.

Table 2.1: EPUK (2010) guidance on impact magnitude

Magnitude of change	Annual mean value increase / decrease (as percentage of assessment level)
Large	>10%
Medium	5 – 10%
Small	1 – 5%
Imperceptible	<1%

With respect to assessing **significance** of ecological effects, it is important to note that the 1% screening threshold is not an effect threshold. The magnitude of impact which might result in a significant ecological effect is likely to depend on baseline conditions and sensitivity of the receiving environment.

CIEEM (2016[7]) define a significant ecological effect as *"an impact on the integrity of a defined site or ecosystem and/or the conservation status of habitats or species within a given geographical area"*. The guidelines do not favour a matrix approach to the assessment of significance, because these can downplay impacts on features of local importance, and the ecological meaning of the resulting terms is often poorly defined. Instead, significance is defined at the geographic scale at which it occurs.

With respect to assessing whether it is possible to conclude no adverse effect on site integrity (European site) and to conclude no damage (SSSIs) in a permitting context in England and Wales, Environment Agency (EA) guidance[8] distinguished between circumstances when:

- the background concentration is less than the appropriate environmental criterion but a small process contribution leads to an exceedance; or
- the background concentration is currently exceeding the appropriate environmental criterion and the new process contribution will cause an additional **small** increase; and

[7] CIEEM (2016). *Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater and Coastal, 2nd edition*. Chartered Institute of Ecology and Environmental Management, Winchester

[8] Environment Agency (2012). *Detailed assessment of the impact of aerial emissions from new or expanding IPPC regulated industry for impacts on nature conservation*. Operational Instruction 67_12, Issued 08/05/12

- the background concentration is less than the appropriate environmental criterion, but the process contribution is significant (*i.e. of higher magnitude*) and leads to an exceedance; or
- the background concentration is more than the appropriate environmental criterion, and the process contribution is **large.**

In the first two circumstances, the EA recommend that a decision is based on local circumstances, based on factors set out in guidance (such as spatial disposition of sensitive habitats relative to predicted effects); in the latter two circumstances, the EA state that it is not possible to conclude no adverse effect. The EA go on distinguish between the varying level of legal and policy protection applied to European sites relative to SSSIs. For European sites (SACs, SPAs and Ramsar sites) the key policy test is 'no likely significant effect', which is best understood as 'no possible significant effect according to best available scientific knowledge'. For SSSIs, the EA refer to 'operations likely to damage' a SSSI.

2.3 Personnel

The report has been prepared by Kevin Barry Honour MSc MCIEEM, a freelance ecologist and Director of Argus Ecology Ltd. He specialises in ecological interpretation of air quality assessments, Habitats Regulations Assessment, Ecological Impact Assessment, habitat surveys (including UKHC / NVC / EUNIS), and ornithological surveys. He has undertaken numerous interpretations of model outputs for point-source discharges, assessing effects on a wide variety of sites and habitat types, and assessed sensitivity of birds to noise and disturbance impacts. He is familiar with the key species of Dearne Valley Wetlands SSSI, including in particular willow tit.

He was previously a Senior Lecturer in Ecology at the University of Sunderland, with responsibility for teaching air pollution ecology at undergraduate and Masters level.

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3 Assessment of sensitivity to air quality and noise impacts

3.1 Dearne Valley Wetlands SSSI

Location and component sites

Dearne Valley Wetlands SSSI was notified by Natural England on 13 May 2021 under Section 28 of the Wildlife and Countryside Act 1981, and was confirmed on 19 January 2022 following a period of consultation with stakeholders from 13 May - 13 September 2021[9].

Dearne Valley Wetlands is a multi-site SSSI, incorporating a number of discrete and linked component sites. Sites within 2km of the planned Facility are shown on Figure 1, with their relevant SSSI Unit number.

Notified features and supporting habitat

Natural England's SSSI supporting information document[10] sets out the site's notified features, and gives some indications of relevant supporting habitat. Notified features are summarised in the table below, with supporting habitat added. These have been translated to equivalent European Nature Information System (EUNIS) habitats[11,12] , in order to facilitate comparison with nitrogen deposition Critical Load information published by APIS[13]. Note that the EUNIS classification has recently been revised, with different habitat codes; however, this process is still ongoing, and has not yet been adopted on the APIS website (see e.g. Arts *et al*, 2022[14]), so the older system is retained here for clarity. However, it should be noted that a recent review of European critical

[9] https://consult.defra.gov.uk/natural-england/dearne-valley-wetlands-sssi/ (accessed 06/04/2023)
[10] Natural England (2021). *Dearne Valley Wetlands SSSI: Supporting Information*. 13 May 2021. https://consult.defra.gov.uk/natural-england/dearne-valley-wetlands-sssi/supporting_documents/Dearne%20Valley%20Wetlands%20Supporting%20Information%20notified%2013%20May%202021.pdf
[11] Strachan, I.M. (2015). *Manual of terrestrial EUNIS habitats in Scotland*. Scottish Natural Heritage Commissioned Report No. 766
[12] Davies, C.E., Moss, D., & Hill, M.O. (2004). *EUNIS Habitat Classification Revised 2004.* European Environment Agency, October 2004
[13] APIS: *Indicative values within nutrient nitrogen critical load ranges for use in air pollution impact assessments*. https://www.apis.ac.uk/indicative-critical-load-values (accessed 06/04/2023)
[14] Arts, G., Watson, M., Lyche Solheim, A., Schaminée, J., Evans, D., Lund, M. & Tryfon, E., (2022). *Revision of the EUNIS inland surface water habitat group: finalisation of level 3 and outlook to level 4*. ETC/BD report to the EEA

loads (Bobbink *et al*, 2022[15]) and a publication on Scottish nitrogen deposition impacts[16] both use the new EUNIS system.

Table 3.1: Dearne Valley Wetlands SSSI notified features

Notified Feature	Supporting habitats
Gadwall (non-breeding) Shoveler (non-breeding)	C1. Surface standing waters
Gadwall (breeding) Shoveler (breeding) Garganey (breeding) Pochard (breeding)	C1. Surface standing waters C3.2 Water-fringing reedbeds and tall helophytes C3.4 Species-poor beds of low-growing water-fringing or amphibious communities D4.1 Rich fens, including eutrophic tall-herb fens D5 Sedge and reedbeds normally without free-standing water E3.4 Moist or wet eutrophic and mesotrophic grassland
Black-headed gull (breeding)	C1. Surface standing waters C3.5 Periodically inundated shores with pioneer or ephemeral vegetation C3.6 Unvegetated or sparsely-vegetated shores with soft or mobile sediments
Bittern (breeding)	C3.21 *Phragmites australis* (reed) beds
Willow tit (breeding)	G1.1 Riparian and gallery woodland with dominant *Alnus, Betula, Populus* or *Salix* G1.2 Mixed riparian and gallery woodland G5.7 Coppice and early-stage plantations F3.1 Temperate thickets and scrub F9.2 *Salix* carr and fen scrub
Breeding bird assemblage of lowland open waters and their margins and lowland fens	C1. Surface standing waters C3.2 Water-fringing reedbeds and tall helophytes C3.4 Species-poor beds of low-growing water-fringing or amphibious communities D4.1 Rich fens, including eutrophic tall-herb fens D5 Sedge and reedbeds normally without free-standing water

[15] Bobbink R, Loran C, Tomassen H, eds. (2022). *Review and revision of empirical critical loads of nitrogen for Europe*. Dessau-Rosslau: German Environment Agency

[16] Britton, A.J., Fielding, D.A. & Pakeman, R.J. (2023) *Nitrogen mitigation: A review of nitrogen deposition impacts and mitigation potential in Scottish semi-natural ecosystems*. The James Hutton Institute, Aberdeen

Notified Feature	Supporting habitats
Breeding bird assemblage of lowland damp grassland	E3.4 Moist or wet eutrophic and mesotrophic grassland
Breeding bird assemblage of dense scrub	F3.1 Temperate thickets and scrub F9.2 *Salix* carr and fen scrub

Natural England's supporting information also lists the component species of the three breeding bird assemblage features which are present in Dearne Valley Wetlands SSSI.

Table 3.2: Breeding bird assemblage component species

Assemblage	Component species
Breeding bird assemblage of lowland open waters and their margins and lowland fens	Avocet *Recurvirostra avosetta* Bearded tit *Panurus biarmicus* Bittern *Botaurus stellaris* Cetti's warbler *Cettia cetti* Common tern *Sterna hirunda* Cuckoo *Cuculus canorus* Gadwall *Mareca strepera* Garganey *Spatula querquedula* Grasshopper warbler *Locustella naevia* Great crested grebe *Podiceps cristatus* Grey wagtail *Motacilla cinerea* Kingfisher *Alcedo atthis* Little grebe *Tachybaptus ruficollus* Little ringed plover *Charadrius dubius* Mute swan *Cygnus olor* Pochard *Aythya ferina* Redshank *Tringa totanus* Reed bunting *Emberiza schoeniclus* Reed warbler *Acrocephalus scirpaceus* Sedge warbler *Acrocephalus schoenobaenus* Shelduck *Tadorna tadorna* Shoveler *Spatula clypeata* Snipe *Gallinago gallinago* Tufted duck *Aythya fuligula* Water rail *Rallus aquaticus* Willow tit *Poecile montanus* Yellow wagtail *Motacilla flava*
Breeding bird assemblage of lowland damp grassland	Cuckoo *Cuculus canorus* Gadwall *Mareca strepera* Garganey *Spatula querquedula* Grasshopper warbler *Locustella naevia* Lapwing *Vanellus vanellus* Mute swan *Cygnus olor* Pochard *Aythya ferina* Redshank *Tringa totanus* Reed bunting *Emberiza schoeniclus* Sedge warbler *Acrocephalus schoenobaenus* Shelduck *Tadorna tadorna* Shoveler *Spatula clypeata* Snipe *Gallinago gallinago* Yellow wagtail *Motacilla flava*

Assemblage	Component species
Breeding bird assemblage of dense scrub	Bullfinch *Pyrrhula pyrrhula* Cuckoo *Cuculus canorus* Garden warbler *Sylvia borin* Grasshopper warbler *Locustella naevia* Lesser whitethroat *Sylvia curruca* Linnet *Carduelis cannabina* Long-eared owl *Asio otus* Long-tailed tit *Aegithalos caudatus* Willow tit *Poecile montanus* Yellowhammer *Emberiza citrinella*

3.2 Sensitivity of supporting habitat to air quality impacts

Nitrogen deposition critical loads

APIS list recommended critical loads for environmental assessment purposes for a range of EUNIS habitat types (shown in bold with range). The table below lists these for relevant supporting habitats of the SSSI notified features. In some cases critical loads are sourced from the APIS GIS app for other sites with the same notified feature; in other cases the habitats are translated to similar equivalents.

Table 3.3: Critical Loads for nitrogen deposition of SSSI supporting habitats

SSSI supporting habitat	Relevant habitat listed by APIS	Critical load (kg N/ha/yr)
C1. Surface standing water C3.4 Species-poor beds of low-growing water-fringing or amphibious communities	C1. Surface standing water	Sensitivity depends on N or P limitation
C3.2 Water-fringing reedbeds and tall helophytes	Not listed	No critical load assigned
D4.1 Rich fens, including eutrophic tall-herb fens	D4.1 Rich fens	**15** - 30
E3.4 Moist or wet eutrophic and mesotrophic grassland	E2.2 Low and medium altitude hay meadows	**20** - 30
G1.1 Riparian and gallery woodland with dominant *Alnus, Betula, Populus* or *Salix* G1.2 Mixed riparian and gallery woodland G5.7 Coppice and early-stage plantations F9.2 *Salix* carr and fen scrub	G1.A Meso- and eutrophic *Quercus* woodland	**15** - 20

Using APIS Query by Location for the proximal 1km grid square, modelled background deposition rates are well above the critical load for woodland habitats, and above the critical load for both grassland and fen habitats.

Woodland background deposition rates are modelled at 37.54 kgN/ha/yr; grassland and wetland rates are 21.86 kgN/ha/yr.

Acid deposition rates

The APIS Query by Location tool was used to find appropriate critical loads for acid deposition for the relevant broad habitat. The following values (CLmaxN) were obtained:

Table 3.4: Critical loads for acid deposition

Location	Broad habitat	Critical load (keq/ha/yr)	Background (keq/ha/yr)
441373, 407895	Broadleaved, mixed and yew woodland	3.044	2.81
441430, 406730	Calcareous grassland (meadow)	5.071	1.66
441260, 407090	Fen, marsh and swamp	Not sensitive	1.66

Ammonia critical level

The 3μg/m^3 critical level for ammonia is appropriate for these habitats, as they are not notified for the presence of important lower plant (bryophyte or lichen) communities. Background levels are modelled at 2.6μg/m^3 for the relevant 1km grid square, 87% of the critical level.

Hydrogen fluoride (HF) critical level

The 0.5μg/m^3 weekly mean critical level has been applied as a screening threshold in the AQA. This is in accordance with APIS guidance; exceedance of this value can affect the most sensitive species[17] of grassland and wetland margin habitats, which on this site could include yellow flag iris (*Iris pseudacorus*). Exceedance can result in visible injury symptoms, but ecosystem level effects (e.g changes in the species composition or structure of plant communities) are less certain.

[17] https://www.apis.ac.uk/node/1132

3.3 Sensitivity to noise impacts

Sensitivity of wetland bird species and assemblages

The *Waterbird Disturbance Mitigation Toolkit*[18] classifies a number of wetland bird species according to sensitivity to noise and disturbance, based on a range of empirical data. Although primarily developed to inform construction works on non-breeding birds in estuarine habitats, it is relevant for inland wetland habitats, with some of the same species represented. For those which are not represented, application of values from the most sensitive species provides a precautionary approach. The table below gives disturbance thresholds for species which are notified features or members of the wetland bird assemblages present at Dearne Valley Wetlands SSSI.

Table 3.5: Noise disturbance thresholds for wetland bird species

Species	Disturbance potential	Caution advised above...	Background noise threshold
Shelduck	High	60dB	70dB
Lapwing	Moderate	55dB	72dB
Redshank	High (for noise)	55dB	70dB

Notified species such as gadwall, shoveler and pochard, together with members of the wetland bird assemblage such as avocet and snipe are not listed in the *Toolkit*; however, application of the 55dB threshold should define a 'no likely effect' zone of low level noise stimulus for both sudden and continuous noise. Sudden noise of >55dB, and continuous noise above 70dB are defined by the *Toolkit* as a 'moderate disturbance stimulus'.

Sensitivity of willow tit and bird assemblage of scrub habitats

Scientific evidence

There is no published guidance on noise sensitivity for birds of scrub and woodland habitats, which are dominated by passerine (songbird) species. It is therefore necessary to examine published research on the subject, in order to determine whether the relevant species are likely to be sensitive, and if possible to derive an appropriate threshold value.

[18] Cutts, N, Hemingway, K and Spencer, J (2013). *Waterbird Disturbance Mitigation Toolkit Informing Estuarine Planning and Construction Projects*. Institute of Estuarine & Coastal Studies (IECS) University of Hull. Version 3.2.

There is a significant scientific literature on the subject, mostly addressing potential effects of road noise on breeding birds. Studies have found effects on population density, clutch size / breeding success, and population structure.

Early studies found a reduction in population density of a range of woodland breeding birds related to distance from road; this included significant correlations with traffic noise levels for a number of species (Reijnen *et al*., 1995[19]). Studies have also found effects of traffic noise on reproductive success, with smaller great tit (*Parus major*) clutches in noisier areas (Halfwerk *et al.*, 2011[20]). In this study noise levels were monitored across the sampling area taking account of spatial heterogeneity with a range of 46-67dB(A), but didn't include any data on values with no or minimal effect or attempt to define effect thresholds. The level of traffic noise in the frequency band that overlaps most with the lower frequency part of great tit song best explained the observed variation in breeding success.

Studies which identify traffic noise as the primary causative agent have been challenged, one study of bird species / richness abundance (Summers et al, 2011[21]) indicating traffic mortality was a more likely causative relationship for the effects noted alongside roads. North American studies of oil extraction infrastructure in forest clearings provide a more robust comparison of point-source industrial noise, with compressor stations providing a noise source, and well-heads providing effectively silent controls. A study of ovenbirds (*Seiurus aurocapilla*- a Parulid warbler) in poplar forest (Habib *et al*., 2007[22]) found reduced pairing success around compressor stations compared to wellheads, together with a higher proportion of younger (i.e. less experienced) birds. Another study of well-head sites using two North American sparrow (Passerellidae) species (Kleist *et al.*, 2016[23]), spotted towhee (*Pipilo maculatus*) and chipping sparrow (*Spizella passerina*), found a delayed response time to song playback, indicating a weaker territorial response in noisier environments. In the study

[19] Reijnen, R., Foppen, R., Braak, C.T. & Thissen, J. (1995) The effects of car traffic on breeding bird populations in woodland. III Reduction of density in relation to the proximity of main roads. *Journal of Applied Ecology*, **32**, 187– 202.

[20] Halfwerk, W., Holleman, L.J.M., Lessells, C.M. and Slabbekoorn, H. (2011). Negative impact of traffic noise on avian reproductive success. *Journal of Applied Ecology*, **48**, 210–219.

[21] Summers, P.D., Cunnington, G.M. & Fahrig, L. (2011). Are the negative effects of roads on breeding birds caused by traffic noise? *Journal of Applied Ecology*, **48**, 1527–1534.

[22] Habib, L., Bayne, E.M. & Boutin, S. (2007). Chronic industrial noise affects pairing success and age structure of ovenbirds Seiurus aurocapilla. *Journal of Applied Ecology*, 44, 176–184.

[23] Kleist, N.J., Guralnik, R.P., Cruz, A., & Francis, C.. (2016). Anthropogenic noise weakens territorial response to intruder's songs. *Ecosphere*, **7** (3) 1-12.

response time increased with increasing background noise from 33.9 - 52.4dB(A); in the data responses were greatest over 50dB(A).

Avian responses to elevated background noise levels include changes in both song frequency and amplitude. A study of nightingale (*Luscinia megarhynchos*) in territories where mean background noise varied from 40-64dB(A) indicated that they adjusted sound pressure levels (SPL) up to 5x (Brumm, 2004[24]). There was a statistically significant and obvious relationship between SPL of the song and background noise level - at 40dB(A) background, bird sang at 77dB(A) at 1m distance; in the noisiest territory the bird sang at 91dB(A) at 1m average SPL. This increased song volume effect was seen at low background levels of <50dB(A).

A larger number of studies have noted shifts in song frequency with increased background noise. Slabekoorn & Ripmeester (2007)[25] found that great tits in noisier territories sang with higher minimum frequencies, thereby avoiding masking by low-pitched traffic noise. Rheindt (2003)[26] described an effect at bird community level, finding a significant relationship between dominant song frequency and decline in abundance towards a motorway, suggesting that having a higher-pitched song with frequencies well above those of traffic noise makes species less susceptible to noise pollution. Francis *et al.* (2011)[27] analysed species abundance and nesting data for birds at New Mexico well-head / compressor sites, finding that vocalisation frequency was strongly correlated to noise tolerance - species with higher frequency songs were more tolerant of noisy environments. Comparable findings were recorded by Polak *et al.* (2013)[28] with respect to road noise in Polish forest habitats. Numbers of birds and species diversity were surveyed at 54 observation points located at three distances (60, 310, 560 m) from the road, subject to mean noise intensities of 69.9, 53.3 and 50.1dB(A) respectively during the surveys. Species richness was lowest close to the road, but highest at intermediate points, while numbers of birds of 9 common species increased with distance from the road. The most sensitive species were those with

[24] Brumm, H. (2004). The impact of environmental noise on song amplitude in a territorial bird. *Journal of Animal Ecology*, **73**, 434–440.

[25] Slabekoorn H. & Ripmeester, E.A.P. (2007). Birdsong and anthropogenic noise: implications and applications for conservation. *Molecular Ecology.* doi: 10.1111/j.1365-294X.2007.03487.x

[26] Rheindt, F. (2003). The impact of roads on birds: Does song frequency play a role in determining susceptibility to noise pollution?. *Journal für Ornithologie*. **144**. 295 - 306.

[27]Francis, C.D., Ortega, C.P., & Cruz, A. (2011). Noise Pollution Filters Bird Communities Based on Vocal Frequency. *PLoS ONE* **6**(11): e27052. doi:10.1371/ journal.pone.0027052

[28] Polak, M., Wiącek, J., Kucharczyk, M. & Orzechowski, R. (2013). The effect of road traffic on a breeding community of woodland birds. *European Journal of Forest Research*. **132**. 10.1007/s10342-013-0732-z

low-frequency calls, while two species (great tit and song thrush (*Turdus philomelos*)) were more frequent closer to the road.

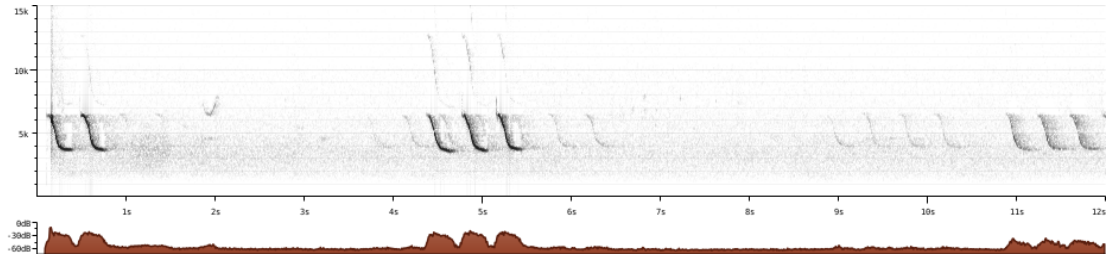
Implications for sensitivity

The literature search demonstrates there is good evidence that acoustic masking is a key mechanism for negative effects of noise on the woodland bird assemblage. There is also evidence for a greater effect on species with lower frequency songs and calls. However, there are no clear effect thresholds which can be expressed in terms of SPLs, other than a tentative implication from some studies that mean values below 50dB(A) are unlikely to have a significant effect on species abundance or diversity.

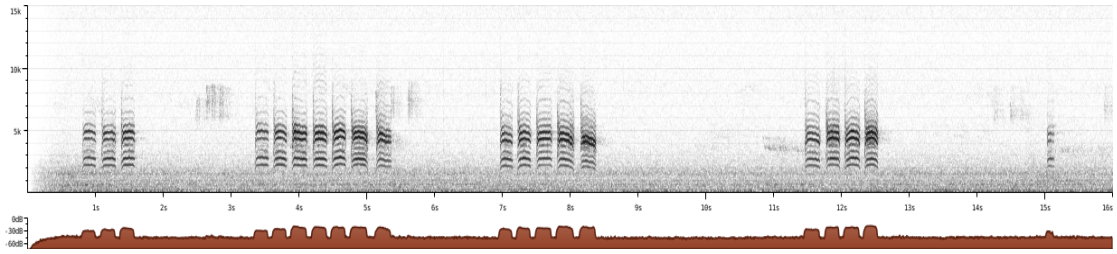
With respect to the likely sensitivity of notified species and features, there is no published data on the noise sensitivity of willow tit. Great tit is a member of the same family (Paridae), and is cited in some papers as relatively less sensitive, occurring within noisy environments and with adaptive capacity through alteration of call frequency. Comparison of peak frequencies may help to assess the relative sensitivity of willow tit. The sonagrams below have been taken from recordings published on the Xeno Canto website, in both cases limited to the UK subspecies with 'A' graded quality recordings:

Fig. 3.1: Comparative sonagrams of willow tit and great tit

(a) willow tit song (ssp. *kleinschmidti,* South Yorkshire)[29]

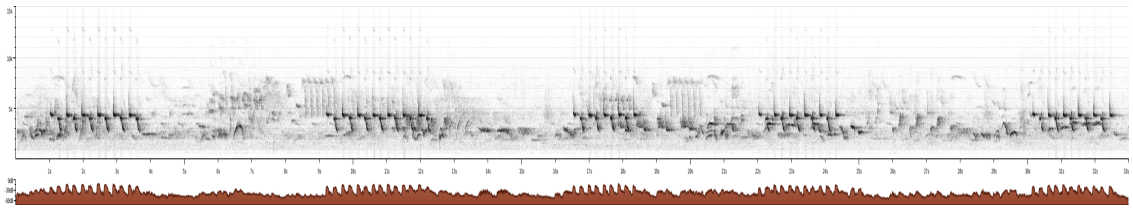


(b) willow tit call (ssp. *kleinschmidti,* South Yorkshire)[30]

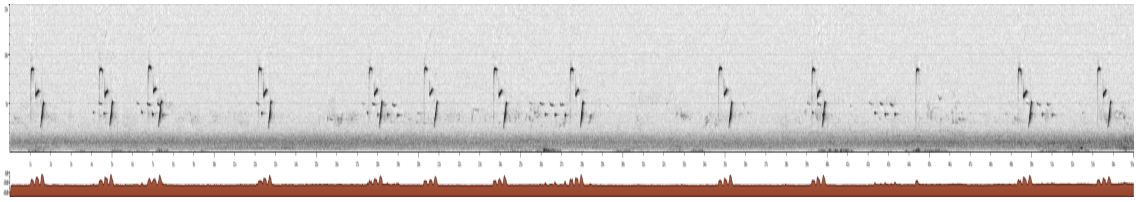


[29] https://xeno-canto.org/462898 (accessed 26/04/2023)
[30] https://xeno-canto.org/619945 (accessed 26/04/2023)

(c) great tit song (ssp. *newtoni,* Brighton)[31]



(d) great tit call (ssp. *newtoni*, London)[32]



Recordings of great tits are from urban locations (therefore likely to be higher frequency), and of willow tit from the local South Yorkshire population. Analysis of MP3 files using Audacity software produced spectrum plots with the following peak frequencies:

Table 3.6: Peak frequencies of selected willow tit and great tit vocalisations

Xeno-canto file	Species	Vocalisation	Peak (kHz)	Range of peak values (kHz)
XC462898	willow tit	song	3.58	3.6 - 4.7
XC619945	willow tit	call	4.54	2.4 - 4.5
XC623581	great tit	song	4.18	3.9 - 4.2
XC32100	great tit	call	3.69	3.7 - 8.3

Although willow tit song has the lowest peak frequency, subsidiary peaks in the recording extended to 5.7kHz. Peak frequency of the willow tit call was, perhaps counterintuitively, higher than the great tit call - although the latter had higher subsidiary peaks of up to 8.3kHz, while subsidiary peaks of willow tit call extend down to 2.4kHz. There is considerable overlap in the frequency range of both species, particularly in the song. Based on vocalisation frequency, while it is not possible to conclude that willow tit are quite as tolerant of noise as great tit, there is no reason to suggest particularly high sensitivity. In terms of a potential effect threshold, 50dB(A) is therefore likely to be sufficiently precautionary.

[31] https://xeno-canto.org/623581 (accessed 26/04/2023)
[32] https://xeno-canto.org/32100 (accessed 26/04/2023)

3.4 Distribution of notified features in vicinity of development

Existing data

As Dearne Valley Wetlands is a multi-site SSSI with habitats varying across different component sites, not every notified feature or avian assemblage member will occur in every site. Edderthorpe Flash (SSSI unit 4) is listed as a 'hotspot' on the citizen science eBird website, and is regularly recorded by volunteer observers, with 158 checklists including 145 species. Examination of bar charts[33] for the site gives an indication of species frequency by month, and therefore of the likely occurrence of notified features in this unit.

The table below summarises the recorded occurrence of notified features within the Site. Note that eBird sometimes restricts display of sensitive records, and as in the case of all biological records, data quality is dependent on observer coverage, and cannot be assumed to be comprehensive.

Table 3.7: Recorded occurrence at Edderthorpe Flash (from eBird[34])

Notified Features	Occurrence at Edderthorpe Flash
Gadwall; Shoveler (non-breeding)	Regularly recorded outside breeding season
Gadwall; Shoveler; Pochard (breeding)	Regularly recorded within breeding season
Garganey (breeding)	Infrequently recorded, mostly at end of breeding season (indicating possible breeding elsewhere?)
Black-headed gull (breeding)	Frequently recorded within breeding season
Bittern (breeding)	Not recorded
Willow tit (breeding)	Not recorded (but see below)
Breeding bird assemblage of lowland open waters and their margins and lowland fens	Frequently recorded in breeding season: avocet, mute swan, redshank, shelduck, tufted duck. Quite frequent in breeding season: little ringed plover, reed bunting. Few records: Cetti's warbler, kingfisher, little grebe, reed warbler, sedge warbler, common snipe. No breeding season records: great crested grebe, grey wagtail, water rail, yellow wagtail. No records: bearded tit, common tern, cuckoo, grasshopper warbler.

[33] https://ebird.org/barchart?r=L4880051&yr=all&m= (last accessed 08/05/2023)
[34] Data ©Cornell Lab of Ornithology

Notified Features	Occurrence at Edderthorpe Flash
Breeding bird assemblage of lowland damp grassland	Additional species of assemblage: lapwing frequently recorded in breeding season.
Breeding bird assemblage of dense scrub	Frequently recorded: long-tailed tit. Occasional breeding-season records: bullfinch, linnet, garden warbler, yellowhammer. Few breeding-season records: lesser whitethroat. No records: long-eared owl (*sensitive species*)

The *Willow tit Conservation Handbook*[35] reports the results of survey work undertaken in 2015 in the Dearne Valley Wetlands area. Three territories were identified in the wider vicinity of the Facility, including one to the east of Edderthorpe Flash in the area included in the present survey, and three further south around SSSI units 6 & 7. Based on these data, it should therefore be assumed that willow tit are likely to utilise suitable habitats in the vicinity of the Facility.

Survey results: woodland habitats

A description of proximal woodland habitats within unit 5 of the SSSI is given in Appendix 1, divided for the purpose of description into 5 distinct habitat areas; their location, spatial extent and relevant EUNIS habitat is shown on Figure 2.

Woodland and scrub habitats present included the following:

- G1.A: Meso- and eutrophic *Quercus* woodland (part of area 1 and 2);
- G1.91: *Betula* woodland not on marshy terrain (part of area 2);
- G1.11: Riverine *Salix* woodland (part of area 1; area 3 and 5); and
- F3.11: Temperate thickets and scrub (area 4).

In addition, an open area within woodland area 2 supports tall ruderal vegetation (E3.51 Anthropogenic tall-herb stands).

In terms of sensitivity to air quality impacts of supporting habitat, the G1.91 *Betula* (silver birch) woodland is established on what appears to be relatively acid soils derived from colliery spoil, and for this community it is appropriate to assign a **10kg N/ha/yr** critical load for nitrogen deposition. All other woodland communities are associated

[35] Back from the Brink (undated). *Willow Tit Conservation Handbook.* https://naturebftb.co.uk/wp-content/uploads/2021/09/25221_BftB_Willow_Tit_Handbook_V6.pdf

with naturally more eutrophic habitats, and it is more appropriate to use the 15kg critical load for these areas as explained in section 3.2 above.

There were some indicators of background nutrient enrichment in the epiphyte flora, in the form of free-living algae on tree and shrub boles; however, nitrophilous lichens were infrequent (a few *Physcia* sp. lichens; no *Xanthoria* recorded) and the lower plant flora was generally impoverished. This is likely a reflection of historically poor air quality in the area, due to former industrial emission sources. There is therefore no justification for applying the lower critical load for ammonia on this site.

In terms of notified features, most of the woodlands visited provided suitable habitat, variously supporting deadwood habitats suitable for nesting, a dense shrub layer, humid conditions, and a varied structure including open areas with tall herb vegetation. The only woodland area which may be considered sub-optimal was the small area of birch woodland, which had a very open structure with limited low cover and a short bryophyte-dominated field and ground layer. This may become more suitable in the future if some trees die back and provide small-diameter standing deadwood habitat.

Willow tits were not recorded during the field survey, although this does not imply absence from the survey area; as a relatively sparsely-distributed species with fairly large range size, a site visit would not be expected to always give positive results.

Survey results: wetland and grassland habitats

Two wetland areas were observed in the survey from the disused rail line, at a distance which would not give rise to disturbance of Schedule 1 or other breeding bird species.

The main area of open water to the north (Edderthorpe Flash) is a ca. 11.7ha area of open water set in neutral grassland, with an extensive area of wet rush-pasture (E3.4 Moist or wet eutrophic and mesotrophic grassland habitat) on the east side of the waterbody. Tussocky rush-pasture extended in a narrow marginal band around the water, but there were no obvious areas of tall-herb fen, reed-beds or other helophytes visible. There also appeared to be some areas of shorter vegetation or bare ground on some of the water margins.

A smaller area of open water to the south of Edderthorpe Flash and west of the River Dearne was viewed from an old rail bridge over the river. This supported a similar range of habitats around an open water body of ca. 1ha in area, including some exposed mud margins, and an band of taller bulrush (*Typha latifolia*) swamp on the western margin.

In terms of sensitivity to air quality impacts, the low and medium altitude hay meadow critical load of 20kg N/ha/yr seemed appropriate for what is in broad habitat terms a neutral grassland (EUNIS E2 Mesic grasslands) surrounding the wetlands.

Birds recorded during the survey from each wetland are listed in Appendix 2, and are consistent with the Edderthorpe Flash eBird records, having regard for the survey season (early breeding season with some over-wintering species still present).

Species of open water habitats, and species of wet grassland habitats were well represented, reflecting habitat availability on site. Conversely, bird species not recorded or infrequent in the eBird records include those of more extensive reedbed habitats such as bittern and bearded tit.

4 Ecological assessment of air quality effects

4.1 Predicted maxima within Dearne Valley Wetlands SSSI

AQA predictions

The AQA predicts maximum concentrations and deposition rates at the southern boundary of the Edderthorpe Flash section of the SSSI (part of unit 5), 0.31km north of the Facility boundary. The following table summarises the modelled predictions for all parameters where the process contributions (PC) exceeds Environment Agency screening thresholds (1% PC for long-term values; 10% for short-term values):

Table 4.1: Maximum predicted impacts at Dearne Valley Wetlands SSSI

Parameter (sensitive receptor)	**EQS (critical level or load)**	**Background (% EQS)**	**PC (% EQS)**	**PEC (% EQS)**
NOx (long-term, all habitats)	30µg/m^3	12.3µg/m^3 (41.0%)	1.19µg/m^3 (**4.0%**)	13.49µg/m^3 (45.0%)
NH_3 (all habitats)	3µg/m^3	2.6µg/m^3 (86.7%)	0.06µg/m^3 (**2.0%**)	2.66µg/m^2 (88**.7%**)
SO_2 (all habitats)	10µg/m^3	1.7µg/m^3 (17%)	0.36µg/m^3 (**3.6%**)	2.06µg/m^2 (20.6%)
N deposition (G1.9 woodland)	10kg N/ha/yr	36.5kg/ha/yr (**365%**)	0.81kg/ha/yr (**8.1%**)	37.3kg/ha/yr (**373%**)
N deposition (G1.A woodland)	15kg N/ha/yr	36.5kg/ha/yr (**243%**)	0.81kg/ha/yr (**5.4%**)	37.3kg/ha/yr (**249%**)
N deposition (grassland)	20kg N/ha/yr	21.3kg/ha/yr (**107%**)	0.48kg/ha/yr (**2.4%**)	21.8kg/ha/yr (**109%**)
Acid deposition (woodland)	3.044keq/ha/yr	2.81keq/ha/yr (92.3%)	0.216keq/ha/yr (**7.1%**)	3.026keq/ha/yr (**99.4%**)
Acid deposition (grassland)	5.071keq/ha/yr	1.67keq/ha/yr (32.9%)	0.107keq/ha/yr (**2.1%**)	1.78keq/ha/yr (35.0%)
HF (all habitats - weekly mean)	0.5µg/m^3	n/a	0.057µg/m^3 (**11.5%)**	n/a

Note that these values are based on the assumption that all habitats occur at the point of maximum impact; overlays of concentration and deposition rate contours on habitats show that this is only true of the small area of G1.9 birch woodland; the maximum nitrogen deposition rate to G1.A eutrophic woodland is ca. 0.7kg/ha/yr (4.6% of 15kg critical load) and to grassland habitats just over 0.2kg/ha/yr (>1%, <1.25% of 20kg critical load).

The modelling results for oxides of nitrogen and sulphur dioxide levels for all habitats, and acid deposition rates to grassland habitats indicate a predicted environmental concentration (PEC) well below the 70% threshold; in accordance with Environment Agency guidance, no further assessment is required.

Impacts requiring further assessment

The following predicted impacts require further assessment:

- **Ammonia levels** - a small magnitude increase in ammonia levels in circumstances where the PEC remains just below the critical level;
- **Nitrogen deposition to woodland habitats** - a medium magnitude increase in nitrogen deposition rates, in circumstances where the background already greatly exceeds the critical load;
- **Nitrogen deposition to grassland habitats** - a small magnitude increase in nitrogen deposition rates, in circumstances where the background already slightly exceeds the critical load;
- **Acid deposition rates to woodland habitats** - a medium magnitude increase in acid deposition rates, in circumstances where the PEC remains just below the critical load; and
- **Hydrogen fluoride levels to wetland margin habitats** - a low magnitude increase in HF levels just over the short-term (10%) screening threshold for the weekly mean critical level.

4.2 Predicted ecological effects of ammonia levels

Extent of exceedance

There is no predicted exceedance of the critical level, with the maximum PEC predicted at just under 90%. IAQM (2020) guidance[36] (paragraph 5.5.3.2) for planning

[36] Holman *et al* (2020). *A guide to the assessment of air quality impacts on designated nature conservation sites – version 1.1,* Institute of Air Quality Management, London

applications emphasises that the 70% PEC threshold is a trigger for detailed dispersion modelling, and is not a damage threshold. Detailed deposition modelling has been undertaken in the AQA; in terms of assessing potential ecological effects, it is important to assess whether there is any risk that the critical level would be exceeded through changes in background levels, and to assess whether any exceedance would be reflected in effects on SSSI notified features.

Trends in ammonia emissions and background levels

Given the PEC is predicted to remain below the critical level, there is no risk of any ecological effects at present. However, it is necessary to consider likely future trends in background ammonia levels.

Government data on ammonia emission rates[37] shows a -14% reduction from 1980 - 2021, to a total of 265,000 tonnes. Emission rates reduced to 2008, then remained largely stable until 2013. More recently there have been increases and decreases, but a -10% reduction since 2005 means the UK is compliant with National Emission Ceilings Regulations 2018 (NECR) /Convention on Long Range Transboundary Air Pollution (CLRTAP) emission commitments. While there is no clear current downward trend, the need to comply with CLRTAP 2020-2029 emission reduction commitments means that background levels are unlikely to exceed the critical load during the operational lifetime of the Facility. It is not therefore necessary to consider the effects of exceedance on SSSI notified features.

4.3 Nitrogen deposition to woodland habitats

Ecological effects

In common with almost all (95%) of woodland sites in England, background nitrogen deposition rates greatly exceed the critical load for the habitat. This is the case both for the less sensitive eutrophic woodland communities (G1.A and related habitats) as well as the most sensitive birch woodland (G1.9) communities.

APIS report a range of effects of excess nitrogen deposition to woodland habitats[38], including increased sensitivity to natural stress, impacts on roots, reduced species diversity of the ground vegetation, reduced growth, and an unbalanced nutritional status due to eutrophication and acidification. For example, there is good evidence of

[37] https://www.gov.uk/government/statistics/emissions-of-air-pollutants/emissions-of-air-pollutants-in-the-uk-ammonia-nh3 (accessed 03/05/2023)
[38] https://www.apis.ac.uk/overview/ecosystems/overview_woodlands.htm (accessed 04/05/2023)

changes in ground vegetation involving a shift in vegetation towards nutrient-demanding species in locations subject to high levels of nitrogen deposition, such as in the vicinity of livestock units with elevated atmospheric NH_3 levels. Research in Scotland (Pitcairn *et. al.* (1998))[39] found nitrophilous species such as stinging nettle (*Urtica dioica*) increasing in areas with high N deposition rates, and species such as sweet woodruff (*Galium odorata*) being rare where deposition rates exceed 25kg N/ha/yr. Bobbink & Hettelingh (2011)[40] review a number of studies involving repeat surveys of woodlands in areas with high N deposition rates, which show an increase in nitrophilous species.

Given elevated background deposition rates, at least some of these effects will be apparent already in the woodlands. The field survey found relatively little evidence of nitrophilous lichens, but overall there was a poor epiphyte flora, with free-living algae on many tree boles. The species composition of the woodland field layer included nutrient-demanding species in places where these would be expected (e.g. low-lying areas), but as all the woodland is of apparently secondary origin following former extractive industry use, it lacks the specialist flora associated with ancient and long-established woodland. In addition, some soils are of recent origin with a likely derivation from colliery spoil, and remain nutrient-poor despite contributions from atmospheric inputs. This can be seen particularly in the G1.9 birch woodland community, which retains a sparse field layer and well-developed ground layer of acidophilous bryophytes.

Extent of exceedance

Figure 3 shows the spatial extent of exceedance of the 1% PC threshold (using contour plot data supplied by Sol Environment). This covers a total of ca.3.4ha of woodland habitats, including ca.0.38ha of birch woodland, with the remainder comprising more eutrophic oak and willow woodland communities. This represents a total of 0.52% of the area of the SSSI.

[39] Pitcairn, C. E. R., Leith, I. D., Sheppard, L. J., Sutton, M. A., Fowler, D., Munro, R. C., Tang, S., and Wilson, D. (1998). The relationship between nitrogen deposition, species composition and foliar nitrogen concentrations in woodland flora in the vicinity of livestock farms. *Environmental Pollution*, **102**: 41-48.
[40] Bobbink, R. & Hettelingh, JP (*eds.*) (2011). *Review and revision of empirical critical loads and dose-response relationships.* Co-ordination Centre for Effects, National Institute for Public Health & The Environment (RIVM), http://www.rivm.nl/cce

Potential effects on SSSI notified features

The two notified features dependent on woodland habitats are willow tit, and (to an extent) the breeding bird assemblage of dense scrub.

The habitat requirements of willow tit do not suggest a clear effect pathway whereby excess nitrogen deposition could affect their habitat quality. As noted in Section 3, the features listed in the *Willow Tit Conservation Handbook* are primarily connected with habitat structure (dense shrub layer 1-4m high, mosaic of varied height), soil moisture (preference for wet woodland for breeding), and presence of dead wood. None of these are likely to be directly affected by excess nitrogen deposition, and in fact some habitat attributes such as dense low cover may be promoted by a higher soil nutrient status.

4.4 Nitrogen deposition to grassland and wetland habitats

Ecological effects of excess nitrogen deposition

APIS report a number of effects of excess nitrogen deposition on neutral grassland, which in their definition includes areas subject to winter flooding, and are therefore relevant to the habitats present in proximal areas of Dearne Valley Wetlands SSSI. Effects include:

- Growth of coarser grasses at the expense of finer-leaved species;
- Reduced plant species richness, particularly herb-richness;
- Reduction in pH in surface soils, increase in acid cations (Al, Mn); and
- Increased rates of mineralization of organic N.

There are a number of mechanisms whereby excess nutrient deposition to neutral grassland habitat may adversely affect breeding wader habitat. These include (for some species) a loss of preferred short sward habitats; changes in the invertebrate community leading to a reduction in available food resources; and a reduction in structural diversity for species which prefer a mixture of short and tussocky swards[41].

Extent of exceedance

Figure 4 shows the spatial extent of exceedance of the 1% PC threshold (contour plot data supplied by Sol Environment). The 1% contour (0.2kg N/ha/yr) is restricted to a

[41] Vickery, J.A., Tallowin, J.R., Feber, R.E., Asteraki, E.J., Atkinson, P.W., Fuller, R.J. and Brown, V.K. (2001), The management of lowland neutral grasslands in Britain: effects of agricultural practices on birds and their food resources. *Journal of Applied Ecology*, **38**: 647-664.

very small area of grassland habitat on the eastern margin of the Edderthorpe Flash section of the SSSI, no more than ca. 0.28ha in area.

Potential effects on SSSI notified features

Whilst there is a credible effect pathway, the risk of any effect on SSSI notified species is very low. The small area affected with an >1% PC is sub-optimal in any event for breeding waders and waterfowl, due to its location adjoining woodland habitats at the edge of the grassland.

Given background deposition rates only slightly exceed the lower critical load, not all of the above effects may be apparent. Soil nutrient status is likely to be influenced by past disturbance history (e.g. former mining leading to loss of topsoil and nutrient depletion) and the degree of inundation by seasonal flooding (i.e. nutrient-enriched inputs from River Dearne), both potentially having considerably more influence than atmospheric deposition rates.

Management of the site to optimise bird habitat may lead to net nutrient export by grazing or mowing. The relevant SSSI unit has been recently assessed as being in Favourable condition, indicating that nutrient enrichment is either not an issue, or is adequately offset by management actions.

Trends in nitrogen deposition rates

There is a downward trend in nitrogen deposition rates, reflected in a lower spatial extent and magnitude of critical load exceedance on protected sites (Rowe et al, 2021[42]). The area of N-sensitive habitats in the UK with exceedance of nutrient N critical loads decreased from 75.0% in 1996 to 58.9% in 2018, while average accumulated exceedance also reduced by more than 30%.

This trend is likely to be driven by reductions in NOx emissions and a consequent lower contribution of oxidised nitrogen to deposition rates. Given the high contribution of road transport to this figure and ongoing changes in vehicle emission factors, it is reasonable to expect that habitats with low magnitude background exceedance would see future reductions below the critical load within the lifetime of the Facility. In this context, the low magnitude PC will not significantly impede this process.

[42] Rowe EC, Sawicka K, Tomlinson S, Levy P, Banin LF, Martín Hernandez C & Fitch A (2021). *Trends Report 2021: Trends in critical load and critical level exceedances in the UK*. Report to Defra under Contract AQ0849, UKCEH project 07617. https://uk-air.defra.gov.uk/library/reports?report_id=1020

4.5 Acid deposition rates to woodland habitats

Ecological effects of excess acid deposition

APIS report a number of potential ecological effects of acid deposition on broadleaved, mixed and yew woodland broad habitat[43], including:

- Decline and change in epiphytic lichen flora;
- Decline in species richness of ground flora;
- Visible tree decline symptoms;
- Poor tree health, increasing likelihood of secondary stress causing damage (e.g. from pests and pathogens, or climatic factors);
- Root damage due to aluminium toxicity; and
- Increased risk of nutrient imbalance (e.g. poor phosphorus availability).

Past effects of acid deposition can be difficult to disaggregate from sulphur toxicity, since sulphur compounds were a major contributor; at present when nutrient nitrogen is a major contributor, effects can be difficult to disaggregate from those attributed to eutrophication.

Extent of exceedance

There is no predicted exceedance, with the PEC predicted to remain just below the critical load (99.4%). In order to assess whether there is any risk to SSSI notified features of woodland habitats, it is therefore important to consider likely trends over the operational lifetime of the Facility.

Trends in acid deposition rates

There is a clear downward trend in acid deposition critical load exceedance, with a decline in the total percentage area subject to exceedance of almost 50% from 1996 - 2018 (Rowe *et al.,* 2021). This is a more pronounced downward trend than nitrogen deposition, due to the large reduction in SO_2 emissions in recent decades. Further reductions are likely to occur due to reductions in NOx emissions. It is therefore reasonable to conclude that the acid deposition critical load will not be exceeded during the operational life of the Facility.

[43] https://www.apis.ac.uk/node/922 (accessed 06/05/2023)

4.6 Hydrogen fluoride levels

Extent of exceedance

The predicted pattern of HF threshold exceedance differs from other parameters, being located in two small areas in SSSI unit 5 to the west of the Facility. This includes an area of wet grassland to the south of the smaller open water body (survey area 7), and an area on the margin of wet willow woodland (area 3). Figure 5 shows the extent of exceedance.

Potential effects

Based on APIS advice on sensitivity, the most vulnerable habitat would be aquatic marginal vegetation around the margins of open water, were this to contain any yellow iris (*Iris pseudacorus*), which is regarded as relatively sensitive. This was not recorded in the survey; however, the emergent *Typha* beds on the western shore of the wetland could contain this species. The modelled 10% exceedance contour does not reach this habitat, so effects are unlikely.

As there is no evidence that visible injury symptoms could translate to ecological effects in terms of plant community composition or vegetation structure, there is no obvious effect pathway whereby any critical level exceedance could impact on SSSI notified features.

Trends in HF levels

HF background levels are not monitored or modelled in the UK, but emissions information is available from the National Atmospheric Emissions Inventory (NAEI)[44]. This shows a 93% drop in emissions from 1990 - 2020 due to the decline in coal combustion. Given this clear declining trend, it is less likely that the Facility would contribute to an exceedance of the critical level on this site.

[44] https://naei.beis.gov.uk/overview/pollutants?pollutant_id=112

5 Ecological assessment of noise effects

5.1 Predicted effects on waterbirds

The Noise Assessment contour plot (Sol Acoustics, Fig.D1)[45] for the operational phase of the Facility predicts the 55dB(A)eq value will only slightly overlap with the boundary of the SSSI, on the southern margin of an area of woodland just north of the Facility.

Grassland and wetland margin habitats within the SSSI are predicted to experience a maximum level of 45dB(A)eq. This should not have any impact on SSSI notified features associated with wetland habitats, in accordance with guidance in the *Waterbird Disturbance Mitigation Toolkit*. Consultation with the noise assessors confirms that operational phase noise from a plant of this nature does not normally generate significant peaks, so the dB(A)eq value is a valid predictor of likely noise impacts.

There remains a risk that birds could be disturbed by sudden noises of over 55dB(A) peak during the construction phase. Measures to avoid or screen sudden noises during this period should therefore be considered at sensitive periods.

5.2 Predicted effects on willow tit and species of dense scrub assemblage

The Noise Assessment contour plot predicts the 50dB(A)eq contour will extend onto approximately 0.4ha of SSSI woodland and dense scrub immediately north of the Facility (note that in terms of potential acoustic masking of songbirds, dB(A)eq values are of most relevance, rather than peak values). This includes areas assessed as suitable willow tit foraging habitat (dense scrub), and potentially suitable willow tit nesting habitat (wet willow woodland with elder providing suitable nest excavation habitat), described in Appendix 1 as area 3.

The *Willow Tit Conservation Handbook* reported a radio-tracking survey of willow tits in the Dearne Valley which found home range sizes of between 1.58-6.98ha (average 3.16ha). The area of potential noise impact may therefore represent between 5.7% - 25% of a single willow tit home range, in the context of 18-20 breeding territories within the SSSI. Based on song and call frequency, the 50dB(A) value is likely to be precautionary, and unlikely to result in exclusion from otherwise suitable habitat, but instead defines a zone where some acoustic masking is possible.

[45] Sol Acoustics (2023). *Grid Powr EFW. Environmental Noise Impact Assessment*. Report ref. P2121-REP01-BDH

6 Conclusions

6.1 Ecological significance of air quality impacts

Further ecological interpretation of the results of the dispersion and deposition modelling undertaken in the AQA has been carried out, including further consideration of habitat sensitivities to pollutant impacts. The scope of the further detailed assessment included all exceedances of Environment Agency screening thresholds. These comprised predicted ammonia levels, nitrogen and acid deposition rates, and hydrogen fluoride levels.

Consideration was given to supporting habitat sensitivity, potential ecological effects on supporting habitats, trends in background rates, and effect pathways for SSSI notified features.

Given trends in background levels and deposition rates, no exceedance of environmental quality standards is predicted for ammonia levels or acid deposition rates.

A medium magnitude increase in nitrogen deposition rates to woodland habitats in circumstances where background rates already exceed the critical load is not predicted to translate to any effect on SSSI notified features. A low magnitude increase in nitrogen deposition rates to grassland habitats where the critical load is slightly exceeded is not predicted to result in any effect on notified features, and there is a reasonable prospect that overall deposition rates would reduce below the critical load during the operational life of the Facility. Exceedance of hydrogen fluoride screening thresholds is very unlikely to affect sensitive elements of supporting habitat, and there is no mechanism for ecological effects on notified features.

In conclusion, no significant harm is predicted for notified features of the SSSI as a consequence of emissions to air.

6.2 Ecological significance of noise impacts

The Noise Assessment does not predict any exceedance of disturbance thresholds for notified features associated with wetland and grassland habitats, as a consequence of operational noise levels from the Facility. There is a potential for higher peak levels to occur over a short term period during the construction phase, and measures to mitigate construction noise impacts may be appropriate.

Approximately 0.4ha of woodland habitat is predicted to be subject to operational phase noise levels of 50dB(A)eq, with possible acoustic masking inputs on up to 25% of

a willow tit home range. This is not predicted to significantly degrade habitat quality or contribute to a reduction in the carrying capacity of the site for this SSSI notified feature. In conclusion, no significant harm is predicted for notified features of the SSSI as a consequence of operational phase noise.

Fig.1: Dearne Valley Wetlands SSSI in vicinity of Facility

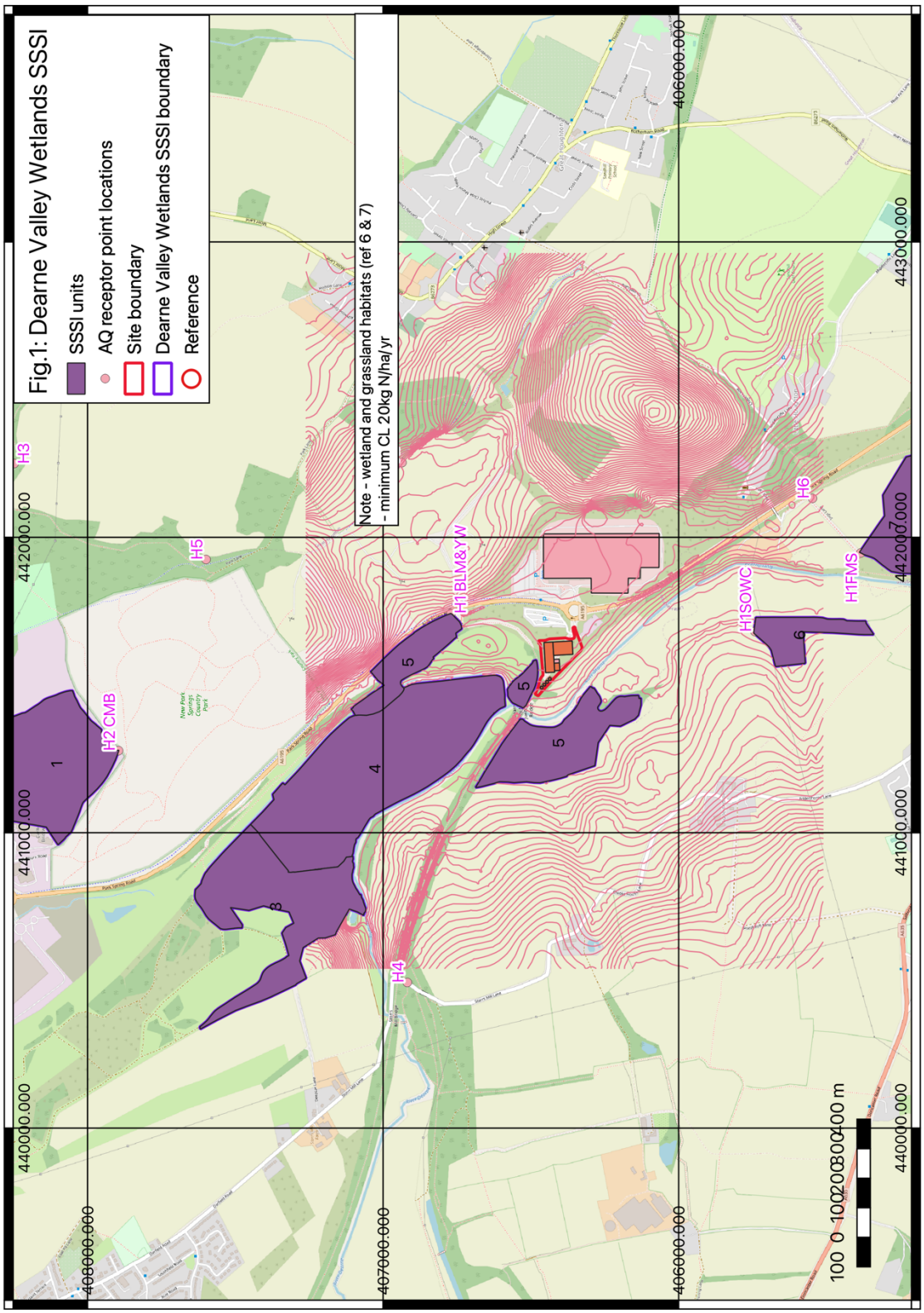


Fig.2: Sensitive habitats in vicinity of proposed development

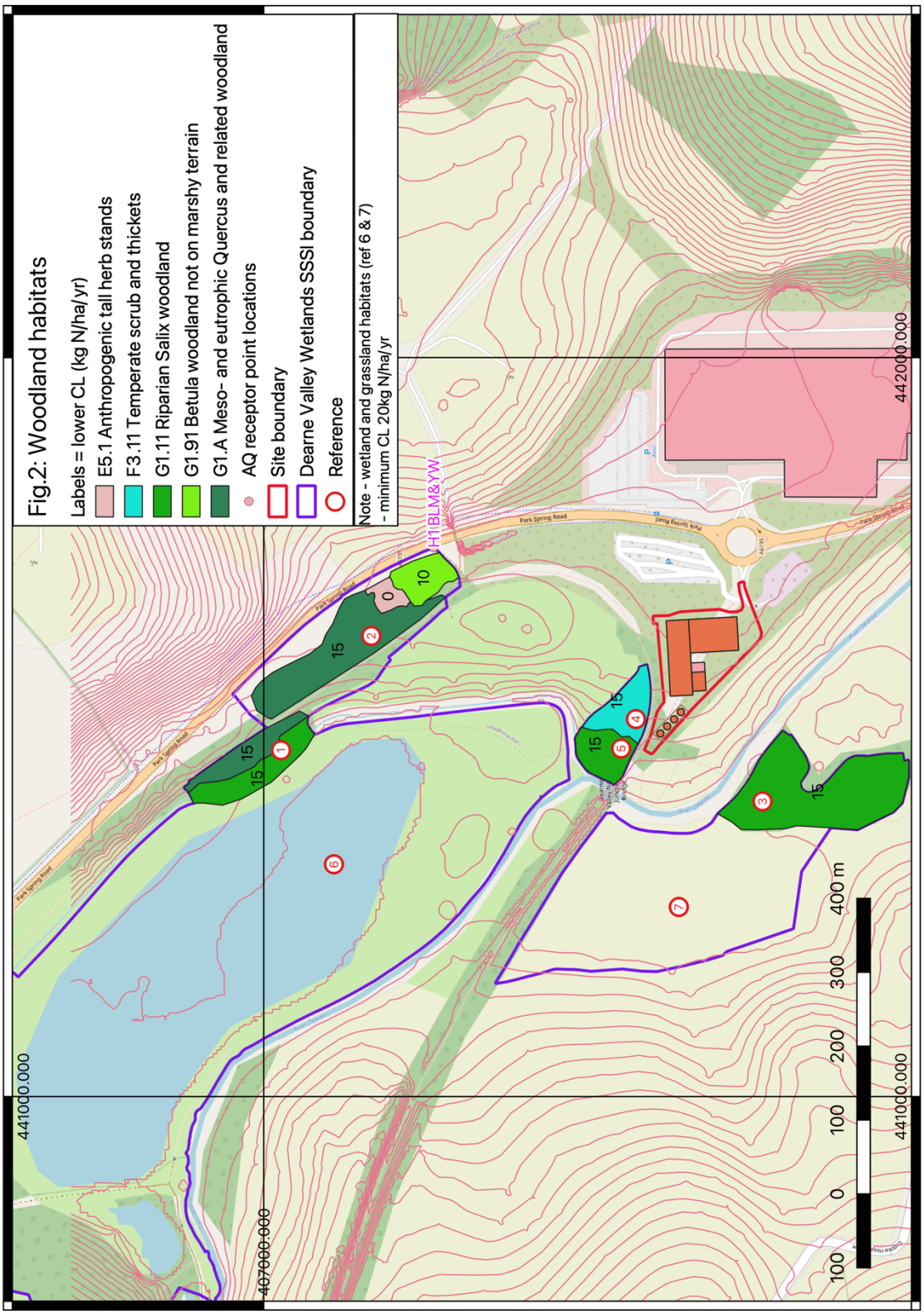


Fig. 3: Nitrogen deposition rates to woodland habitats

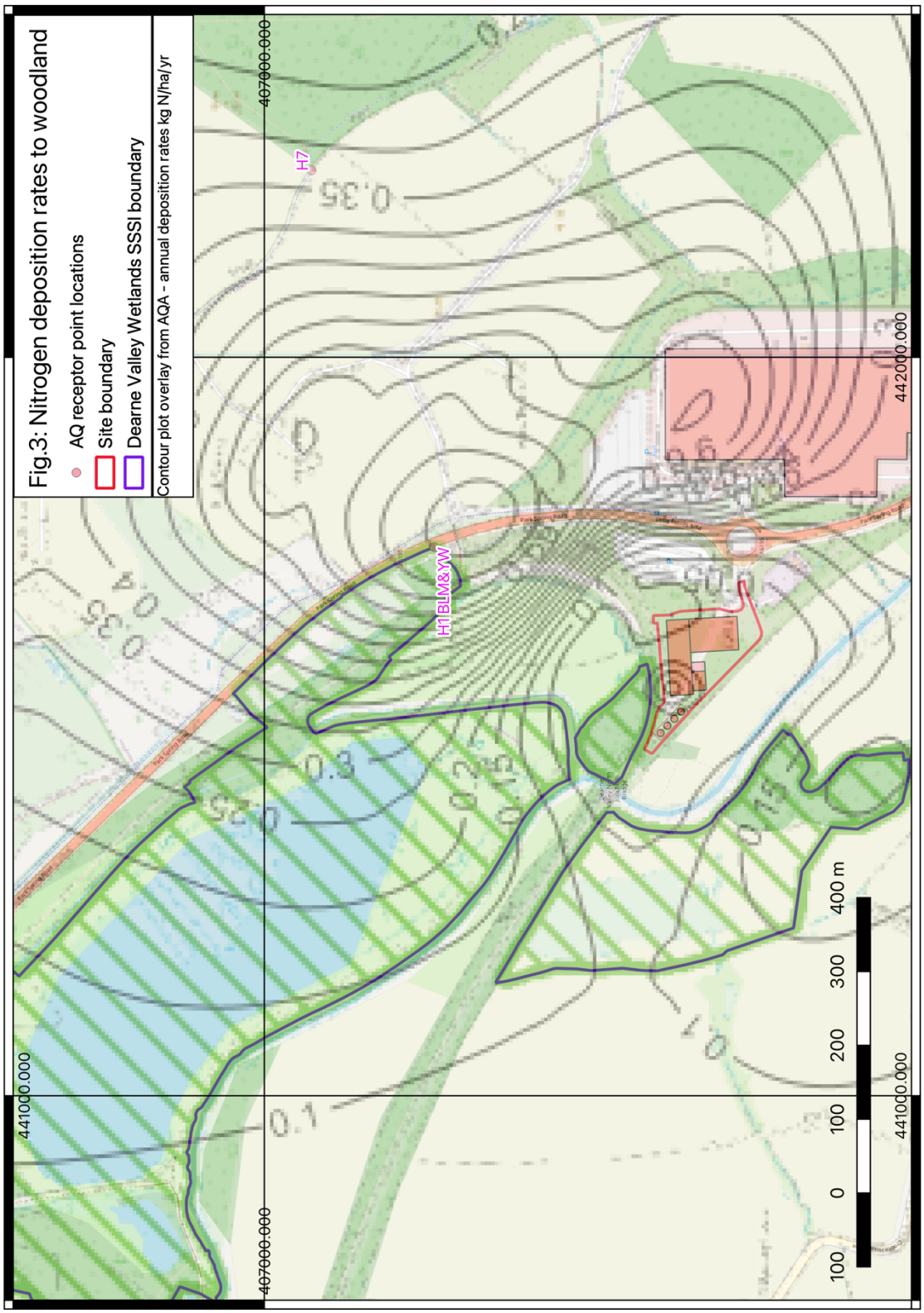


Fig. 4: Nitrogen deposition rates to grassland (heathland deposition velocity)

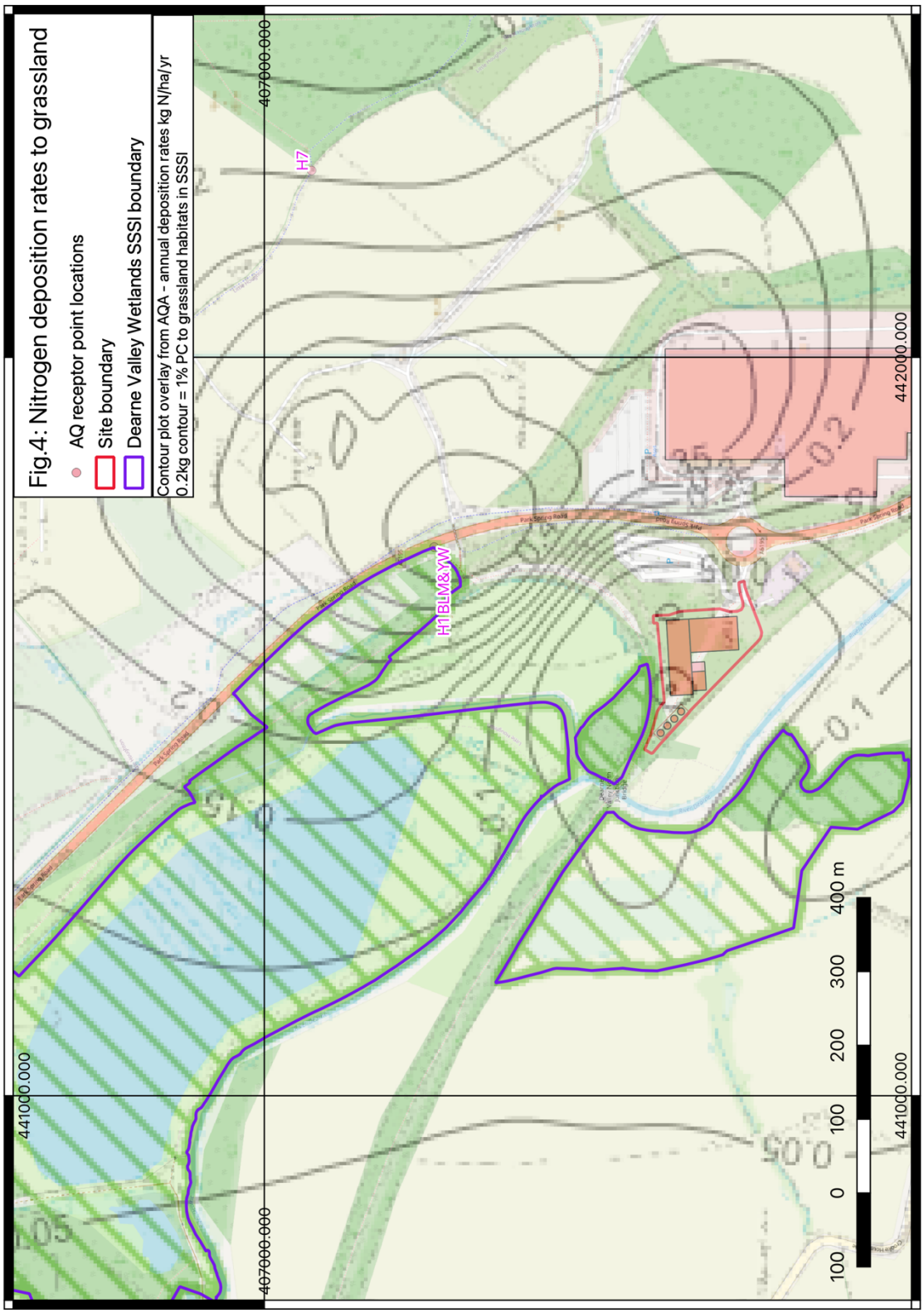
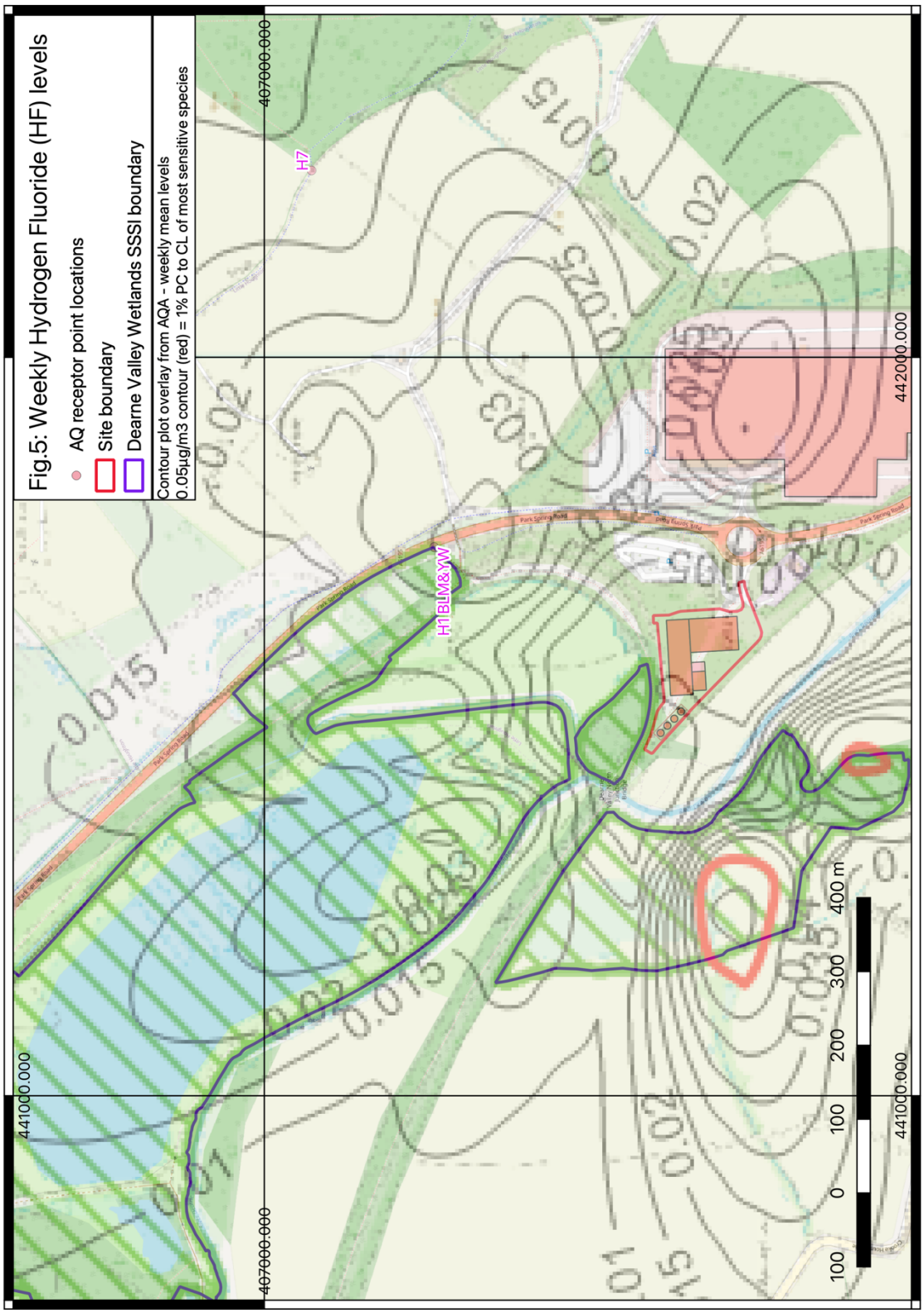


Fig. 5: Weekly Hydrogen Fluoride levels



Appendix 1: Field survey results

A1.1 Woodlands

1 G1.11 Riverine *Salix* woodland

G1.A meso- and eutrophic *Quercus* woodland

Small area of low-lying woodland with mature crack willow (*Salix fragilis*) and young-mature planted oak (*Quercus sp.*) on drier ground. Elder (*Sambucus nigra*) and hawthorn (*Crataegus monogyna*) shrub layer with a sparse bramble field layer. Separated from road to east by tall hawthorn hedgerow.

Not a close match to NVC communities due to plantation origin.

Epiphyte flora very limited - bryophytes on lower boles, with free-living algae higher up. Lichen flora restricted to very small *Physcia* and *Parmelia* spp. - not obviously subject to eutrophication but limited in extent and species-poor.

Supporting habitat suitability: Canopy height sub-optimal for willow tit, but well-developed shrub layer with elder (providing softer excavation habitat), and humid conditions in lower section provide suitable habitat conditions for occupancy and possible breeding.

2a G1.91 *Betula* woodland not on marshy terrain

Young birch (*Betula pendula*) woodland mostly <10m tall, with a few grey sallow (*Salix cinerea*) in canopy. Open structure with sparse shrub layer, including a few oak (*Quercus robur*), hawthorn and younger birch trees.

Field layer grassy with common bent (*Agrostis capillaris*) and Yorkshire fog (*Holcus lanatus*); abundant bryophytes typical of neutral to acid soils, including abundant *Rhytidiadelphus squarrosus*; frequent *Pseudoscleropodium purum*; locally frequent *Rhytidiadelphus triquetrus, Hylocomium splendens, Thuidium tamariscinum*; rare *Polytrichastrum formosum*.

Epiphyte flora very poor, with free-living algae locally abundant on birch bark.

Typical of NVC W11 birchwood, although clearly of secondary origin, developed on what is likely to be former colliery waste.

Supporting habitat suitability: Sub-optimal for willow tit due to open structure of birch woodland, lacking dense cover, and relatively dry conditions. May develop suitable nesting habitat if some trees die back and provide small-diameter standing deadwood habitat.

2b G1.A Meso- and eutrophic *Quercus* woodland

Northern section of woodland comprises two areas.

To the east is a very dense birchwood with occasional goat willow (*Salix caprea*) and taller poplars (*Populus* sp.) emerging from a 10-12m tall birch canopy. Shrub layer with abundant hawthorn. Field layer indicative of neutral, moderately nutrient-rich conditions, with Yorkshire fog, rough meadow-grass (*Poa trivialis*), male fern (*Dryopteris filix-mas*), stinging nettle (*Urtica dioica*) and tufted hair-grass (*Deschampsia cespitosa*). Bryophytes include *Brachythecium rutabulum* and *Kindbergia praelonga*.

Western section includes a dense canopy of birch and grey sallow, with large, multi-stemmed goat willow and oak. Nutrient-demanding species in field layer include hogweed (*Heracleum sphondylium*); other species comprise tufted hair-grass and regenerating ash (*Fraxinus excelsior*) seedlings. Dense leaf litter with scattered *Kindbergia praelonga*. Epiphyte flora very poor.

Not a close match to NVC communities due to plantation origin.

Suitability as supporting habitat: Dense shrub layer provides suitable foraging habitat for willow tit; few obvious nesting opportunities but standing small-diameter birch deadwood likely to develop in future due to competition / self-thinning.

3 G1.11 Riverine *Salix* woodland

Woodland dominated by mature crack willow (*Salix fragilis*) occupying low-lying site adjacent to River Dearne, but separated from it by a flood bank. Location likely to be naturally nutrient-rich due to past flooding / deposition of alluvium.

Many fallen trees and branches, re-growth of willows forming a dense shrub layer. Field layer dominated by stinging nettle (*Urtica dioica*) with Himalayan balsam (*Impatiens glandulifera*), with some wood garlic (*Allium ursinum*) visible around the

margins of the woodland. Bryophytes include abundant *Brachythecium rutabulum* on fallen and horizontal willow boles; otherwise epiphyte-poor apart from bryophytes in basal forks of some trees.

Supporting habitat suitability: Dense shrub layer and fallen trees / branches in humid woodland provide suitable habitat for willow tit with some nesting opportunities.

4 F3.11 Temperate thickets and scrub

Tall hawthorn, bounded by taller birch on the southern SSSI boundary adjoining a dismantled rail line (pictured). Hawthorn is quite dense but with little basal foliage, interspersed with taller young-mature oak, and forming a dense multi-layered structure.

Supporting habitat suitability: Dense shrub layer provides good willow tit foraging habitat, but not suitable as nesting habitat with no deadwood and little softer wood species such as elder.

5 G1.11 Riverine *Salix* woodland

Very tall willows, some collapsed with deadwood, and tall oaks around an open, damp depression. Shrub layer includes frequent elder on slightly drier slopes. Field layer dominated by stinging nettle. Epiphytes include bryophytes on lower boles and horizontal branches, with *Lepraria* - type lichens on main boles and *Physia sp.* in bark crevices.

Supporting habitat suitability: Potentially suitable nesting habitat in wet conditions with elder and deadwood.

A1.2 Wetland and wet grassland habitats

6 Edderthorpe Flash:

C1. Surface standing water / C3.4 Species-poor beds of low-growing water-fringing or amphibious communities

E3.4 Moist or wet eutrophic and mesotrophic grassland / E2 Mesic grasslands

Neutral grassland broad habitat (E2) surrounding open water body with rush-pasture (E3.4) habitat around margins, and forming a more extensive area on eastern shore. Photo shows north end of lake, taken from dismantled rail line.

Supporting habitat suitability: Primarily suitable for birds of open water with short margins / lowland wet grassland assemblage. Notified features recorded in survey included shoveler, gadwall, pochard and black-headed gull. Assemblage members included mute swan, tufted duck, avocet, lapwing and redshank.

7 Wetland to south in SSSI unit 5:

C1. Surface standing water / C3.4 Species-poor beds of low-growing water-fringing or amphibious communities / C3.23 Water-fringing helophytes - *Typha* beds

E3.4 Moist or wet eutrophic and mesotrophic grassland / E2 Mesic grasslands

Smaller (ca. 1ha) waterbody to south of flash, similar vegetation with area of tall *Typha* on eastern margin. Photo looking west from dismantled rail line bridge over River Dearne.

Supporting habitat suitability: Suitable for similar range of species to Edderthorpe Flash but likely to support lower waterfowl numbers due to smaller size (<10% of open water area). Possibly shallower as no diving ducks (e.g. pochard, tufted duck) recorded. Notified features recorded in survey included shoveler, gadwall and black-headed gull. Assemblage members included avocet, lapwing and redshank.

Appendix 2: Bird species recorded

Edderthorpe Flash

Species	Count
Greylag Goose (Anser anser)	7
Canada Goose (Branta canadensis)	2
Mute Swan (Cygnus olor)	2
Common Shelduck (Tadorna tadorna)	4
Northern Shoveler (Spatula clypeata)	32
Gadwall (Mareca strepera)	42
Eurasian Wigeon (Mareca penelope)	32
Mallard (Anas platyrhynchos)	34
Eurasian Teal (Anas crecca)	10
Common Pochard (Aythya ferina)	8
Tufted Duck (Aythya fuligula)	5
Common Pheasant (Phasianus colchicus)	1
Eurasian Coot (Fulica atra)	5
Pied Avocet (Recurvirostra avosetta)	13
Eurasian Oystercatcher (Haematopus ostralegus)	1
Northern Lapwing (Vanellus vanellus)	12
Common Redshank (Tringa totanus)	3
Black-headed Gull (Chroicocephalus ridibundus)	52
European Herring Gull (Larus argentatus)	7
Great/White-breasted Cormorant (Phalacrocorax carbo)	4
Eurasian Magpie (Pica pica)	1
Eurasian Blue Tit (Cyanistes caeruleus)	1
Common Chiffchaff (Phylloscopus collybita)	3
Eurasian Wren (Troglodytes troglodytes)	2
Common Blackbird (Turdus merula)	1
European Robin (Erithacus rubecula)	3
Dunnock (Prunella modularis)	1
Common Chaffinch (Fringilla coelebs)	1
European Goldfinch (Carduelis carduelis)	1

Wetland in SSSI Unit 5 (stationary count from lat./long. ref. 53.55378, -1.37653)

Species	Count
Greylag Goose (Anser anser)	1
Common Shelduck (Tadorna tadorna)	2
Northern Shoveler (Spatula clypeata)	4
Gadwall (Common) (Mareca strepera strepera)	7
Mallard (Anas platyrhynchos)	3
Eurasian Teal (Anas crecca crecca)	23
Common Moorhen (Gallinula chloropus)	2
Eurasian Coot (Fulica atra)	3
Pied Avocet (Recurvirostra avosetta)	2
Northern Lapwing (Vanellus vanellus)	1
Common Redshank (Tringa totanus)	3
Black-headed Gull (Chroicocephalus ridibundus)	1
European Green Woodpecker (Picus viridis)	1
Common Chiffchaff (Phylloscopus collybita)	1