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HS2

High Speed Rail (Crewe – Manchester) Environmental Statement

Volume 5: Appendix EC-016-00003

Ecology and biodiversity

Document to inform a Habitats Regulations Assessment for Rostherne Mere Ramsar site and Midland Meres and Mosses Phase 1 Ramsar site

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Department for Transport

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1 Introduction

1.1 Purpose of report

1.1.1 There are certain ecological sites that are designated for their international importance and to which special considerations attach under the Conservation of Species and Habitat Regulations 2017 ('the Habitats Regulations')[1], either through operation of law or government policy.

1.1.2 These sites include Special Areas of Conservation (SAC) that have been designated to protect certain species and habitats; Special Protection Areas (SPA), designated to protect certain species of wild birds; and Ramsar sites designated to protect internationally important wetland areas.

1.1.3 These sites are subject to special legal protection that imposes restrictions on a 'competent authority' from granting consent permission or authorisations for any plan or project that may affect the conservation status and integrity of these designations. In the case of the hybrid Bill, the responsible competent authority is Parliament as it is the enactment of the Bill as legislation that grants consent for the hybrid Bill scheme to be undertaken.

1.1.4 The Habitats Regulations require the competent authority, before deciding to undertake, or give any consent, permission or other authorisation for, a plan or project which is likely to have a significant effect on these designated sites (either alone or in combination with other plans or projects) to make an appropriate assessment of the implications of the plan or project for potentially affected sites in view of those sites' conservation objectives.

1.1.5 There are normally two stages in the process of discharging the duties imposed by the Habitats Regulations. The first is to undertake a 'screening' exercise to determine whether there is no reasonable scientific doubt that the plan or project will be likely to have a significant effect on the site's conservation objectives. If no such likelihood is identified, the competent authority may proceed to grant consent for the plan or project in question. If, on the other hand, there remains a reasonable scientific doubt as to its effects on the integrity of the site at this stage, the competent authority must move to a second stage and undertake a more detailed assessment, commonly referred to as an 'appropriate assessment' to determine whether, having regard to any mitigation measures that are proposed to be adopted in the delivery of the Proposed Scheme, there will be an adverse effect on the integrity of the site.

1.1.6 If the appropriate assessment does not identify an adverse effect on the integrity of the site, the competent authority may proceed to grant the consent. If an adverse effect cannot be

[1] *The Conservation of Habitats and Species Regulations 2017* (2017/1012), as amended by The Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019 (2019/579). London, Her Majesty's Stationery Office.

ruled out, consent can only be granted on the basis that there are: no alternative solutions; there are imperative reasons of overriding public importance for the plan or project to proceed; and appropriate compensatory measures have been secured.

1.1.7 It is Parliament as legislator (and not HS2 Ltd as the prospective developer) that is the competent authority and the body which is required to comply with the requirements of the Habitats Regulations. The purpose of this Habitat Regulations Assessment (HRA) report is, however, to provide information to Parliament, based on HS2 Ltd's assessment of the hybrid Bill scheme, in order to inform and assist Parliament in complying with its obligations under the Habitats Regulations.

1.2 Background

1.2.1 This document replaces two HRA Screening Reports for Rostherne Mere Ramsar Site[2] and The Midlands Meres and Mosses Phase 1 Ramsar site[3], both prepared in 2012. The rationale for pursuing a joint HRA primarily reflects the hydrological linkages between Rostherne Mere and The Mere, Mere as both lie within the same catchment, and both could be affected by the excavation of new cuttings.

1.2.2 The 2012 HRAs explored ten potential route options and were also considered in the HS2 Phase 2 Appraisal of Sustainability (AoS) in 2013[4]. These identified three potential threats to both Ramsar sites, namely: impacts on both the surface and sub-surface hydrological regimes; and pollution (and similar) impacts associated with construction related activities.

1.2.3 Although the potential for these impacts varied in severity and likelihood between each route, the 2012 HRAs were able to conclude that likely significant effects could be ruled out alone and in-combination, provided a range of mitigation measures were employed.

1.2.4 This new HRA is required to take account of changes in our understanding of the ecological characteristics of Rostherne Mere, and the nature and scale of anticipated impacts associated with the Proposed Scheme. For example, between 2018 and 2021, traffic and air quality modelling identified that air pollution (in terms of nitrogen deposition) from construction and operational traffic could impact both Ramsar sites. Similarly, the continued evaluation of existing hydrological data alongside new investigations carried out by HS2 Ltd has provided a greater understanding of the local hydrological regime. Both merited a re-evaluation of the previous outcomes.

1.2.5 In addition to Rostherne Mere and the Mere, Mere, the effects of air pollution arising from the Proposed Scheme has required the preparation of a new HRA for two further components of the Midland Meres and Mosses Phase 1 Ramsar site: Tatton Meres (see

[2] Temple-ERM (2012), *HRA Screening Report for Rostherne Mere Ramsar Site.*

[3] Temple-ERM (2012), *HRA Screening Report for Midland Meres and Mosses Phase 1 Ramsar Site.*

[4] Temple-ERM (2013), *High Speed Rail: Consultation on the route from the West Midlands to Manchester, Leeds and beyond Sustainability Statement.*

Volume 5 Appendix: EC-016-00006) and Wybunbury Moss SSSI (see Volume 5 Appendix: EC-016-00009).

1.2.6 The new HRA also provides an opportunity to take full account of recent changes in case law and best practice. For instance, it should be noted that both previous HRAs pre-dated the People Over Wind[5] judgement that subsequently restricted mitigation to the appropriate assessment stage. However, information in the previous HRAs that remains robust and up to date has been relied upon and used to inform the outcomes here.

1.2.7 This report has been prepared to provide all the necessary information for the competent authority to carry out an HRA under 3 of the Conservation of Habitats and Species Regulations 2017, as amended by the Conservation of Habitats and Species (amendment) (EU Exit) Regulations 2019[6]. It is informed by contemporary Department for Environment, Food and Rural Affairs (Defra), and Ministry of Housing, Communities and Local Government (MHCLG) guidance[7,8] and best practice. Where relevant, it takes full account of case law including the People Over Wind and the Wealden[9] judgements, amongst others.

1.2.8 Information for both Ramsar sites is provided in this document. However, any information in the original HRA screening reports that remains robust and up to date has been relied upon and used to inform the outcomes reported here.

1.2.9 Rostherne Mere is a single, 'standalone' Ramsar site. In contrast, the Midland Meres and Mosses Phase 1 Ramsar site comprises 16, hydrologically and geographically discrete water bodies situated across Cheshire, Shropshire and beyond, each notified as individual Sites of Special Scientific Interest (SSSI).

1.2.10 For simplicity, The Mere, Mere component of the Midlands Meres and the Mosses Phase 1 Ramsar site will, hereafter, simply be referred to as The Mere, Mere. In the context of this HRA, this will apply solely to its Ramsar designation and features and not those of the underpinning SSSI of the same name, unless stipulated. Reference to the Midland Meres and Mosses Phase 1 Ramsar site will only be made when wider issues are debated.

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[5] People Over Wind and Peter Sweetman v Coillte Teoranta (2018), High Court (Ireland), Case C-323/17 (also referred to as the Sweetman II judgement).

[6] The amended regulations generally seek to retain the requirements of the 2017 Regulations but with adjustments for the UK's exit from the European Union. See Regulation 4, which also confirms that the interpretation of these Regulations as they had effect, or any guidance as it applied, before exit day, shall continue to do so.

[7] Department for Environment, Food and Rural Affairs and Natural England (2021), *Habitats regulations assessments: protecting a European site*. Available online at: https://www.gov.uk/guidance/habitats-regulations-assessments-protecting-a-european-site.

[8] Ministry of Housing, Communities & Local Government (2019), *Planning Practice Guidance.* Available online at: https://www.gov.uk/guidance/appropriate-assessment.

[9] Wealden District Council v SS Communities and Local Government, Lewes District Council and South Downs National Park Authority (2016), High Court of Justice, Case CO/3943/2016. No EWHC 351.

2 Context

2.1 Description of the Proposed Scheme

2.1.1 The Proposed Scheme comprises the construction and operation of a high speed railway between Crewe and Manchester with a connection onto the West Coast Main Line (WCML).

2.1.2 Important elements of the Proposed Scheme are listed below in order from south to north. Names of structures are provided in full, but note that for simplicity, all future references to the Hoo Green structures will use the term 'Hoo Green cuttings', due to changes in design.

Design elements in the Pickmere to Agden and Hulseheath (MA03) community area

2.1.3 Design elements in the Pickmere to Agden and Hulseheath (MA03) community area between the Heyrose embankment to Hoo Green North embankment retaining wall No.2 includes:

- Hoo Green South embankment No.2 retaining wall, 177m in length and up to 5m in height (see Volume 2: MA03 Map Book, map CT-06-319, I6 to J6);
- Hoo Green North embankment retaining wall No.2, 172m in length and up to 3m in height (see Volume 2: MA03 Map Book, map CT-06-320, B6 to C6); and
- Hoo Green North cutting, 2.7km in length, up to 13m in depth and 92m in width (see Volume 2: MA03 Map Book, map CT-06-320, C6 to J5 and map CT-06-321, A4 to H5).

2.1.4 Design elements associated with the HS2 Manchester Spur and Northern Powerhouse Rail (NPR) London to Liverpool junction include:

- Hoo Green South cutting retaining wall, 359m in length, all of which will be below existing ground level, located to the west and east of the HS2 Manchester spur (northbound), 120m east of Winterbottom Lane (see Volume 2: MA03 Map Book, map CT-06-319, I5 to J6 to map CT-06-320, A6 to B6);
- Hoo Green box structure, 232m in length and up to 5m in height, to carry the HS2 Manchester spur (southbound) around Hoo Green tunnel (see Volume 2: MA03 Map Book, map CT-06-319, J6 and map CT-06-320, A6 to B6);
- Hoo Green tunnel, 297m in length and up to 6m in depth, to carry the HS2 Manchester spur (northbound) under the route of the Proposed Scheme and NPR London to Liverpool junction (southbound) (see Volume 2: MA03 Map Book, map CT-06-320, B6 to C6);
- Hoo Green North embankment No.2, 205m in length and up to 3m in height (see Volume 2: MA03 Map Book, map CT-06-320, B6 to C6);

- Hoo Green North cutting retaining wall, 501m in length in this section, all of which will be below existing ground level, located to the west and east of the HS2 Manchester spur (northbound) (see Volume 2: MA03 Map Book, map CT-06-320, C6 to F6); and
- Hoo Green North cutting, 905m in length, up to 13m in depth and 92m in width (see Volume 2: MA03 Map Book, map CT-06-320, F6 to J7).

Design elements in the Hulseheath to Manchester Airport (MA06) community area

2.1.5 Design elements in the Hulseheath to Manchester Airport (MA06) community area include:

- Rostherne cutting, 1.2km in length, up to 6m in depth and 83m in width, (see Volume 2: MA06 Map Book, map CT-06-352, H5 to J7 and 353, A5 to E5) with retaining walls to the west and east as follows:
  - Rostherne Cutting retaining wall west, 110m in length, all of which will be below ground level (see Volume 2; MA06 Map book, map CT-06-352, H5 to I5);
  - Rostherne Cutting retaining wall east, 323m in length, all of which will be below ground level (see Volume 2: MA06 Map Book, CT-06-353, D5 to E5); and
  - Millington cutting (containing the Millington North cutting), 1.5km in length, up to 13m in depth and 94m in width (see Volume 2: MA06 Map Book, map CT-06-351, F6 to J4, and map CT-06-352, A7 to H6).

2.1.6 Discrete sections of the construction traffic routes lie in proximity to Rostherne Mere or The Mere, Mere. In the case of Rostherne Mere, the construction traffic route along Cherry Tree Lane lies immediately adjacent to the Ramsar site. The Mere, Mere lies 193m north of a construction traffic route along the A50. All roads within 200m of both Ramsar sites have been subjected to air quality analysis to determine the scale of potential impacts from air pollution.

2.2 Previous assessment

Rostherne Mere Ramsar site

2.2.1 In November 2012, the original HRA screening exercise assessed the impacts of ten potential route options on Rostherne Mere. Whilst this identified potential effects from pollution incidents (or similar) associated with construction activities, and the intrusion of (some) potential routes into the groundwater catchment of this Ramsar site, it subsequently concluded that the adoption of best-practice working methods and suitable engineering techniques to address possible changes in sub-surface flows would rule out the possibility of likely significant effects alone or in-combination.

The Midland Meres and Mosses Phase 1 Ramsar Site

2.2.2 In 2012, an HRA screening report was prepared for two of the constituent SSSI of the Midland Meres and Mosses Phase 1 Ramsar Site in closest proximity to the Proposed Scheme; Betley Mere SSSI and The Mere, Mere SSSI which, at the time, were 400m and 1.2km distant respectively from the closest potential HS2 route. Whilst distances to the land required for construction of the Proposed Scheme remain unchanged, design changes now mean The Mere, Mere lies 193m from a construction traffic route.

2.2.3 All of the other constituent SSSIs were screened out of the HRA process in 2012 on the basis of distance (all were found to be more than 2km distant) supported by a hydrological assessment based on evidence available at the time.

2.2.4 The 2012 HRA identified that risks from construction related activities such as waterborne pollution were low, given the distances between the Ramsar sites and the land required for the construction of the Proposed Scheme. However, it also identified possible permanent hydrological impacts where potential route options of the Proposed Scheme would intrude on areas considered to be within the groundwater catchment of The Mere, Mere SSSI, even though significant effects on water levels were thought unlikely. However, in order to avoid the possibility of any effect, it was proposed that groundwater underpass structures would be incorporated into the Hoo Green North and Hoo Green South cuttings (or the 'Hoo Green Cuttings', to reflect current design and nomenclature).

2.2.5 As part of HS2 Phase 2a, an addendum to the HRA screening report was prepared in 2017 to assess the potential impact of gravel extraction from a borrow pit approximately 280m from Betley Mere. It concluded that, as a result of the measures that would be put in place, likely significant effects on the Betley Mere SSSI component of the Midland Meres and Mosses Phase 1 Ramsar site could be ruled out, either alone or in combination with other plans or projects.

2.3 Site description and conservation objectives

Rostherne Mere Ramsar site

2.3.1 Rostherne Mere Ramsar site extends over 79.76ha comprising, amongst other features, 45.8ha of open water and 3.3ha of fringing reed swamp. It is wholly contained within the larger Rostherne Mere SSSI (152.9ha), which is also designated as a National Nature Reserve (NNR).

2.3.2 It is listed under Ramsar Criterion 1[10] because it is one of the deepest and largest of the meres (lakes) of the Shropshire-Cheshire Plain. The Ramsar description adds that Rostherne Mere supports little submerged vegetation, but its shoreline is fringed with common reed swamp for over half its circumference. As in the case here, Ramsar qualifying features are often broadly described in the formal 'Information Sheet' and to provide clarity, Natural England has relied on the descriptions and objectives provided by the Favourable Condition Tables (FCT)[11] for the underpinning SSSI. This was confirmed by Natural England during consultation in 2019 (Annex A). This confirms the qualifying features are:

- standing open water habitat: natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation; and
- fen, marsh and swamp habitat (edge component of the above standing open water): water-fringe vegetation.

2.3.3 Unlike SPA and SAC, Ramsar sites do not benefit from the production of formal conservation objectives, Site Improvement Plans (SIP) or Supplementary Advice. Consequently, Natural England also draws on the objectives from the FCT, relevant extracts of which are provided below.

Habitat extent

2.3.4 To maintain the designated features in favourable condition, which is defined in part in relation to a balance of habitat extents (extent attribute). Favourable condition is defined at this site in terms of the following site-specific standards:

- no permanent change in lake area (48.7ha); and
- no significant loss (>5%) in fringing reed swamp (3.3ha).

Site specific habitat condition objectives for open water

2.3.5 To maintain the standing open water and canals at Rostherne Mere in favourable condition, with particular reference to relevant specific designated interest features. Favourable condition is defined at this site in terms of the following site-specific standards:

- presence of at least six characteristic species;
- presence of characteristic zones of vegetation. No deterioration in extent from baseline situation;
- the maximum depth of plant colonisation should be at least 3.5m;

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[10] Joint Nature Conservation Committee (2008), *Ramsar Information Sheet (RIS). Rostherne Mere.* Available online at: https://jncc.gov.uk/jncc-assets/RIS/UK11060.pdf.

[11] Natural England (2016), *Definitions of Favourable Condition for designated features of interest. Rostherne Mere*.

- total nitrogen TN annual mean 0.6 mg L^{-1}. This is a site-specific target;
- no deterioration in hydrological regime compared with baseline; and
- no loss of [hydrological] connectivity (between lake and surrounding areas).

2.3.6 It should be noted that FCT were designed to facilitate monitoring activities and so where quantitative parameters are described (e.g. no loss in habitat extent above 5%) this should be viewed in the context of natural change; it does not mean that losses below 5% as a consequence of development would be acceptable. This also applies to the FCT of The Mere, Mere below.

Condition assessment

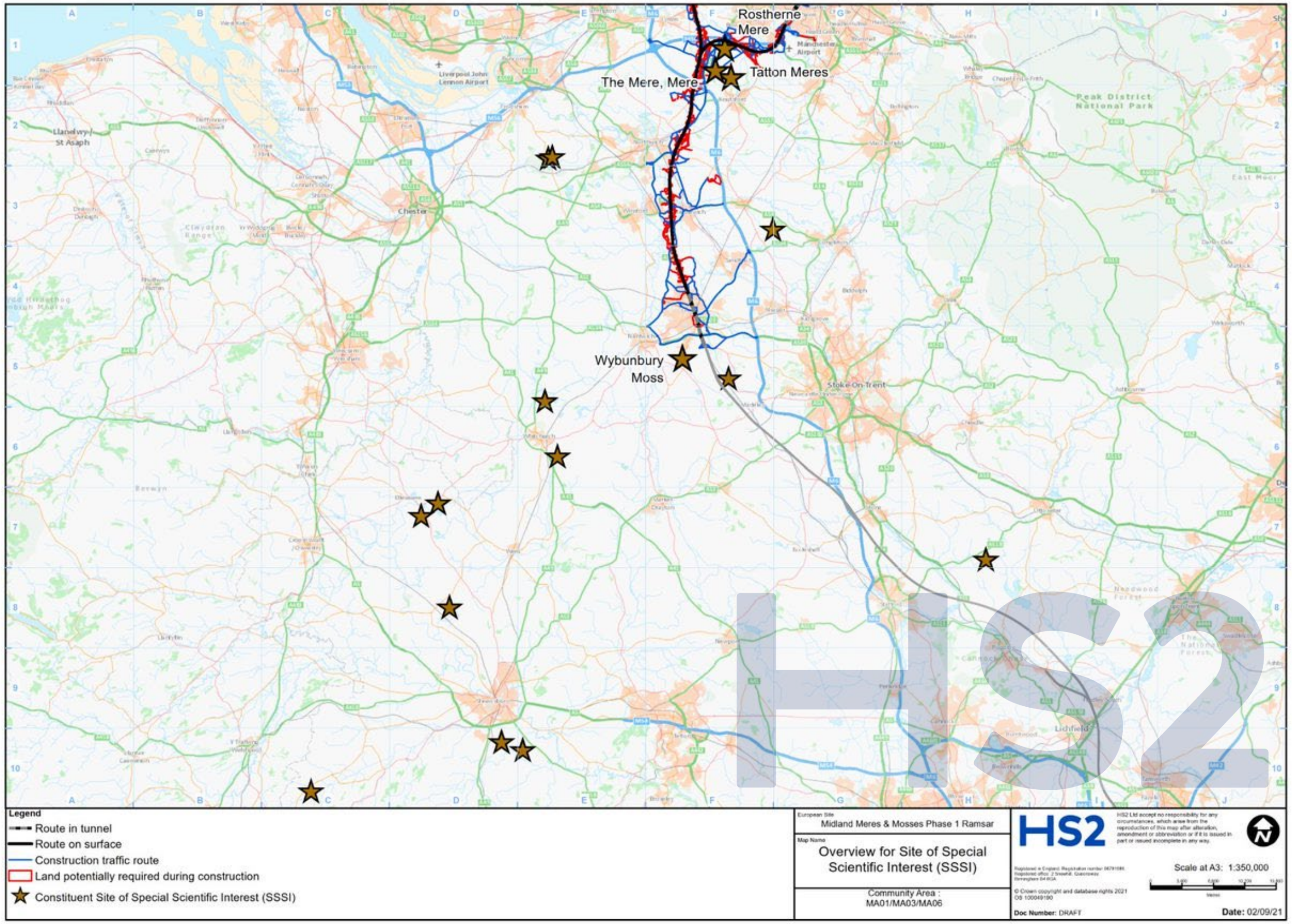
2.3.7 Natural England's condition monitoring programme evaluates the status of SSSIs against these objectives. The last assessment for Rostherne Mere was carried out in 2009[12] and found that 48.2% was in 'favourable' condition, 15.1% 'unfavourable recovering and 36.7% 'unfavourable no change'. Whilst this encompassed a wider area than the Ramsar site, the division by habitat clearly shows that the entire unfavourable component comprised the open water within the Ramsar boundary. In contrast, all terrestrial habitats were favourable or unfavourable recovering.

The Midland Meres and Mosses Phase 1 Ramsar site

2.3.8 The Midland Meres and Mosses Phase 1 Ramsar site (total area 510.88 ha) is composed of a series of 16 discrete sites across the north-west Midlands. These sites, which include open water (meres) and their associated fringing habitats (for example, reed swamps, fen, carr and damp pasture) and a smaller number of nutrient poor peat bogs (mosses), are individually designated as SSSI for their characteristic habitats, flora and fauna. The location of the constituent SSSI of Midland Meres and Mosses Phase 1 Ramsar, which highlights those relevant to the Proposed Scheme, is provided in Figure 1 below.

[12] Natural England (2009), *SSSI Condition Summary: Rostherne Mere SSSI*. Available online at: https://designatedsites.naturalengland.org.uk/ReportConditionSummary.aspx?SiteCode=S1003353&ReportTitle=Rostherne%20Mere%20SSSI.

Figure 1: Location of the SSSI forming the Midland Meres and Mosses Phase 1 Ramsar site and Rostherne Mere



2.3.9 The main interest of the Ramsar site is the wide range of lowland wetland types and successional stages present within a distinct biogeographical area. The FCT[13] for the nearest component of the Ramsar site to the Proposed Scheme, 'The Mere, Mere SSSI' identifies that the qualifying features of this component are:

- fen, marsh and swamp: S4 *Phragmites australis* reedbed and S6 *Carex riparia* swamp; and
- standing open water: Standing water on sedimentary rock, eutrophic pH >7: A8 *Nuphar lutea* community.

2.3.10 The Mere, Mere SSSI comprises two discrete water bodies, The Mere and Little Mere, separated by a narrow spillway. These once comprised a single water body with a fluctuating water level that left large expanses of bare mud exposed in late summer/autumn. This supported the rarest plant communities and so represented the most important feature of the site. Exposure of the lake sediments now occurs less frequently since the removal of a sluice around 30 years ago. In its absence, the primary interest comprises the beds of water lilies, marginal sedge and reed swamp and the populations of red-eyed damselfly.

2.3.11 Conservation Objectives are taken from the FCT for The Mere, Mere SSSI; relevant extracts are provided below:

Habitat extent

2.3.12 To maintain the designated features in favourable condition, which is defined in part in relation to a balance of habitat extents (extent attribute). Favourable condition is defined at this site in terms of the following site-specific standards:

- the lake needs to fluctuate on an annual basis in order to maintain the habitat and vegetation; and
- there should be no reduction in the combined area of open water and drawdown zone habitat that is exposed to full sunlight.

Site-specific definitions of favourable condition for fen, marsh and swamp

2.3.13 To maintain the fen, marsh and swamp at The Mere, Mere in favourable condition, with particular reference to relevant specific designated interest features:

- no reduction in the total combined extent of swamp in relation to the established baseline;
- the total extent of emergent swamp should not exceed 50% of the shoreline and should not be less than 10%;

[13] Natural England (2008), *Conservation objectives and definitions of favourable condition for designated features of interest. The Mere, Mere SSSI. Draft 1*.

- no loss of the following components of the wetland/swamp: *Typha latifolia* swamp; *Phragmites australis* swamp; *Carex riparia* swamp. Presence of some *Typha angustifolia* swamp desirable;
- the Mere should significantly dry up at least one summer each decade and have less than 50% shading around the margin;
- for the S4 *Phragmites australis* reedbed:
  - *Phragmites australis* to form a closed or open stand of >90% cover; and
- for the S6 *Carex riparia* swamp:
  - *Carex riparia* cover >70; and
  - at least two of the following associated species to be present with a combined cover less than 30% (*Phragmites australis*, *Equisetum fluviatile, E. palustre, Phalaris arundinacea, Epilobium hirsutum, Filipendula ulmaria*).

Site-specific definitions of favourable condition for open water

2.3.14 To maintain the open water at The Mere, Mere in favourable condition, with particular reference to relevant specific designated interest features:

- no loss of extent of standing water;
- no loss of characteristic species recorded from the site;
- characteristic zones of vegetation should be present;
- there should be a natural hydrological regime; and
- red-eyed damselfly should be present.

Condition assessment

2.3.15 Natural England's condition monitoring programme evaluates the status of SSSIs against these objectives. The last assessment at The Mere, Mere was carried out in 2008[14] and tested the site against the 2008 conservation objectives. This found that the entire site was considered to be 'unfavourable no change'. There has been no condition assessment against the more recent objectives described in the FCT.

[14] Natural England (2009), *SSSI Condition Summary: The Mere, Mere SSSI.* Available online at: https://designatedsites.naturalengland.org.uk/ReportConditionSummary.aspx?SiteCode=S1001818&ReportTitle=The Mere.

2.4 Case law

2.4.1 In recent years there have been a number of important rulings made by both domestic and European courts which could influence this HRA. The most relevant are described below.

People Over Wind judgement

2.4.2 The People Over Wind judgement (2017) drew a distinction between incorporated mitigation measures which are represented by the essential characteristics of a scheme and those added specifically to avoid or reduce an impact on qualifying features. The former, such as the general alignment of HS2, can be considered at screening whereas the latter are reserved for consideration in an appropriate assessment.

Wealden judgement

2.4.3 The Wealden judgement (2017) clarifies a limitation on the use of thresholds when used to rule out the likelihood of significant effects alone or in combination with other plans or projects, specifically the use of Annual Average Daily Traffic (AADT) figures. The Court concluded that where the likely effect of an individual plan or project does not itself exceed the threshold of 1,000 AADT, its impact must still be considered alongside the similar effects of other plans and projects to assess whether the combined effect could be significant. Where the in-combination effect is greater than this threshold, an appropriate assessment is typically required. In line with Regulation 63(3), the need to consider in-combination assessment, is also carried through into the appropriate assessment if one is necessary.

Dutch Nitrogen case

2.4.4 Here, the Court of Justice of the European Union (CJEU)[15] confirmed that an appropriate assessment is not to take into account the future benefits of mitigation measures if those benefits are uncertain, including where the procedures needed to accomplish them have not yet been carried out or because the level of scientific knowledge does not allow them to be identified or quantified with certainty.

[15] Coöperatie Mobilisation for the Environment UA, Vereniging Leefmilieu v College van gedeputeerde staten van Limburg, College van gedeputeerde staten van Gelderland, European Court of Justice, (C 293/17, C 294/17) [2019] Env. L.R. 27 at paragraph 30.

Compton case

2.4.5 This case[16] explored how exceedances of the critical loads should be assessed. The Court ruled that when considering what approach is required in order to conclude no adverse effect on the integrity of a site:

> 'That could not be answered, one way or the other, by simply considering whether there were exceedances of critical loads or levels, albeit rather lower than currently. What was required was an assessment of the significance of the exceedances for the SPA birds and their habitats …'.

2.5 Changes in evidence since 2012 HRAs

Reliance on previous HRAs

2.5.1 The original 2012 'HRA Screening Reports' concluded that likely significant effects on both Rostherne Mere and The Mere, Mere could be ruled out, subject to the implementation of mitigation; an outcome that was subsequently endorsed by Natural England.

2.5.2 Defra guidance[7] allows competent authorities to rely on previous HRAs if they remain both *robust and up to date*, or, in other words, that there has been no material change in evidence in the intervening period. In terms of broad design parameters, the identification of potential impacts and vulnerable sites, for example, much within the original HRAs remains valid and where possible, these elements are relied upon in this report.

2.5.3 However, new assessment will be needed where new issues (such as air pollution) have arisen which have not been evaluated before. Similarly, the HRA will have to take account of new case law, such as the Wealden decision[9] and People Over Wind. Furthermore, new plans and projects nearby such as the A556 could either affect the environmental baseline or influence any in-combination assessment, if required. In addition, the ecological and hydrological characteristics of Rostherne Mere in particular are now better understood and all will require consideration. These are discussed below.

Ecological characteristics of Rostherne Mere and the Midland Meres and Mosses

2.5.4 The 2009 draft conservation objectives for Rostherne Mere have been replaced, and its features and characteristics have been more clearly defined, by the 2016 FCT, the understanding of which has been further refined in 2019 (Annex A). However, the condition

[16] Compton Parish Council, Julian Cranwell and Ockham Parish Council v Guildford Borough Council, SoS for Housing, Communities and Local Government (2019), High Court of Justice, EWHC 3242 (Admin) CO/2173,2174,2175/2019.

of the SSSI has not been assessed against these new criteria. In contrast, the 2005 FCT for The Mere, Mere remain valid.

2.5.5 In addition, botanical surveys of accessible wetland habitats at Rostherne Mere and The Mere, Mere were carried out in July 2019 and 2020, respectively. In the case of the former, this provides the means to compare change over time with similar surveys carried out over the past decade. Both surveys identify the presence, extent and composition of the qualifying features although in the case of The Mere, Mere, the survey was restricted to terrestrial habitats only.

Implications of the People Over Wind decision

2.5.6 The People Over Wind decision effectively restricts the evaluation of mitigation to the appropriate assessment and, consequently the outcomes of the 2012 HRAs which employed bespoke engineering solutions and the use of the Code of Construction Practice (CoCP) to mitigate potentially harmful, localised effects such as dust pollution at the screening stage, cannot now be relied upon and further consideration will therefore be required.

Design changes

2.5.7 Whilst the broad parameters of the Proposed Scheme remain largely unchanged, recent design changes will require the re-evaluation of previous outcomes. Refinement of the intensity of use and location of construction traffic routes south of The Mere, Mere and around Rostherne Mere, now mean these lie within 200m of the former and 50m of (and at one point directly adjacent to) the latter. All could increase nitrogen deposition within the Ramsar sites and so will also merit new assessment.

2.6 Basis for preparing a joint assessment

2.6.1 The rationale for pursuing a joint HRA primarily reflects the hydrological linkages between Rostherne Mere and The Mere, Mere. The Mere, Mere (itself comprising two water bodies, The Mere and Little Mere), lies within the same catchment as Rostherne Mere. This connection has led to the production of a hydrological assessment and mitigation proposals that address the potential for hydrological change for both sites: Rostherne Mere and The Mere, Mere-Impact of cuttings on the water environment and ecology (hereafter referred to as 'the Technical note' and appended in Annex B).

2.6.2 Similarly, for both sites, the proximity of nearby roads requires consideration of the impact of air pollution (in the form of nitrogen deposition) and has prompted production of an air quality assessment (Annex C).

2.6.3 In addition, Rostherne Mere and all 16 components of the Midland Meres and Mosses display similar characteristics: highly characteristic water bodies with distinctive hydrological regimes, water chemistry and vegetation communities. Although Ramsar site selection criteria are quite broadly described, this HRA assumes that both Rostherne Mere and all components of the Midland Meres and Mosses Phase 1 Ramsar sites share similar features. Confidence in this approach can be drawn from the relatively standardised wording of the relevant FCT.

2.6.4 The Ramsar description for the entire Midland Meres and Mosses includes 'an assemblage of rare wetland invertebrates'. This does not mean that all components of the assemblage are present at each of the 16 component sites but rather that together, they support the overall assemblage. Although not listed as a feature within the FCT for the Mere, Mere, the red-eyed damselfly is present and comprises part of the assemblage and is described as 'should be present' as a component of the standing open water community. Given the limited knowledge surrounding the abundance and distribution of this species, it is not assessed specifically in this HRA, but its requirements are considered to be addressed satisfactorily in the assessment of its supporting habitat.

3 Likely significant effects

3.1 The likely significant effects test

3.1.1 Regulation 63(1) identifies whether a proposed development will result in a 'likely significant effect … (either alone or in combination …)' on a European site. An 'in combination' assessment is only required where an impact is identified which would not result in a significant effect on its own but where significant effects may arise when combined with other plans or projects. The screening test is seen only as a 'trigger'[17] and identifies whether the greater scrutiny of an 'appropriate assessment' is necessary. Case law interprets how Regulation 63(1) should be interpreted as follows:

- 'significant' means 'any effect that would undermine the conservation objectives of a European site'[18];
- 'Likely' is a low threshold and simply means that there is a 'risk' or 'doubt' regarding such an effect[19]; and
- [it] '… is not that significant effects are probable, a risk is sufficient'… and there must be 'credible evidence that there was a real, rather than a hypothetical, risk'[20].

3.2 Potential impacts

3.2.1 Drawing on the outcomes of the original 2012 HRA and more recent information summarised in Sections 2.3 and 2.4 above, the following impacts on Rostherne Mere and The Mere, Mere have been identified as requiring further consideration in this joint HRA:

- construction related impacts typically comprising inter alia, localised contamination of air, water and land as a consequence of dust, siltation and erosion (though excluding emissions from construction vehicles);
- changes to the local hydrological regime from construction of the Rostherne, Millington, Hoo Green cuttings; and
- nitrogen deposition from air pollution caused by:
  - construction traffic within the alignment near Rostherne Mere;
  - from construction and operational traffic using Cherry Tree Lane, Marsh Lane, Rostherne Lane, New Road, Chester Road and the A556 near Rostherne Mere; and

[17] Bagmoor Wind Limited v The Scottish Ministers (2012), Court of Session, CSIH 93.

[18] Landelijke Vereniging tot Behoud van de Waddenzee and Nederlandse Vereniging tot Bescherming van Vogels v Staatssecretaris van Landbouw, Natuurbeheer en Visserij (2004), European Court of Justice, C-127/02 (referred to as the Waddenzee judgement) at paragraphs 44, 47 and 48.

[19] Waddenzee at paragraph 44.

[20] Boggis at paragraphs 36 and 37.

- from construction and operational traffic using the A5034 Mereside Road and the A50 Warrington Road both near The Mere, Mere.

3.2.2 The potential for likely significant effects as a result of these impacts is discussed below.

3.3 Construction related activities

3.3.1 The Cherry Tree Lane construction traffic route runs within 50m of Rostherne Mere along much of the northern boundary, and lies directly adjacent, at one point. The land required for construction of the Proposed Scheme extends southwards to Cherry Tree Lane at several points. The Ramsar site will therefore be at risk from a range of possible effects including pollution of surface and sub-surface flows from spillages, siltation and airborne dust from vehicles amongst others. All provide mechanisms by which harm could arise, for instance via eutrophication of wetland features and the subsequent encouragement of more ruderal communities at the expense of the typically more sensitive qualifying features. It should be noted that air pollution from construction vehicle exhausts are assessed under 'nitrogen deposition'.

3.3.2 In 2012, the potential for harm arising from these activities was considered remote, given implementation of the CoCP and the distances involved. However, the People Over Wind decision now prevents consideration of the CoCP at the screening stage, and, therefore, harm cannot be screened out.

3.3.3 Therefore, there is a credible risk that the Proposed Scheme could undermine the conservation objectives of Rostherne Mere and The Mere, Mere and that likely significant effects cannot be ruled out (alone); an appropriate assessment is therefore required.

3.4 Construction/excavation of cuttings

3.4.1 This potential effect is concerned with the long-term impact on surface and sub-surface flows resulting from drainage to cuttings excavated along the route of the Proposed Scheme. A preliminary review shows that the wetland features of Rostherne Mere and The Mere, Mere could be affected. The potential hydrological impacts were considered in the separate Technical note (Annex B).

3.4.2 Aquatic and fringing macrophyte communities are all dependent to a greater or lesser degree on the maintenance of a favourable hydrological regime that incorporates both water quality and water resource elements. The Hoo Green cuttings along the proposed alignment are located, in part, up-gradient of Rostherne Mere and may, therefore, affect groundwater flows in the catchment. In addition, it is possible, although unlikely, that the cuttings could affect groundwater flows to The Mere, Mere. The Millington and Rostherne cuttings could have an additional effect in the catchment of Rostherne Mere. Consequently, both Rostherne Mere and The Mere, Mere could be vulnerable. Drainage of groundwater in the cuttings might possibly affect surface or sub-surface flows to both Ramsar sites, potentially prompting changes to the extent, species composition, abundance and/or distribution of wetland communities.

3.4.3 Therefore, there is a credible risk that the Proposed Scheme could undermine the conservation objectives of Rostherne Mere and The Mere, Mere, and that likely significant effects cannot be ruled out (alone) and an appropriate assessment is therefore required.

3.5 Nitrogen deposition

Methodology

3.5.1 The assessment of air pollution is influenced by established best practice provided by Highways England (the Design Manual for Roads and Bridges (DMRB))[21], Natural England[22] and the Institute for Air Quality Management (IAQM)[23]. Together, these make clear that vehicle emissions can increase the airborne concentration of nitrogen oxides (NO_x) and the subsequent rate of nitrogen deposition; the latter, can lead to nutrient enrichment and, over time, not only hinder the growth, abundance and distribution of (especially lower) plants but can also prompt the growth of ruderal species which can lead to changes in structure and function of qualifying habitats. Whilst certain species and communities are less susceptible to harm than others, nitrogen deposition can also exacerbate the effects of other factors such as climate change or pathogens leading to negative, synergistic effects.

3.5.2 However, the rate of nitrogen deposition falls quickly in the first few metres from the roadside before gradually levelling out; beyond 200m, it becomes difficult to distinguish from background levels. In other words, impacts at 10m, 50m or more can be very different from those at the roadside, and beyond 200m, significant effects can be ruled out.

3.5.3 Assessment of nitrogen deposition is required for ecologically sensitive sites within 200m of roads where one or more of the following DMRB criteria are met:

- change in road alignment by 5m or more;
- change in daily traffic flows by 1,000 vehicles or more as AADT;
- change in daily flows of Heavy Duty Vehicles (HDVs)[24] by 200 AADT or more;

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[21] Highways England, Transport Scotland, Welsh Government & Department for Infrastructure (2019), *Design Manual for Roads and Bridges LA105 Air quality*.

[22] Natural England (2018), *Natural England's approach to advising competent authorities on the assessment of road traffic emissions under the Habitats Regulations* – v1.4 Final. Available online at: http://publications.naturalengland.org.uk/publication/4720542048845824.

[23] Holman et al. (2019), *A guide to the assessment of air quality impacts on designated nature conservation sites – version 1.0,* Institute of Air Quality Management, London. Available online at: https://iaqm.co.uk/text/guidance/air-quality-impacts-on-nature-sites-2019.pdf.

[24] HDVs are defined as those with an unladen weight of greater than 3.5 tonnes, including large vans; medium goods vehicles (rigid and artic); heavy goods vehicles (rigid and artic) and buses/coaches.

- change in daily average speed by 10kph or more; or
- change in peak hour speed by 20kph or more.

3.5.4 It can be seen, therefore, that the additional nitrogen deposition that might arise from increased traffic is only likely to be significant where a European site lies within 200m of a road, and where traffic flows are expected to increase (or other changes are apparent see bullet points above), and where a feature is known to be sensitive to such effects. Should these criteria be met, best practice recommends that the ecological characteristics of the site should be explored and, if necessary, traffic and/or air quality assessments carried out to evaluate any impacts during construction or subsequent operation as appropriate.

3.5.5 The ecological characteristics of a site are derived from the formal citations, condition assessments, conservation objectives, FCT, SIP, supplementary advice and any other surveys and management plans where available. Traffic flows are assessed by calculating AADT figures. The latter introduces further thresholds and where changes in flows (alone and in-combination) are less than 1,000 AADT[25] or 200 HDV, the risk of a significant effect can be ruled out and no further assessment is required. Should flows exceed these values, air quality analysis is required. Here, impacts are assessed by calculating the relative contribution of the plan or project in relation to the relevant *critical level* for NO_x and the *critical loads* for nitrogen deposition for the individual qualifying features. The air quality analysis typically models the rates of deposition at fixed points on a 200m transect extending from the roadside.

3.5.6 The critical level for NO_x is fixed and is expressed as a concentration: 30µgm^3. It is a precautionary threshold below which there can be confidence that harmful effects on vegetation will not arise, and further assessment may not be necessary. If exceeded, assessment of critical loads is required. The critical loads for nitrogen deposition vary and are specific to each qualifying feature. These are presented as a range of values (expressed as a rate, e.g. 10kg N/ha/yr – 20kg N/ha/yr) and typically, as a precautionary approach, only the lowest value is used (unless there are compelling reasons to do otherwise) as this will emphasise any negative outcomes.

3.5.7 Should nitrogen deposition increase by less than 1% of the lower critical load, likely significant effects can be ruled out. However, should the 1% threshold be exceeded, a significant effect cannot be ruled out and an appropriate assessment will be required. It should be noted that the 1% threshold, set at two orders of magnitude below the critical load, is highly precautionary. Furthermore, an exceedance of the threshold does not mean that a significant (or adverse) effect *will* automatically occur, it only represents a trigger that prompts further assessment. Indeed, this emphasises that assessment is not about establishing a simple mathematical relationship. Account must be taken of the type of

[25] These values are utilised as there is evidence to show that these equate approximately to a 1% change in critical loads (see paragraph 2.4.3).

habitats (some are more resilient than others) and the distribution of the designated features as not all will be distributed evenly across sites, and other factors may be at play.

3.5.8 Natural England adds that where the existing background levels of NO_x or rates of deposition already exceed these values prior to implementation of a plan or project, the conservation objectives shift from seeking to maintain the condition of the qualifying features to aiming to restore them to a favourable conservation status. This reflects the greater challenge of restoring a site that could already be suffering harm from air pollution. It also makes clear that the impact assessment should focus on those objectives related to the structure and function of a site; those objectives most relevant to the impacts that could arise from air pollution are provided in Section 2.3 above.

3.5.9 Whilst assessment should, in the first instance, evaluate the plan or project in isolation, the Wealden decision makes clear that should insignificant outcomes arise alone, the outcomes should also be assessed in combination with other plans or projects. This test is also carried through to the appropriate assessment (if one is required). As The Mere, Mere is one of 16 discrete components of the Midland Meres and Mosses Phase 1 Ramsar site (which, in straightforward terms, is regarded as the sum of its parts), there is a separate need to assess the impact of air pollution on all other components as well.

3.5.10 To determine whether a formal screening exercise is required, this document to inform HRA firstly assesses the preliminary criteria: proximity of the European site to a road and the volume of anticipated traffic. If necessary, it then screens the construction and/or operational phase either alone or in-combination. An appropriate assessment follows subsequently, should one be considered necessary. An assessment of any impacts on the entire Midland meres and Mosses Phase 1 Ramsar site follows.

Initial assessment

Background

3.5.11 Key information is presented in Additional air quality information to inform a Habitats Regulations Assessment (Annex C) which summarises the associated air quality analysis. The following assessment draws on best practice from Natural England, DMRB and IAQM.

Proximity

3.5.12 Rostherne Mere is bordered by both the old and the new A556 to the west, Cherry Tree Lane to the north, Marsh Lane in the east and Rostherne Lane to the south. All lie well within the 200m threshold. Consequently, a traffic assessment is required.

3.5.13 The Mere, Mere is bordered by A5034 Mereside Road to the east, and north, A50 Warrington Road to the south and Chester Road to the west. The latter lies over 200m from the site and so is dismissed from any further scrutiny. In contrast, the A5034 Mereside Road and

Warrington Road lie within the 200m threshold and, consequently, a traffic assessment is required.

Traffic assessment

3.5.14 At Rostherne Mere, a planned construction traffic route runs along Chester Road and Cherry Tree Lane for part of the construction period, with approximately 200 HDV movements per day predicted. In addition, an internal haul road runs parallel to Cherry Tree Lane. Other roads will be subjected to increased traffic flows from journeys domestic traffic unrelated to HS2 displaced from other routes by delays and diversions during the construction and operation periods. Construction is anticipated to commence in 2025 and cease in 2038 when the operational phase begins.

Rostherne Mere (construction phase)

Air quality assessment of traffic flows (construction phase) alone

3.5.15 The air quality assessment of traffic flows at Rostherne Mere has been undertaken in accordance with the Volume 5, Appendix CT-001-00001, Environmental Impact Assessment Scope and Methodology Report (SMR). The assessment is summarised in Annex C. Despite the presence of the construction traffic route, impacts are primarily the result of increased flows of traffic along the A556 re-distributed from other routes during construction of the Proposed Scheme.

3.5.16 Annex C identifies that four roads were found to exceed the screening thresholds:

- A556;
- Chester Road (between Millington Lane and Cherry Tree Lane);
- Cherry Tree Lane (between Chester Road and Birkinheath Lane); and
- an on-site haul route, north of Cherry Tree Lane.

3.5.17 Six transects (T3, T4, T5, T6, T7 and T9), each 200m long, were established around the circumference of Rostherne Mere; T3 and T4 in the west near the A556, T5 in the north-west near Cherry Tree Lane, and, T6, T7 and T9 to the north and north-west, again near Cherry Tree Lane. Each transect started from the kerbside and intercepted the boundary of the European site at 194m, 184m, 53m, 86m, 72m and 0m, respectively. All subsequent points fell within the Ramsar site. The location and distribution of transects is shown in Figure 2.

3.5.18 The air pollution assessment has used traffic data based on an estimate of the average daily flows in the peak year during the construction period and adopts vehicle emission rates and background pollutant concentrations from the first year of construction. It should be noted that the air quality model takes a conservative approach and assumes that the highest flows in any one year are applied to the entire construction period. In reality, there will be considerable periods, perhaps years, where traffic flows and hence nitrogen deposition are less than this. However, the approach adopted meets the precautionary principle embedded in the Habitats Regulations.

3.5.19 Background NO_x and nitrogen deposition rates were obtained from the Air Pollution Information System (APIS)[26]. Several habitat types were identified within the European site and are listed below with the appropriate critical loads:

- arable and horticultural (no critical load);
- neutral grassland (20kg N/ha/yr – 30kg N/ha/yr);
- broadleaved woodland (10kg N/ha/yr – 20kg N/ha/yr); and
- poor fen (10kg N/ha/yr – 15kg N/ha/yr).

3.5.20 The allocation of critical loads merits clarification. Best practice encourages the use of the lowest value in the critical load range as a precautionary measure, as it will emphasise any negative outcomes. However, the European site includes a discrete parcel of arable land to the west. This is not a qualifying feature, but it is understood it was included within the site boundary to provide influence over surrounding land management. Its agricultural management is dependent on the addition of inorganic (nitrogen-based) fertiliser and so it is regarded as 'site-fabric'[27] and is allocated no critical load. Rostherne Mere also includes substantial areas of farmed and grazed semi-improve pasture. This too is not a qualifying feature and, again, it is understood it was included within the site boundary to provide influence over the management of the surrounding land. Whilst this too is regarded as site-fabric, in contrast to the arable farmland, nutrient inputs are now restricted, it is more semi-natural in nature and so, as a precautionary measure, it has been classified as neutral grassland (with a critical load of 20kg N/ha/yr – 30kg N/ha/yr). However, reflecting its classification as site-fabric, the highest value of the range (i.e. 30kg N/ha/yr) has been employed.

3.5.21 Similarly, the extensive woodlands of Harpers Bank Wood and Mere Covert (excluding Gale Bog) do not represent a qualifying feature and it is understood these too were included within the site boundary to provide influence over surrounding land management. Again, it is regarded as site fabric but in reflection of its semi-natural character it has been classified as broadleaved woodland with a critical load of 10kg N/ha/yr – 20kg N/ha/yr though again, the highest value in the range has been used.

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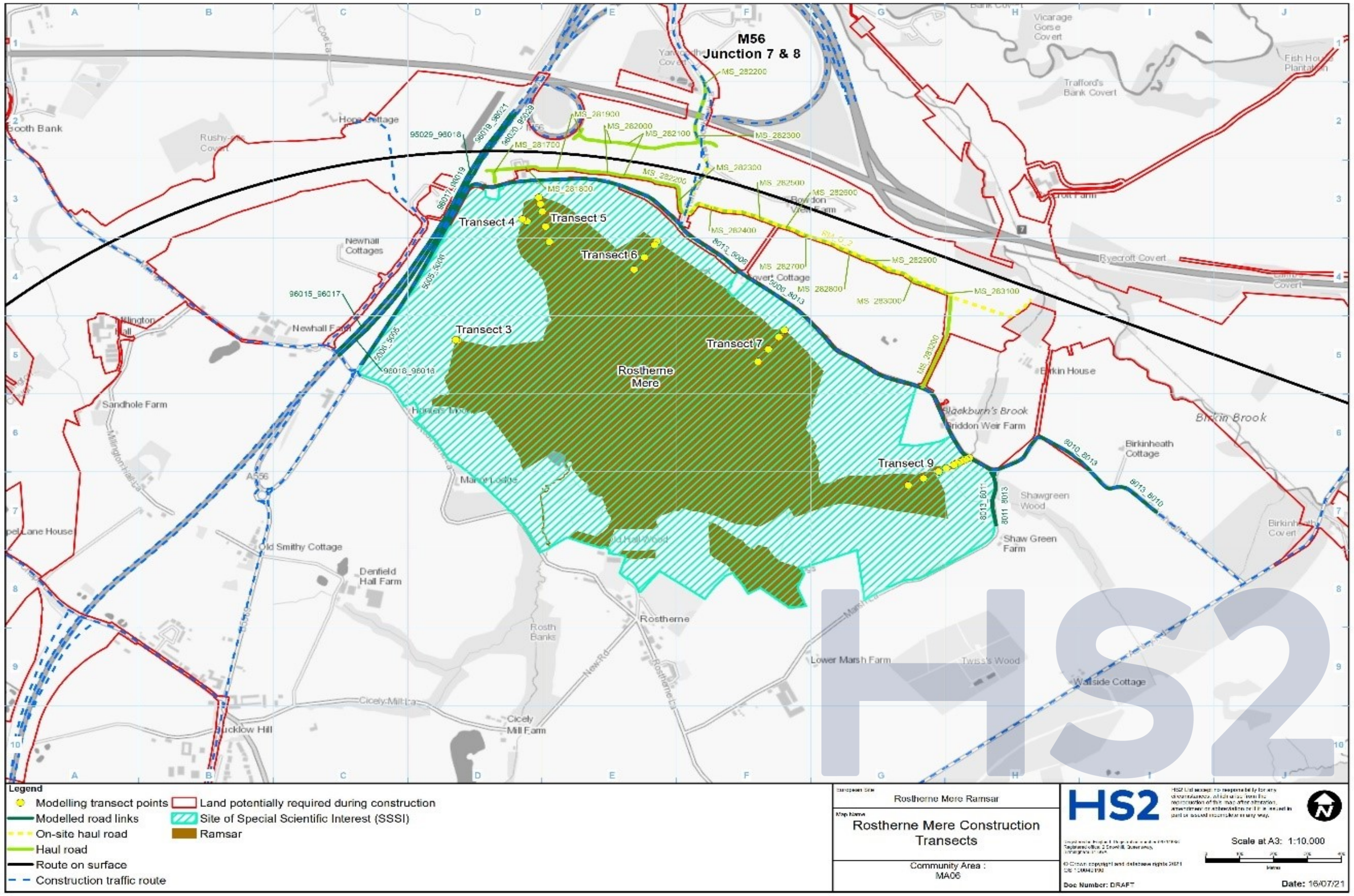
[26] UK Centre for Ecology and Hydrology (2021), *Air Pollution Information System*. Available online at: http://www.apis.ac.uk/.

[27] Site fabric is defined in Natural England (2018) as '… land and or permanent structures present within a designated site boundary which are not and never have been, part of the special interest of the site, nor do they contribute towards supporting a special interest feature in any way, but which have been unavoidably included within a boundary for convenience or practical reasons. Areas of site fabric … will not be expected to make a contribution to the achievement of conservation objectives.'

Figure 2: Distribution of transects, Rostherne Mere



3.5.22 The correct identification of the qualifying feature at Rostherne Mere that best represents the Ramsar criteria is of fundamental importance as the differing critical loads will directly influence the overall outcome of this assessment. Table 2 of the FCT identifies that the National Vegetation Classification (NVC) communities that comprise the fen, marsh and swamp community at Rostherne Mere comprise the following:

- S4 - *Phragmites australis* swamp and reed-beds;
- S13 - *Typha angustifolia* swamp; and
- S26 - *Phragmites australis-Urtica dioica* tall-herb fen.

3.5.23 This has been confirmed by site survey in July 2019. Based on Natural England's advice (Annex A), these three communities, despite occupying neutral, eutrophic locations and dominated by tall emergent vegetation and more akin to the late successional stages of swamp vegetation, are considered to represent 'poor fen' communities. The prevalence of these floristic characteristics can also be found in previous surveys referred to by the FCT, suggesting little change over the last decade or so.

3.5.24 Importantly, although undeniably wet woodland today, management objectives for Gale Bog seek to restore this to fen, marsh and swamp or similar vegetation and so, again on the advice on Natural England, this too is evaluated as a component of this poor fen community. Similarly, and importantly, the standing open water is also evaluated under the critical loads used for poor fen.

3.5.25 In order to satisfy the precautionary nature of HRA, best practice recommends that unless there are compelling reasons to do otherwise, only the lowest figure in the range should be used. Consequently, the value of 10kg N/ha/yr for poor fen was used to assess the wetland qualifying features.

3.5.26 Table C4 describes the change in NO_x concentrations brought about by the Proposed Scheme alone during construction and is described in Annex C as follows:

> 'NO_x concentrations are predicted to be within the air quality standard in 2025 at all locations with or without the Proposed Scheme'.

3.5.27 Despite this positive outcome, an assessment of nitrogen deposition was also made across all transects during the construction period (alone) (see Table D5) and repeated below in Table 1[28].

[28] Note that all tables in this HRA are drawn from Annex C. Whilst minor changes have been made to the layout, the data remains unchanged.

Table 1: Assessment of nitrogen deposition (construction, Proposed Scheme alone – Rostherne Mere)

Transect (T)	Distance to road (m)	Dry deposition (kg N/ha/yr)			Change in nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)	% Change in relation to lower critical load
		2018 baseline	2025 without the Proposed Scheme	2025 with the Proposed Scheme			
T3	194	39.91	39.64	39.66	0.02	20	0.1%
	200	39.89	39.63	39.65	0.02	20	0.1%
T4	184	24.23	24.03	24.05	0.02	10	0.2%
	200	24.19	24.01	24.03	0.02	10	0.2%
T5	53	24.20	24.01	24.03	0.02	10	0.2%
	75	24.17	24.00	24.02	0.02	10	0.2%
	100	24.15	23.99	24.00	0.01	10	0.2%
	150	24.10	23.96	23.98	0.02	10	0.2%
	200	24.07	23.94	23.96	0.02	10	0.1%
T6	86	39.58	39.47	39.50	0.03	20	0.1%
	100	39.58	39.47	39.49	0.02	20	0.1%
	150	39.58	39.47	39.49	0.02	20	0.1%
	200	39.59	39.47	39.49	0.02	20	0.1%
T7	72	39.44	39.39	39.41	0.02	20	<0.1%
	75	39.44	39.39	39.41	0.02	20	<0.1%
	100	39.44	39.39	39.41	0.02	20	<0.1%
	150	39.44	39.39	39.41	0.02	20	<0.1%
	200	39.44	39.39	39.41	0.02	20	<0.1%
T9	0	39.41	39.38	39.45	0.07	20	0.3%
	10	39.39	39.37	39.40	0.03	20	0.1%
	20	39.39	39.37	39.39	0.02	20	0.1%
	30	39.39	39.37	39.39	0.02	20	<0.1%
	40	39.39	39.37	39.38	0.01	20	<0.1%
	50	39.39	39.37	39.38	0.01	20	<0.1%
	75	39.39	39.37	39.38	0.01	20	<0.1%
	100	39.39	39.37	39.38	<0.01	20	<0.1%
	150	39.39	39.37	39.38	<0.01	20	<0.1%
	200	39.39	39.37	39.37	<0.01	20	<0.1%

3.5.28 With reference to this data, Annex C states:

> 'Nitrogen deposition is predicted to be above the lower critical load in all scenarios. However, the changes in nitrogen deposition due to the Proposed Scheme are lower than 1% of the lower critical load at all modelled receptors. No potentially significant effects are therefore predicted.'

3.5.29 This evidence shows that predicted increases in deposition brought about by the Proposed Scheme alone are modest, and no higher than 0.07kg N/ha/yr at any point on any transect. Indeed, the 1% threshold is not exceeded anywhere and only a handful of points on Transects T4 and T5 actually fall within the poor fen/open water qualifying feature, the rest falling on land regarded as site fabric. Best practice is clear that with such modest increases, likely significant effects can be ruled out. However, mindful of the requirements of the Wealden decision, an in-combination assessment is also required.

Screening opinion for Rostherne Mere (construction) alone

3.5.30 The Proposed Scheme has been screened for the purposes of Regulation 63 of the Habitats Regulations 2017 as amended. It is considered that there is no credible risk that nitrogen deposition during the construction phase could undermine the conservation objectives of Rostherne Mere and likely significant effects (alone) can be ruled out. An in-combination assessment is required.

Air quality assessment of traffic flows (construction phase) in-combination

Rationale

3.5.31 Although likely significant effects during construction alone were ruled out in Section 3.5.30, an assessment of the Proposed Scheme during construction in combination with other plans or projects is also required. As the Directive[29] makes clear, the in-combination test seeks to identify cumulative effects, and consequently they are limited to those that can affect the same feature. Therefore, the in-combination assessment was limited to those plans or projects that had the potential to increase nitrogen deposition on the qualifying features of Rostherne Mere; all other potential impacts were ruled out. The range and scope of in-combination assessments has been addressed in various settings; relevant examples include:

- Regulation 63(2) states:

> [the developer] ‘must provide such information as the competent authority may reasonably require for the purposes of such an assessment.’

[29] *Directive 92/43/EEC of the European Parliament and of the Council of 21st May 1992 on the conservation of natural habitats and of wild fauna and flora aims to promote the maintenance of biodiversity, taking account of economic, social, cultural and regional requirements*. Strasbourg, European Parliament and European Council.

- Furthermore, on 22 April 2005, the European Commission stated, in response to a parliamentary question (P-0917/05):

  'The [in-] combination provision must be applied in a manner that is proportionate …'

- In Foster and Langton[30], the Court stated:

  'There is no basis to carry out an assessment of the in-combination effects when there are no effects to take into account.' (paragraph 36).

3.5.32 This evidence has determined the need for and scope of any in-combination assessment required for this European site as explained in Section 5.2.

Methodology

3.5.33 In-combination effects are largely taken into account in the traffic data used for the assessment which incorporates likely changes brought about by other proposed and committed developments. The approach to this assessment, which has been agreed with Natural England, is provided in Section 2 of Annex C.

3.5.34 In order to comply with the Wealden decision, the scope of the in-combination assessment has been limited to those plans or projects that could contribute to a cumulative increase in air pollution at Rostherne Mere. Annex C details how development that could cause traffic emission related in-combination effects have been accounted for within the traffic data used in the air quality assessment of traffic flows. Searches were also carried out for the following non-traffic related emission sources (which are also included in the air quality model) within a 5km radius:

- combustion and energy > 1MW;
- farming, livestock and poultry (any);
- waste, e.g. landfill gas (any); and
- minerals activities.

3.5.35 This is considered to be reasonable and proportionate and meets the expectations laid down in Section 4.48 of Natural England's guidance[22].

Air quality assessment of traffic flows in-combination

3.5.36 Annex C identifies that three roads were found to exceed the screening thresholds:

- A556;
- Chester Road (between Millington Lane and Cherry Tree Lane);

[30] R (Foster and Langton) v Forest of Dean DC and Homes and Communities Agency (2015), High Court of Justice, EWHC 2684.

- Cherry Tree Lane (between Chester Road and Birkinheath Lane); and
- on-site haul route, north of Cherry Tree Lane.

3.5.37 Despite the presence of the construction traffic route, impacts are primarily the result of increased flows of traffic growth along the A556 from the 2018 Base Year.

3.5.38 As with the assessment of the Proposed Scheme alone, changes in NO_x are summarised first and reference to Table D7 is encouraged for the detail. Annex C states:

> ‘NO_x concentrations are predicted to be within the air quality standard in 2025 at all locations with or without the Proposed Scheme.’

3.5.39 Despite the same positive outcome as achieved in the assessment alone, an assessment of nitrogen deposition was also made across all transects during the construction period (in-combination) (see Table D8) and is repeated below in Table 2.

Table 2: Assessment of nitrogen deposition (construction, Proposed Scheme in-combination – Rostherne Mere)

Transect (T)	Distance to road (m)	Dry deposition (kg N/ha/yr)			Change in nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)	% Change in relation to lower critical load
		Baseline 2018	2025 do nothing	2025 with the Proposed Scheme			
T3	194	39.91	39.60	39.66	0.06	20	0.3%
	200	39.89	39.59	39.65	0.06	20	0.3%
T4	184	24.23	24.00	24.05	0.05	10	0.5%
	200	24.19	23.98	24.03	0.05	10	0.5%
T5	53	24.20	23.99	24.03	0.04	10	0.5%
	75	24.17	23.97	24.02	0.05	10	0.4%
	100	24.15	23.96	24.00	0.04	10	0.4%
	150	24.10	23.94	23.98	0.04	10	0.4%
	200	24.07	23.93	23.96	0.03	10	0.3%
T6	86	39.58	39.45	39.50	0.05	20	0.2%
	100	39.58	39.45	39.49	0.04	20	0.2%
	150	39.58	39.46	39.49	0.03	20	0.2%
	200	39.59	39.46	39.49	0.03	20	0.2%
T7	72	39.44	39.39	39.41	0.02	20	0.1%
	75	39.44	39.39	39.41	0.02	20	0.1%
	100	39.44	39.39	39.41	0.02	20	0.1%
	150	39.44	39.39	39.41	0.02	20	<0.1%
	200	39.44	39.39	39.41	0.02	20	<0.1%
T9	0	39.41	39.38	39.45	0.07	20	0.3%
	10	39.39	39.37	39.40	0.03	20	0.2%
	20	39.39	39.37	39.39	0.02	20	0.1%

Transect (T)	Distance to road (m)	Dry deposition (kg N/ha/yr)			Change in nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)	% Change in relation to lower critical load
		Baseline 2018	2025 do nothing	2025 with the Proposed Scheme			
	30	39.39	39.37	39.39	0.02	20	0.1%
	40	39.39	39.36	39.38	0.02	20	0.1%
	50	39.39	39.36	39.38	0.02	20	<0.1%
	75	39.39	39.36	39.38	0.02	20	<0.1%
	100	39.39	39.36	39.38	0.02	20	<0.1%
	150	39.39	39.36	39.38	0.02	20	<0.1%
	200	39.39	39.36	39.37	0.01	20	<0.1%

3.5.40 With reference to this data, Annex C states:

> 'Nitrogen deposition is predicted to be above the lower critical load in all scenarios. However, the changes in nitrogen deposition due to the Proposed Scheme in-combination are lower than 1% of the lower critical load at all modelled receptors. No potentially significant effects are therefore predicted.'

3.5.41 This evidence shows that predicted increases in deposition brought about by the Proposed Scheme in combination with other plans or projects are modest, and no higher than 0.07kg N/ha/yr at any point on any transect. Indeed, the 1% threshold is not exceeded anywhere and only a handful of points on Transects T4 and T5 actually fall within the poor fen/open water qualifying feature, the rest falling on land regarded as site fabric. Best practice is clear that with such modest increases, likely significant effects can be ruled out. As this assessment has been carried on in combination with other plans or projects, there is no need for any further assessment.

Screening opinion for Rostherne Mere (construction) in-combination

3.5.42 The Proposed Scheme has been screened for the purposes of Regulation 63 of the Habitats Regulations 2017 as amended. It is considered that there is no credible risk that nitrogen deposition during the construction phase could undermine the conservation objectives of Rostherne Mere and likely significant effects (in-combination) can be ruled out. No further assessment is required.

Rostherne Mere (operational phase)

Air quality assessment of traffic flows (operation phase) alone

3.5.43 The same tasks, according to the same criteria as for the screening assessment for construction alone (see paragraphs 3.5.15 to 3.5.19), were carried out for the operational phase and so they are not repeated here.

3.5.44 Annex C identifies that the only road meeting the screening thresholds under this scenario was the A556. Traffic impacts are primarily the result of increased traffic along the A556.

3.5.45 Consequently, only Transects 3 and 4 were triggered. As with the assessment of the Proposed Scheme alone, changes in NO_x are summarised first and reference to Table D11 is encouraged for the detail. Annex C states:

> 'NO_x concentrations are predicted to be within the air quality standard in 2038 at all locations with or without the Proposed Scheme.'

3.5.46 This is the same positive outcome as achieved for the assessments for the construction phase both alone and in-combination, albeit from 2038 onwards. As with those exercises, an assessment of nitrogen deposition was also made across all transects during the construction period (in-combination) (see Table D12) and is repeated below in Table 3.

Table 3: Assessment of nitrogen deposition (operation, Proposed Scheme alone – Rostherne Mere)

Transect (T)	Distance to road (m)	Dry deposition (kg N/ha/yr)			Change in nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)	% Change in relation to lower critical load
		2018 baseline	2038 without the Proposed Scheme	2038 with the Proposed Scheme			
T3	194	39.91	39.46	39.46	<0.01	20	<0.1%
	200	39.89	39.45	39.46	<0.01	20	<0.1%
T4	184	24.23	23.89	23.89	<0.01	10	<0.1%
	200	24.19	23.88	23.89	<0.01	10	<0.1%

3.5.47 Annex C states:

> 'Nitrogen deposition is predicted to be above the lower critical load in all scenarios. However, the changes in nitrogen deposition due to the Proposed Scheme are lower than 1% of the lower critical load at all modelled receptors. No potentially significant effects are therefore predicted.'

3.5.48 Again, the evidence shows that predicted increases in deposition brought about by the Proposed Scheme alone are modest, and no higher than 0.01kg N/ha/yr at any point on either of the two transect. The 1% threshold is not exceeded anywhere and only two points on Transect T4 fall within the poor fen/open water qualifying feature, the rest falling on land regarded as site fabric. Best practice is clear that with such modest increases, likely significant effects alone can be ruled out. However, mindful of the requirements of the Wealden decision, an in-combination assessment is also required.

Screening opinion for Rostherne Mere (operation) alone

3.5.49 The Proposed Scheme has been screened for the purposes of Regulations 63 of the Habitats Regulations 2017 as amended. It is considered that there is no credible risk that nitrogen deposition during the construction phase could undermine the conservation objectives of Rostherne Mere and likely significant effects (alone) can be ruled out. An in-combination assessment is required.

Air quality assessment of traffic flows (operation phase) in-combination

3.5.50 The same tasks, according to the same criteria as for the screening assessment for construction in-combination (see paragraphs 3.5.31 to 3.5.35), were carried out for the operational phase and so are not repeated here.

3.5.51 Reflecting the outcome for the operational phase alone, the only road meeting the screening thresholds under this scenario was the A556. Traffic impacts are primarily the result of increased traffic growth along the A556 from the 2018 Base Year Consequently, only Transects 3 and 4 were triggered. As with the assessment of the Proposed Scheme alone, changes in NO_x are summarised first and reference to Table C14 is encouraged for the detail. The Annex C states:

> ‘NO_x concentrations are predicted to be within the air quality standard in 2038 at all locations with or without the Proposed Scheme.’

3.5.52 This is the same positive outcome, albeit from 2038 onwards, as achieved under other scenarios. As with those exercises, an assessment of nitrogen deposition was also made across all transects during the construction period (in-combination) (see Table D15) and is repeated below in Table 4.

Table 4: Assessment of nitrogen deposition (operation, Proposed Scheme in-combination – Rostherne Mere)

Transect (T)	Distance to road (m)	Dry deposition (kg N/ha/yr)			Change in nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)	% Change in relation to lower critical load
		Baseline 2018	2038 do nothing	2038 with the Proposed Scheme			
T3	194	39.91	39.44	39.46	0.02	20	0.1%
	200	39.89	39.43	39.46	0.03	20	0.1%

Transect (T)	Distance to road (m)	Dry deposition (kg N/ha/yr)			Change in nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)	% Change in relation to lower critical load
		Baseline 2018	2038 do nothing	2038 with the Proposed Scheme			
T4	184	24.23	23.87	23.89	0.02	10	0.2%
	200	24.19	23.87	23.89	0.02	10	0.2%

3.5.53 Annex C states:

> 'Nitrogen deposition is predicted to be above the lower critical load in all scenarios. However, the changes in nitrogen deposition due to the Proposed Scheme in-combination are lower than 1% of the lower critical load at all modelled receptors. No potentially significant effects are therefore predicted.'

3.5.54 Again, the evidence shows that predicted increases in deposition brought about by the Proposed Scheme in-combination are modest, and less than 0.1kg N/ha/yr at any point on either of the two transect. The 1% threshold is not exceeded anywhere and only two points on Transect T4 fall within the poor fen/open water qualifying feature, the rest falling on land regarded as site fabric. Best practice is clear that with such modest increases, likely significant effects can be ruled out. As this assessment has been carried out in combination with other plans or projects, there is no need for any further assessment.

Screening opinion for Rostherne Mere (operation) in-combination

3.5.55 The Proposed Scheme has been screened for the purposes of Regulations 63 of the Habitats Regulations 2017 as amended. It is considered that there is no credible risk that nitrogen deposition during the operation phase could undermine the conservation objectives of Rostherne Mere and likely significant effects (in-combination) can be ruled out. No further assessment is required.

The Mere, Mere (construction phase)

3.5.56 The air quality assessment of traffic flows at the Mere, Mere has been undertaken in accordance with the Volume 5, Appendix CT-001-00001, Environmental Impact Assessment SMR. Each scenario is taken in turn below. The assessment is summarised in Annex C. The methodology, guidance and legislation described for the assessment of Rostherne Mere above all applies to the various exercises carried out below and is not repeated here.

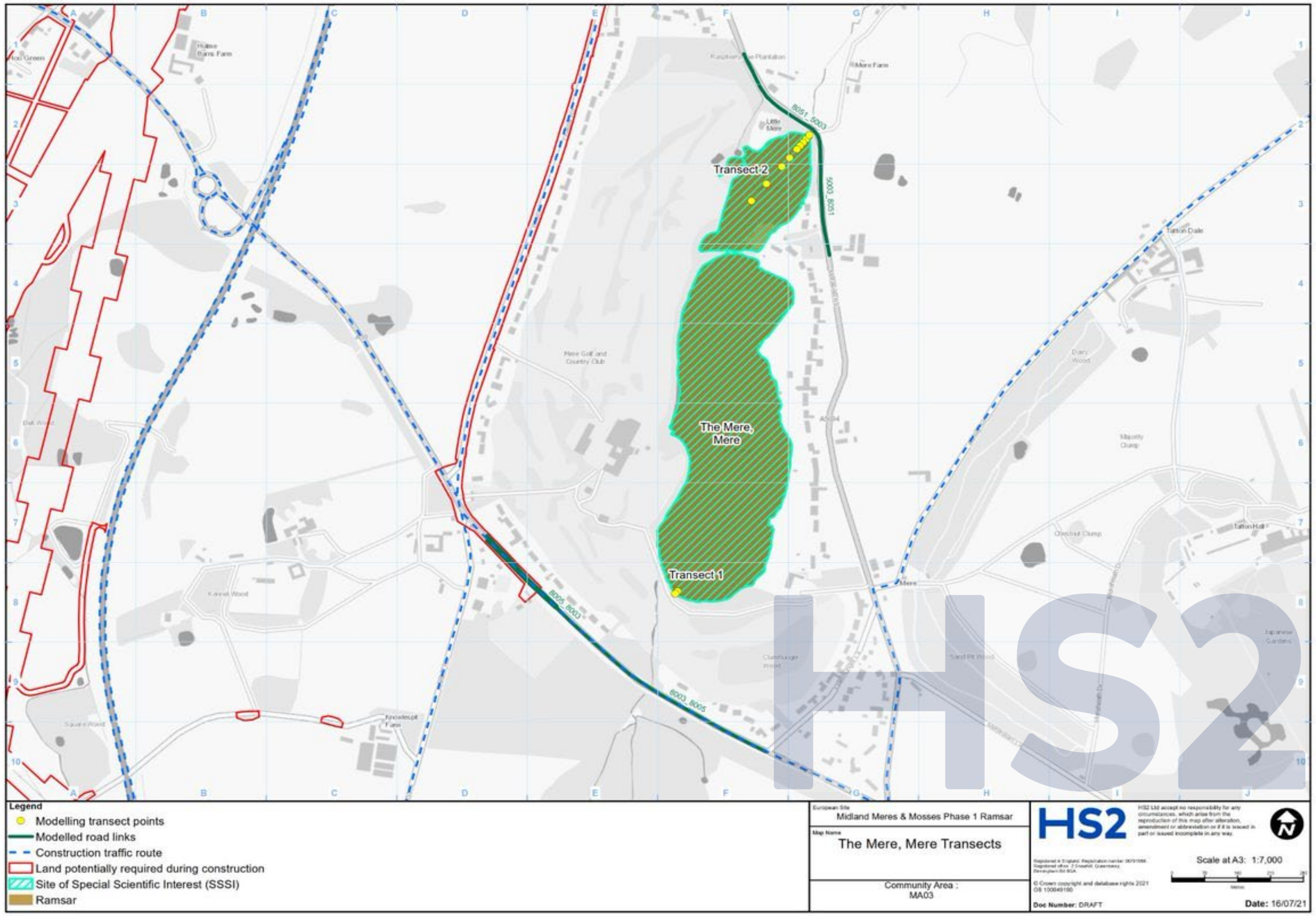
3.5.57 The assessment of traffic flows identified that the screening thresholds were triggered during both the construction and operational periods, both alone and in-combination. Each scenario is taken in turn below.

Air quality assessment of traffic flows (construction phase) alone

3.5.58 Annex C shows that only one road, the A50 (Warrington Road), was found to exceed the screening thresholds. Traffic impacts are primarily the result of increased traffic along the A50 Warrington Road from diversionary effects during the construction phase. Consequently, a single 200m transect (T1) was established; its location is shown on Figure 3. This transect started at the kerbside and intercepted the site at a distance of 193m. (Note that Figure 3 also shows the location of an additional transect (T2) on A5034 Mereside Road to the north required for the assessment of in-combination impacts described subsequently).

3.5.59 The methodologies described above for Rostherne Mere were also applied to The Mere, Mere and are not repeated here. In contrast, given its different characteristics, only one habitat type, 'poor fen' with a critical load of 10kg N/ha/yr – 15kg N/ha/yr was of relevance here.

Figure 3: Location of transects, The Mere, Mere



3.5.60 Table D11 describes the change in NO_x concentrations brought about by the Proposed Scheme alone during construction and is described in Annex C as follows:

> 'NO_x concentrations are predicted to be within the air quality standard in all scenarios with or without the Proposed Scheme.'

3.5.61 Despite this positive outcome, an assessment of nitrogen deposition was also made across both transects during the construction period (alone) (see Table D12) and repeated below in Table 5. Despite not triggering the need for assessment, results for the second transect (T2) on Mereside Road are also presented but are not discussed further.

Table 5: Assessment of nitrogen deposition (construction, Proposed Scheme alone – The Mere, Mere)

Transect (T)	Distance to road (m)	Dry deposition (kg N/ha/yr)			Change in nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)	% Change in relation to lower critical load
		2018 baseline	2025 without the Proposed Scheme	2025 with the Proposed Scheme			
T1	193	23.95	23.88	23.89	<0.01	10	<0.1%
	200	23.95	23.88	23.89	<0.01	10	<0.1%
T2	9	24.38	24.06	24.07	<0.01	10	<0.1%
	10	24.35	24.05	24.05	<0.01	10	<0.1%
	20	24.19	23.98	23.98	<0.01	10	<0.1%
	30	24.11	23.94	23.94	<0.01	10	<0.1%
	40	24.05	23.92	23.92	<0.01	10	<0.1%
	50	24.02	23.90	23.90	<0.01	10	<0.1%
	75	23.96	23.87	23.87	<0.01	10	<0.1%
	100	23.92	23.85	23.86	<0.01	10	<0.1%
	150	23.88	23.84	23.84	<0.01	10	<0.1%
	200	23.86	23.83	23.83	<0.01	10	<0.1%

3.5.62 With reference to this data, Annex C states:

> 'Nitrogen deposition is predicted to be above the lower critical load in all scenarios. However, the changes in nitrogen deposition as a result of the Proposed Scheme are lower than 1% of the lower critical load at all modelled receptors. No potentially significant effects are therefore predicted.'

3.5.63 This evidence shows that predicted increases in deposition brought about by the Proposed Scheme alone are modest, and less than 0.01kg N/ha/yr at any point on either transect. Indeed, the 1% threshold is not exceeded anywhere. Best practice is clear that with such modest increases, likely significant effects can be ruled out. However, mindful of the requirements of the Wealden decision, an in-combination assessment is also required.

Screening opinion for The Mere, Mere (construction) alone

3.5.64 The Proposed Scheme has been screened for the purposes of Regulations 63 of the Habitats Regulations 2017 as amended. It is considered that there is no credible risk that nitrogen deposition during the construction phase could undermine the conservation objectives of The Mere, Mere and likely significant effects (alone) can be ruled out. An in-combination assessment is required.

Air quality assessment of traffic flows (construction phase) in-combination

3.5.65 Annex C identifies that two roads were found to exceed the screening thresholds:

- the A50 Warrington Road, Mere; and
- the A5034 Mereside Road.

3.5.66 Traffic impacts are primarily the result of increased traffic along the A50 Warrington Road and A5034 Mereside Road from diversionary effects during the construction phase.

3.5.67 This necessitated the establishment of an additional transect (T2) on Mereside Road to the north, the location of which is shown in Figure 3. In contrast with T1, this intercepted the site at a distance of 9m with all subsequent points falling within the Ramsar site. As with the assessment of the Proposed Scheme alone, changes in NO_x are summarised first and reference to Table D14 is encouraged for the detail. Annex C states:

> 'NO_x concentrations are predicted to be within the air quality standard in all scenarios with or without the Proposed Scheme'.

3.5.68 Despite the same positive outcome as achieved in the assessment alone, an assessment of nitrogen deposition was made across both transects during the construction period (in-combination) (see Table D15). This is shown below in Table 6.

Table 6: Assessment of nitrogen deposition (construction, Proposed Scheme in-combination – The Mere, Mere)

Transect (T)	Distance to road (m)	Dry deposition (kg N/ha/yr)			Change in nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)	% Change in relation to lower critical load
		Baseline 2018	2025 do nothing	2025 with the Proposed Scheme In-combination			
T1	193	23.95	23.87	23.89	0.02	10	0.2%
	200	23.95	23.87	23.89	0.02	10	0.2%
T2	9	24.38	24.10	24.07	<0.01	10	<0.1%
	10	24.35	24.08	24.05	<0.01	10	<0.1%
	20	24.19	24.00	23.98	<0.01	10	<0.1%

Transect (T)	Distance to road (m)	Dry deposition (kg N/ha/yr)			Change in nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)	% Change in relation to lower critical load
		Baseline 2018	2025 do nothing	2025 with the Proposed Scheme In-combination			
	30	24.11	23.96	23.94	<0.01	10	<0.1%
	40	24.05	23.93	23.92	<0.01	10	<0.1%
	50	24.02	23.91	23.90	<0.01	10	<0.1%
	75	23.96	23.88	23.87	<0.01	10	<0.1%
	100	23.92	23.86	23.86	<0.01	10	<0.1%
	150	23.88	23.84	23.84	<0.01	10	<0.1%
	200	23.86	23.83	23.83	<0.01	10	<0.1%

3.5.69 With reference to this data, Annex C states:

> 'Nitrogen deposition is predicted to be above the lower critical load in all scenarios. However, the changes in nitrogen deposition as a result of the Proposed Scheme in-combination are lower than 1% of the lower critical load at all modelled receptors. No potentially significant effects are therefore predicted.'

3.5.70 This evidence shows that predicted increases in deposition brought about by the Proposed Scheme alone are modest, and less than 0.02kg N/ha/yr at any point on either transect. Indeed, the 1% threshold is not exceeded anywhere. Best practice is clear that with such modest increases, likely significant effects can be ruled out.

Screening opinion for The Mere, Mere (construction) in-combination

3.5.71 The Proposed Scheme has been screened for the purposes of Regulations 63 of the Habitats Regulations 2017 as amended. It is considered that there is no credible risk that nitrogen deposition during the construction phase could undermine the conservation objectives of The Mere, Mere and likely significant effects (in-combination) can be ruled out. No further assessment is required.

The Mere, Mere operational phase

Air quality assessment of traffic flows (operational phase) alone

3.5.72 Annex C identifies that only one road was found to exceed the screening thresholds: A50 Warrington Road. Traffic impacts are primarily the result of the re-distribution of traffic along the A50 Warrington Road as a result of the Proposed Scheme.

3.5.73 As with the assessment of the Proposed Scheme alone, changes in NO_x are summarised first and reference to Table D11 is encouraged for the detail. The Annex C states:

> ‘NO_x concentrations are predicted to be within the air quality standard in all scenarios with or without the Proposed Scheme’.

3.5.74 Despite the same positive outcome as achieved above, an assessment of nitrogen deposition was also made during the operational period (see Table D12) and is repeated below in Table 7. As with the construction phase alone, despite not triggering the need for assessment, results for the second transect (T2) on Mereside Road are also presented but are not discussed further.

Table 7: Assessment of nitrogen deposition (operation, Proposed Scheme alone – The Mere, Mere)

Transect (T)	Distance to road (m)	Dry deposition (kg N/ha/yr)			Change in nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)	% Change in relation to lower critical load
		2018 baseline	2038 without the Proposed Scheme	2038 with the Proposed Scheme			
T1	193	23.95	23.83	23.83	<0.01	10	<0.1%
	200	23.95	23.83	23.83	<0.01	10	<0.1%
T2 *	9	24.38	23.90	23.89	<0.01	10	<0.1%
	10	24.35	23.89	23.88	<0.01	10	<0.1%
	20	24.19	23.87	23.86	<0.01	10	<0.1%
	30	24.11	23.85	23.85	<0.01	10	<0.1%
	40	24.05	23.84	23.84	<0.01	10	<0.1%
	50	24.02	23.84	23.83	<0.01	10	<0.1%
	75	23.96	23.83	23.82	<0.01	10	<0.1%
	100	23.92	23.82	23.82	<0.01	10	<0.1%
	150	23.88	23.81	23.81	<0.01	10	<0.1%
	200	23.86	23.81	23.81	<0.01	10	<0.1%

Notes: *indicates that points in this transect cause a reduction in concentrations as a result of the Proposed Scheme - alone and therefore these Transects are not considered within the Proposed Scheme - in-combination

3.5.75 With reference to this data, Annex C states:

> ‘Nitrogen deposition is predicted to be above the lower critical load in all scenarios. However, the changes in nitrogen deposition as a result of the Proposed Scheme are lower than 1% of the lower critical load at all modelled receptors. No potentially significant effects are therefore predicted.’

3.5.76 This evidence shows that predicted increases in deposition brought about by the Proposed Scheme alone are modest, and less than 0.01kg N/ha/yr at any point on either transect. Indeed, the 1% threshold is not exceeded anywhere. Best practice is clear that with such modest increases, likely significant effects can be ruled out.

Screening opinion for The Mere, Mere (operation) alone

3.5.77 The Proposed Scheme has been screened for the purposes of Regulations 63 of the Habitats Regulations 2017 as amended. It is considered that there is no credible risk that nitrogen deposition during the operational phase could undermine the conservation objectives of The Mere, Mere and likely significant effects (alone) can be ruled out. An in-combination assessment is required.

Air quality assessment of traffic flows (operational phase) in-combination

3.5.78 Annex C shows that two roads were found to exceed the screening thresholds:

- the A50 Warrington Road, Mere; and
- the A5034 Mereside Road.

3.5.79 Traffic impacts are primarily the result of the redistribution of traffic along the A50 Warrington Road and the A5034 Mereside Road as a result of the Proposed Scheme.

3.5.80 As with the assessment of the Proposed Scheme alone, changes in NO_x are summarised first and reference to Table D14 is encouraged for the detail. Annex C states:

> 'NO_x concentrations are predicted to be within the air quality standard in all scenarios with or without the Proposed Scheme'.

3.5.81 Despite the same positive outcome as achieved in the assessment alone, an assessment of nitrogen deposition was also made across both transects during the operational period (in-combination) (see Table D15) and is repeated below in Table 8.

Table 8: Assessment of nitrogen deposition (operation, Proposed Scheme in-combination – The Mere, Mere)

Transect (T)	Distance to road (m)	Dry deposition (kg N/ha/yr)			Change in Nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)	% Change in relation to lower critical load
		Baseline 2018	2038 do nothing	2038 with the Proposed Scheme			
T1	193	23.95	23.83	23.83	<0.01	10	<0.1%
	200	23.95	23.83	23.83	<0.01	10	<0.1%

3.5.82 With reference to this data, Annex C states:

> 'Nitrogen deposition is predicted to be above the lower critical load in all scenarios. However, the changes in nitrogen deposition as a result of the Proposed Scheme in-combination are lower than 1% of the lower critical load at all modelled receptors. No potentially significant effects are therefore predicted.'

3.5.83 This evidence shows that predicted increases in deposition brought about by the Proposed Scheme alone are modest, less than 0.01kg N/ha/yr, and restricted to just T1 as the model indicates a reduction in the rate of deposition along T2. Indeed, the 1% threshold is not exceeded anywhere. Best practice is clear that with such modest increases, likely significant effects can be ruled out.

Screening opinion for The Mere, Mere (operation) in-combination)

3.5.84 The Proposed Scheme has been screened for the purposes of Regulations 63 of the Habitats Regulations 2017 as amended. It is considered that there is no credible risk that nitrogen deposition during the operational phase could undermine the conservation objectives of The Mere, Mere and likely significant effects (in-combination) can be ruled out. No further assessment is required.

3.6 Screening assessment

3.6.1 Having applied the screening test in Regulation 63, HS2 Ltd considered that likely significant effects and the need for further assessment could not be ruled out in terms of:

- construction-related impacts on the Rostherne Mere and The Mere, Mere (alone); and
- changes to the hydrological regime from construction of the Rostherne, Millington and Hoo Green cuttings (alone).

3.6.2 In contrast, there is no credible risk that nitrogen deposition during either the construction or operation phases could undermine the conservation objectives of either Rostherne Mere or The Mere, Mere (alone or in-combination) and likely significant effects can be ruled out. No further assessment is required.

3.6.3 Because likely significant effects related to construction related impacts and from changes to the hydrological regime have been identified alone, an appropriate assessment of each is required alone; there is no need for the in-combination assessment of either at this stage.

3.6.4 These outcomes correspond closely with the findings of the 2012 HRA although as the latter pre-dated the People Over Wind decision, these relied upon mitigation at the screening stage.

4 Appropriate assessment

4.1 The appropriate assessment test

4.1.1 The screening assessment has identified that likely significant effects could not be ruled out in terms of impacts arising from construction related activities and the construction/excavation of the Rostherne, Millington and Hoo Green cuttings. Both potential impacts require appropriate assessment. All other potential impacts, including nitrogen deposition have been screened out of the need for further assessment.

4.1.2 The appropriate assessment is defined in Regulation 63(5). The following definitions are applied as necessary to the subsequent assessment of likely significant effects.

4.1.3 Regulation 63(5) states where a project is 'likely to have a significant effect alone or in combination', it can only be consented if the competent authority can ascertain (following an appropriate assessment) that it 'will not adversely affect the integrity of the European site'. Drawing on Waddenzee, the 'in combination test' is also carried forward into the appropriate assessment.

4.1.4 In Sweetman[31], 'integrity' is defined as:

> '...the lasting preservation of the constitutive characteristics of the site ... whose preservation was the objective justifying the designation of the site'.

4.1.5 In Planning Practice Guidance[8] above it is described as:

> '...the coherence of its ecological structure and function, across its whole area, that enables it to sustain the habitat, complex of habitats and/or the levels of populations of the species for which it was designated.'

4.1.6 In Grace & Sweetman[32] the CJEU held that it is only when it is sufficiently certain that a measure will make an effective contribution to avoiding harm, guaranteeing beyond all reasonable doubt that the project will not adversely affect the integrity of the area, that such a measure may be taken into consideration.

4.1.7 Mindful of this, it is clear that for mitigation to be considered to effectively remove adverse effects, it should be effective, reliable, timely and guaranteed to be delivered for as long as necessary to achieve its objectives'[33].

[31] Sweetman v An Bord Pleanála (C 258-11) [2014] PTSR 1092 at paragraph 39.

[32] Grace & Sweetman v An Bord Pleanala (C-164/17) (2019) PTSR 266 at paragraphs 51-53 and 57.

[33] From Tyldesley, D., and Chapman, C. (2013), *The Habitats Regulations Handbook,* April 2021 edition UK: DTA Publications Limited.

4.1.8 The burden of proof is made clear in Waddenzee and where 'doubt remains as to the absence of adverse effects … the competent authority will have to refuse authorisation'[34] and 'that is the case where no reasonable scientific doubt remains as to the absence of such effects'[35]. However, absolute certainty is not required. In Champion, whilst referring to Advocate General Kokott in Waddenzee at paragraph 107, the Supreme Court found that 'absolute certainty' is not required as: '… the necessary certainty cannot be construed as meaning absolute certainty since that is almost impossible to attain …'.

4.2 Construction related activities

Assessment of effects

4.2.1 The screening exercise identified that likely significant effects from pollution and other impacts associated with construction activities cannot be ruled out alone (though this excludes the impact of vehicle emissions which are assessed elsewhere). Construction is anticipated to extend over a period of around four or five years and comprise intense activity, including but not limited to the use of potentially harmful materials and the movement of large number of vehicles, the movement and stockpiling of soils, excavations, and the storage of materials all represent potential risks to the Ramsar sites which could result in contamination of surface and sub-surface flows, or the generation of dust from vehicles on construction traffic routes.

4.2.2 Therefore, in the absence of mitigation, it is uncertain if these potential changes would conflict with the conservation objectives for Rostherne Mere and the Mere, Mere and threaten the integrity of both sites by compromising the ability 'To maintain the designated features in favourable condition …'.

4.2.3 Therefore, in terms of construction related activities, it is concluded that adverse effects on the integrity of the Rostherne Mere and The Mere, Mere cannot be ruled out. Mitigation is required.

Mitigation of construction related impacts

4.2.4 Mitigation is required because adverse effects on the integrity of Rostherne Mere and The Mere, Mere cannot be ruled out in terms of possible effects caused by construction related activities.

4.2.5 The type of effects identified above are common to most major construction projects. Consequently, a range of relatively straightforward, robust and reliable techniques have been developed by the industry over decades to avoid, cancel or reduce the scale of effects

[34] Waddenzee at paragraph 57.

[35] Waddenzee at paragraph 59.

to acceptable levels, even in proximity to fragile sites. Most, if not all, are required as a matter of best practice and law, providing confidence that they will be effective, reliable, deliverable and will be implemented for as long as is necessary.

4.2.6 These are typically supported by sophisticated management and monitoring programmes to ensure correct implementation and enable prompt remedial action should any fail.

4.2.7 These measures are proposed via an Environmental Memorandum forming part of the Environmental Minimum Requirements for HS2. This includes implementation of a (draft) CoCP which contains control measures and the standards to be implemented throughout the Proposed Scheme. For Phase One and Phase 2a of HS2, the CoCP is implemented thought site-specific control measures identified in Local Environmental Management Plans (LEMP) to be developed following consultation with the relevant stakeholders. Additionally, Key Environmentally Sensitive Works Sites are identified for areas with complex and in-combination sensitivities and complex consenting procedures that must be addressed during construction. The nominated undertaker and its contractors will be required to work in accordance with the CoCP and LEMP and prepare and monitor implementation site-specific management plans for environmentally sensitive worksites.

4.2.8 HS2 Ltd will work with Natural England to develop robust and effective local measures for the implementation of the CoCP to avoid adverse effects from the construction of HS2 on Rostherne Mere Ramsar site and the Midland Meres and Mosses Phase 1 Ramsar site. Consequently, there is no reasonable doubt as to why measures to control the effects of construction activities will not be effective at removing the threat throughout the construction process.

4.2.9 Therefore, in terms of construction related activities, it is considered, beyond reasonable scientific doubt, that implementation of the CoCP allows adverse effects on the integrity of Rostherne Mere and The Mere, Mere to be ruled out alone.

4.3 Construction/excavation of cuttings

Assessment of effects

4.3.1 The screening assessment has concluded that a likely significant effect cannot be ruled out alone in terms of the potential impact of changes to the hydrological regime on the wetland features of both Rostherne Mere and The Mere, Mere brought about by construction of the Proposed Scheme.

4.3.2 Locally, the Proposed Scheme comprises a range of features including bridges and cuttings but in terms of the impacts on groundwater, it is the latter which are of most significance. If the depth to the water table is above the base of cutting drainage, the discharge of groundwater to the cutting would give rise to a reduction in groundwater levels over the area surrounding the cutting and affect groundwater flows. Construction of retaining walls in cuttings can prevent, or significantly reduce, the drainage of groundwater to the cuttings although the retaining walls may also interrupt groundwater flow. In addition, if a retaining wall is constructed on only one side of a cutting, drainage of groundwater to the cutting may still occur on the open side of the cutting.

4.3.3 It is uncertain if the potential changes in groundwater flows resulting from the construction of cuttings would conflict with the conservation objectives for both Ramsar sites and threaten their integrity by compromising the ability 'To maintain the designated features in favourable condition …'. Consequently, further scrutiny of the site characteristics is required to thoroughly evaluate this issue.

4.3.4 Both Rostherne Mere and The Mere, Mere support a broadly similar aquatic and fringing macrophyte flora; both also support a characteristic assemblage of macroinvertebrates. All components of these communities are dependent to a greater or lesser extent on the maintenance of a favourable hydrological regime. Reductions in groundwater flow could affect surface and sub-surface flows to both Ramsar sites prompting damaging changes to the extent, species composition, abundance and/or distribution of wetland communities and threaten achievement of the conservation objectives.

4.3.5 Hydrological assessment in the form of the Technical note (see Annex B) has been undertaken to address this issue; extracts and summaries of the details provided in the Technical note are included in the following text. The Technical note takes account of the hybrid Bill design and includes an assessment of the potential impacts of changes in groundwater flows, due to the cuttings, on water levels in Rostherne Mere, based on a water balance model. The effects of these changes in water level on the ecology of Rostherne Mere are also considered.

4.3.6 The water balance model is used to assess the potential impacts for conditions in 2018, a reasonably dry year, and also in very dry or drought conditions as occurred in 1976 and 1996.

4.3.7 Similar levels of data and assessment are not available for The Mere, Mere. For the hydrological assessment, reliance has therefore been placed on publicly available information, a small number of observations in the area in 2018, and information provided by local parish councillors at a meeting in August 2019. Using this information, the Technical note therefore presents a very approximate assessment of a theoretical maximum limit for the impact of the Proposed Scheme cuttings on the water level in Little Mere. This theoretical value would, however, be substantially greater than any impact which may actually occur as explained below (see paragraphs 4.2.49 to 4.3.58). Furthermore, there may be no actual impact at all. Given the distance of The Mere, Mere from land required for the construction of the Proposed Scheme and that the likely maximum zones of influence on groundwater from dewatering/drainage in the cuttings (see below) are likely to be overestimated, the risk of adverse effects arising is considered to be low. Therefore, this approach is considered appropriate in the circumstances but has prompted a highly precautionary approach in terms of the hydrological assessment below.

Hydrological assessment – Rostherne Mere and The Mere, Mere

4.3.8 Rostherne Mere lies in the catchment of the River Bollin just to the south of the M56. The Proposed Scheme lies in part in substantial cuttings in the area between Rostherne Mere and the motorway (MA06), and in the Rostherne Mere catchment area to the west of The Mere, Mere (MA03). The outflow from Rostherne Mere discharges to Blackburn's Brook which then flows into Birkin Brook near the M56. The latter subsequently joins the River Bollin to the north of the motorway.

4.3.9 The Mere, Mere comprises two water bodies, The Mere and Little Mere. Both are located approximately 1.5km upstream of Rostherne Mere and both lie within its surface water catchment. Little Mere lies downstream and to the north of The Mere, and slightly closer to the Proposed Scheme. It is uncertain, however, whether impacts due to the cuttings could occur in either water body.

4.3.10 Springs are located within superficial glaciofluvial deposits, comprising predominantly sands and gravels, or close to the contact between the glaciofluvial deposits and glacial till in the Rostherne Mere catchment. Hence, much of the groundwater in the catchment may emanate from sand and gravel deposits.

4.3.11 The Proposed Scheme intercepts the surface water catchment of Rostherne Mere and The Mere, Mere at the following locations:

- just to the north of Rostherne Mere, in the Rostherne Cutting and Millington Cutting, affecting Rostherne Mere only; and
- to the west of The Mere, Mere and Little Mere, where the Hoo Green cuttings intercept a western extension of the surface water catchment associated with Rostherne Mere, The Mere, Mere and Little Mere.

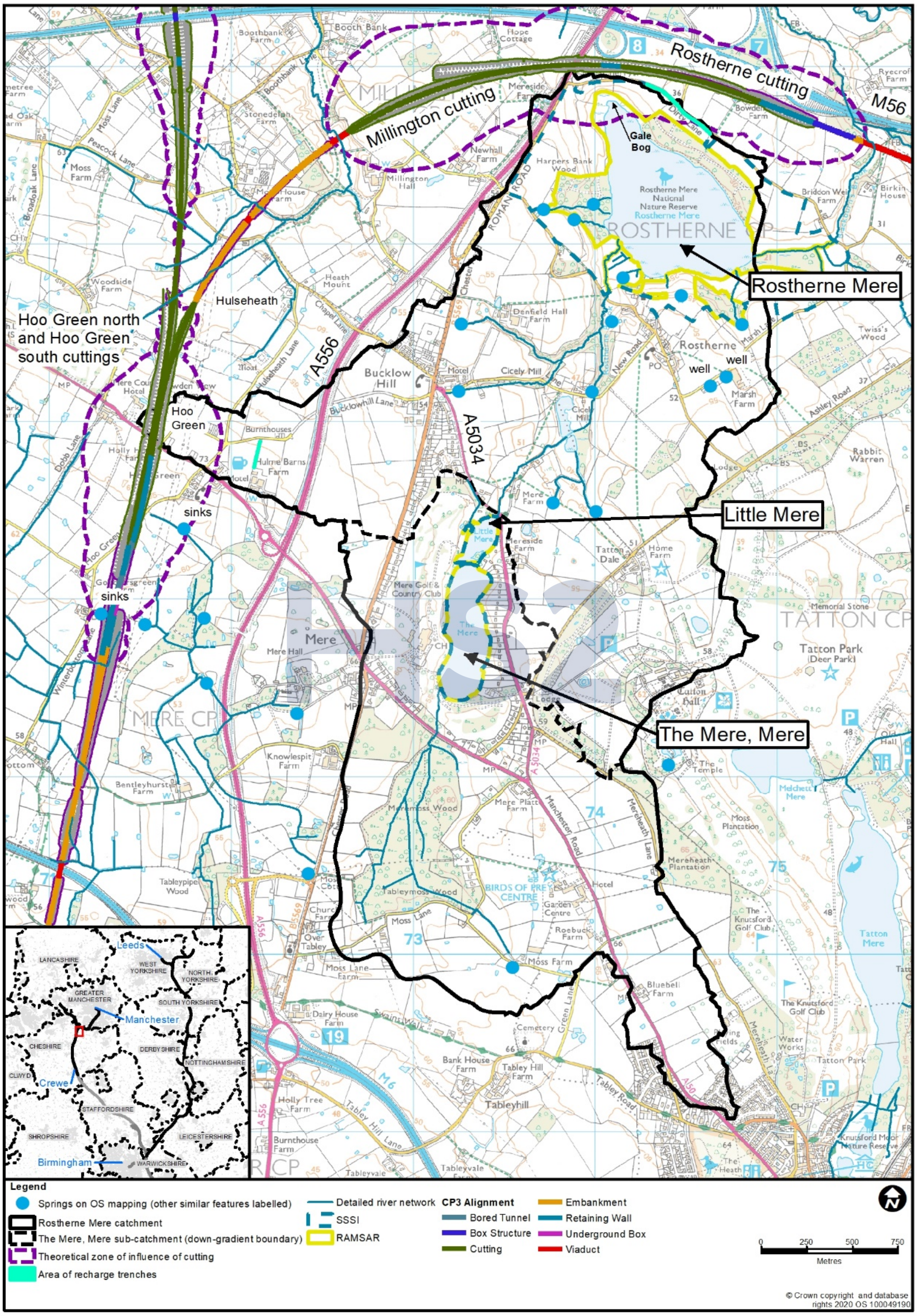
4.3.12 Figure 4 illustrates the location of Rostherne Mere and The Mere, Mere, along with the extent of relevant catchments and sub-catchments, the location of springs and the extent of the proposed cuttings.

4.3.13 The substantial number of springs in the Rostherne Mere catchment indicates that groundwater is likely to play a major role in supporting base flows in streams particularly in dry periods and, therefore, in maintaining water levels in the meres. In turn, they could also influence the type, distribution and species composition of the wetland features of the Ramsar sites. It is, therefore, important to understand the relative contributions to the meres of springs and watercourses, particularly during the drier summer months.

4.3.14 The Millington and Rostherne cuttings are located east and west of the A556 and to the south of an existing slip road between the M56 and A556 close to the northern end of Rostherne Mere. The cuttings would be excavated in glacial till close to the northern boundary of the Rostherne Mere catchment. The likely maximum zone of influence on groundwater from dewatering/drainage from the cuttings includes an area of the Rostherne Mere catchment between the cuttings and Rostherne Mere.

4.3.15 The Hoo Green cuttings to the west of The Mere, Mere and the zone of influence of the cuttings, are located in areas underlain by both glacial till and glaciofluvial deposits within the Rostherne Mere surface water catchment. This area of the Rostherne Mere catchment is not located in the surface water sub-catchment area for The Mere, Mere. However, due to the configuration of the superficial deposits, it is possible that some groundwater from the area might flow to The Mere, Mere sub-catchment.

Figure 4: Location of Ramsar sites, catchments and extent of earthworks



Impact of cuttings on water levels at Rostherne Mere

Impact of Millington and Rostherne cuttings on water levels at Rostherne Mere

4.3.16 At its closest location, the Rostherne and Millington cuttings lie approximately 170m to the north of the Rostherne Mere Ramsar site boundary with a maximum depth of 13.2m.

4.3.17 The theoretical zone of influence of the Millington and Rostherne cuttings includes parts of Gale Bog, the fields behind Gale Bog, the northernmost part of the open water of Rostherne Mere and the northern corner of Mere Covert, all found in or slightly beyond the north-western corner of the Ramsar site. Gale Bog is of particular interest as it once supported a small area of raised bog and is described as such in various formal site descriptions. Whilst this interest has been submerged by rising water levels and affected by vegetation succession, site management objectives seek its restoration to poor fen, or similar, reflecting the marginal vegetation frequently found around the perimeter of the mere.

4.3.18 However, the lowest point in the drainage in the Millington and Rostherne cuttings is approximately 24.8mAOD, with Gale Bog at an elevation of about 21mAOD. As Gale Bog is below the lowest possible level of dewatering in the cutting, in practice, the zone of influence of the cuttings could not extend as far as Gale Bog or the open water of Rostherne Mere.

4.3.19 It is possible that groundwater supplying any seepages within or close to the area of the cuttings could be intercepted within the zone of influence and would discharge to the drainage in the cuttings. However, the drainage in the cuttings could not create a reversal in groundwater flow at or below the level of Rostherne Mere. In addition, seepages in the area of fields located between Gale Bog and Harpers Bank Wood on the western side of Rostherne Mere, and those springs feeding watercourses in Harper Bank Wood are unlikely to be affected. These springs are located well outside the zone of influence of the cuttings.

4.3.20 The Technical note in Annex B observes that in theory, the zone of influence of the Rostherne and Millington cuttings could intercept discharges in a small area of Mere Covert.

4.3.21 Hydrological surveys in late spring and summer 2018 indicated that the groundwater inflow to Rostherne Mere from seepages located within or close to the zone of influence for the Millington and Rostherne cuttings amounted to only 0.1 to 0.3% of the total inflow to Rostherne Mere. In addition, there was no discharge evident from seepages above Gale Bog during surveys in the summer in 2018. However, in the water balance modelling it was assumed that, if the discharge in the area between the cuttings and Rostherne Mere was lost as a result of construction of the cutting, it is assumed (as a worst-case scenario), that total inflows to Rostherne Mere would also be reduced by up to 0.3% in all conditions.

4.3.22 However, in order to assess the impact on the integrity and conservation objectives of the Ramsar site, notably to ensure there is no permanent change in lake area, and no significant loss in the extent of the fringing reed swamp, and to maintain the characteristic zones of vegetation, it is necessary to assess what impact this change in inflow would have on the water level of the mere.

4.3.23 The water balance model used to assess the potential impacts of cuttings on water levels in Rostherne Mere was set up and calibrated using mere water levels and flow data obtained from the field surveys for a period of generally dry, hot weather from late May to September 2018, together with hydrological and meteorological data available from public sources. Model results were also checked against occasional outflow data for the Blackburn's Brook for several years including 1996, a drought year, provided by the Environment Agency. In addition, the model output was checked using mere water level data collected in 2019. This included continuous water level logger data for October and November 2019.

4.3.24 The potential impacts of the cuttings on water levels were then assessed for the conditions in 2018, and also for the very dry or drought conditions which prevailed in 1976 and 1996. In these latter years, flows in the catchment and mere water levels would have been particularly low.

4.3.25 Calibration of the model is explained in the Technical note in Annex B and is not repeated here other than to acknowledge that it has followed best practice, the assumptions made were conservative. Whilst mindful of inevitable limitations, the model results can be considered to provide a reasonable assessment. Overall, there is confidence in using the model to assess the impacts of small changes in inflow to Rostherne Mere, particularly in periods of dry weather as in 2018, when mere water levels are low. This confidence in use of the model was increased by a reasonably close simulation of the outflow data for 1996, provided by the Environment Agency, and also the water level data for 2019.

4.3.26 The model suggested that water levels would decline by a maximum of about 0.6mm from April onwards through the late spring and summer months, as a result of the presence of the Rostherne and Millington cuttings, increasing slightly in the winter period when inflows and water levels are higher.

4.3.27 For comparison, combining the observed low levels in summer 2018 with data from further surveys in 2019, including levels derived from a data logger, suggested that Rostherne Mere experienced a range of water levels of about 0.96m (960mm) in the period July 2018 to October 2019.

Impact of Hoo Green cuttings on water levels at Rostherne Mere

4.3.28 Within the catchment, the maximum depth of the Hoo Green North cutting is approximately 13.7m. Whilst the cutting deepens elsewhere to the north to approximately 23.8m, this point lies around 2km outside the catchment.

4.3.29 The potential zone of influence of the cuttings to the west of The Mere, Mere intersects approximately 2% of the area of the Rostherne Mere surface water catchment downgradient of The Mere, Mere sub-catchment. However, the area of the catchment to the west of The Mere, Mere extends out between the catchments to the south of Hoo Green (Tabley Brook) and to the north towards Hulseheath (Millington Clough). Some groundwater in this area may therefore contribute to the adjacent catchments rather than following a more extended groundwater flow path and direction within the Rostherne catchment.

4.3.30 The model indicates that water levels in Rostherne Mere decline by about 3.5 and 4.0mm from April onwards through the late spring and summer months as a result of the presence of the Hoo Green cuttings. This simulated decline in water level is greater in the winter months or following major rainfall/runoff events. The impact increases to more than 5mm when inflows and water levels are higher. However, if some, or all, of the recharge in the potential zone of influence of the cuttings contributes to the adjacent Tabley Brook and Millington Clough catchments, then the impacts on Rostherne Mere water levels would be reduced in all conditions.

Combined impacts of both sets of cuttings

4.3.31 Taking into account an overall 2.3% reduction in baseflows (ie 0.3% + 2.0%) and model results for extremely dry years in 1976 and 1996, as well as for slightly drier than average conditions in 2018, the water balance assessment suggested that the combined effect of the two sets of cuttings could be to produce a decline in water levels in Rostherne Mere of 4 to 5mm from April onwards through the late spring and summer months. The decline in water level would, again, generally be greater in the winter months, increasing up to 6mm when inflows and water levels are higher.

4.3.32 The modelled hydrographs in Figure 23 of the Technical note (Annex B), with and without the cuttings in place, demonstrate the marginal impact of changes in water level due to the cuttings when compared with the total variation of about 440mm in water levels for the period of modelling from February to September 2018. Importantly, there is only a total of five days (in July/August 2018) when the modelled mere water level with the cuttings in place falls below the minimum modelled water level in 2018 without the cuttings.

4.3.33 In particularly dry conditions such as in 1996, the combined effect was to produce a decline in water levels of 3.5mm to 5mm throughout the period from February to September. Again, this is considered to be marginal when compared with the total modelled variation of about 270mm in 1996. This led to a period of only six days (in August 1996) when the modelled mere water level with the cuttings in place falls below the minimum modelled water level for 1996 without the cuttings.

4.3.34 The same pattern emerged for 1976 when simulated outflow from Rostherne Mere was less than in 1996. Again, water levels were predicted to decline by about 3.5-4.5mm. The range in decline in water level was again considered marginal in the context of overall variation (about 310mm), with 10 days in August/September 1976 when modelled mere water levels fell below the minimum levels without the cuttings in place.

4.3.35 In both 1976 and 1996, the impact of the Millington and Rostherne cuttings was to produce a decline of up to 0.6mm, similar to the late spring and summer of 2018.

4.3.36 In summary, therefore, although the results from the water balance model may not be precise, they do indicate that:

- the Millington and Rostherne cuttings are likely to have an impact of less than one millimetre on water levels in Rostherne Mere, and potentially no impact in particularly dry conditions as seepages in the fields above Gale Bog and the near surface discharges in Mere Covert dry up;
- water levels in Rostherne Mere could decline by up to 3 to 4mm from April onwards through the late spring and summer months in dry or very dry conditions as a result of the presence of the Hoo Green cuttings, increasing slightly in the winter period when inflows and water levels are higher. However, these impacts could be reduced depending on the actual directions of drainage and groundwater flow in the surface water catchment to the west of The Mere, Mere. In addition, a cutting along the new A556 in the Rostherne Mere surface water catchment may have an impact in draining groundwater flow in this area;
- the combined effects of the two cuttings could be to produce a decline in water levels in Rostherne Mere of a few millimetres (modelled as about 4 to 5mm) in dry or very dry conditions. The decline in water level would be slightly greater generally in the late autumn, winter and early spring, or following major rainfall/runoff events, when inflows and water levels are higher; and
- overall, the impact of the cuttings on mere water levels is considered marginal when compared with the total variations in water level which have been modelled. It is reasonable to expect that there would only be short periods (between five and ten days) in low water level conditions in which the mere water level would fall below the minimum water level for that year without the cuttings. These impacts would almost certainly be undetectable and might, potentially, be less than the temporary impact of cutting of reed in Blackburn Brook; without this management, the reedbed could impede outflows and maintain a slightly higher water level in the mere.

4.3.37 Evidence from field visits and local landowners indicates that groundwater seepages and flows in Mere Covert (on the north bank of Rostherne Mere) should not be affected by the Proposed Scheme. Two seepages, identified in Mere Covert during a site reconnaissance visit with Natural England in May 2018, are likely to be too small to be affected by the zone of influence of the Rostherne cutting. The seepages were dry during the site visits between July and September 2018, suggesting they are ephemeral in nature and only active when groundwater levels are high, or after significant rainfall events.

4.3.38 Minor flows seen in a channel through the centre of Mere Covert during the site visits in 2018 are understood to originate as near-surface drainage which responds rapidly to rainfall. Based on topography, surface water resulting from rainfall in the area of the cutting closest to Mere Covert would be expected to drain to the north rather than through Mere Covert to Rostherne Mere. Therefore, the cutting would not be expected to affect the surface flows in Mere Covert, although the current directions of drainage between the cutting and Mere Covert may also be controlled by the depth of any field drains and drainage connections in the area.

4.3.39 Drawing on existing bathymetry survey data, this indicates that for a reduction of 5mm, the loss of lake area would be approximately 0.05ha or 0.1%, and about 2.6% of the shelf area above the 1m depth of water. This evidence suggests that although the anticipated fall in water levels of up to 5mm from both sets of cuttings is considered marginal in a hydrological context, a decline of this magnitude could conflict with the conservation objective to ensure no permanent change in lake area (amongst others). Therefore, further assessment of the impact on the ecology of Rostherne Mere is required.

Groundwater and seepages north of Rostherne Mere

4.3.40 It is acknowledged that although the contribution is small, the seepages to the north do form part of the wider hydrological system that influences, directly, the water balance regime of Rostherne Mere, and, therefore, that the hydrological conservation objectives apply.

4.3.41 The Technical note in Annex B has drawn on an investigation carried out in 1991 for the A556 (M56-M6) to the north and west of Rostherne Mere, to inform a more detailed assessment of the impact of the cuttings on groundwater flows and seepages. The assessment indicated that, over much of the period of monitoring in July to November 1991:

- groundwater levels are likely to have been at about (or possibly just below) average levels for a summer/autumn period; and
- levels were probably close to and slightly above the base of proposed track filter drainage in the cuttings at the closest point to Rostherne Mere, indicating that some groundwater may be intercepted in the drainage in these conditions. This might then give rise to an impact in reducing groundwater seepages in the slopes above Gale Bog. However, whilst the presence of the cuttings might have an effect on seepages, this depends on the directions of groundwater flow between the cuttings and the slopes above Gale Bog.

4.3.42 The evidence from site visits is that groundwater seepages in the slopes above Gale Bog dried up completely in the summer in 2018. In addition, in these drier conditions, it seems very likely that the groundwater level would also fall below the level of the base of the drainage in the cuttings. In drier conditions, therefore, the drainage should not affect any minor groundwater discharges in the area.

4.3.43 The variability of the glacial till underlying the area to the north of Rostherne Mere indicates that sandy deposits in the lower part of the glacial till are unlikely to be a particularly significant aquifer. In addition, these deposits could be poorly connected hydraulically with the mere or Gale Bog through the alluvium, mire and lake bed sediments. Therefore, in average conditions, or in wetter periods, drainage in the cuttings is unlikely to have a discernible impact on any minor groundwater discharge into Gale Bog or Rostherne Mere, if any such discharge does actually occur.

4.3.44 Furthermore, water levels in the soil underlying Gale Bog are likely to be linked closely to water levels in Rostherne Mere when the mere water level is at or below the ground level in the bog. When Gale Bog is inundated/flooded, the surface water level would be the same as for Rostherne Mere.

4.3.45 The zone of influence of the Rostherne cuttings was based on the assumption that groundwater levels are at ground level. However, data from 1991 indicates this is not the case in the area of the cuttings with groundwater levels in some boreholes about 10m or more below ground level. Using data from 1991indicated that the zone of influence is likely to be substantially reduced as indicated in Figure 31 (Depth to groundwater below surface (July to November 1991) in the Technical note Annex B. As a result, fewer seepages should be affected by the cuttings, with a reduction to discharges only from seepages in the slopes around the northern part of Gale Bog. A similar approach was taken in terms of the Millington cutting further to the west. A substantial reduction in the extent of the zone of influence is also indicated for this area.

4.3.46 The data for 1991 only allows an approximate re-assessment of the extent of the zone of influence of some parts of the cuttings based on actual groundwater levels. Furthermore, the extent would increase in higher groundwater level conditions. However, it does indicate that the actual zone of influence of the cuttings is likely to be substantially smaller than produced assuming the groundwater level is at ground level.

4.3.47 Elsewhere, the Technical note in Annex B assesses the design of proposed carrier drains in trenches beneath the Rostherne cutting. It is concluded that the drains should only have a marginal impact at most on groundwater flow, particularly close to the northern end of the Ramsar site where the drains are at their shallowest.

4.3.48 The Technical note also addressed the impact of a proposed overbridge for the A556 close to the eastern end of the Millington cutting. Taking into account the limited extent of the overbridge, it was concluded that the impact of the associated piling on groundwater flows should be negligible.

Impact of cuttings on water levels at The Mere, Mere

4.3.49 Figure 4 shows the location and zone of influence of the Hoo Green cuttings to the west of The Mere, Mere. The Proposed Scheme intercepts only the extreme western extent of the

Rostherne Mere surface water catchment. In addition, Figure 4 shows that the cuttings are not located within the sub-catchment for The Mere, Mere.

4.3.50 The Technical note makes it clear that any groundwater in the Rostherne Mere catchment which would be intercepted by the Hoo Green cuttings is assumed to contribute to the Rostherne Mere catchment. However, as already indicated, some groundwater in this area may contribute to the adjacent catchments rather than following a more extended groundwater flow path and direction within the Rostherne catchment. In addition, the A556 drainage may also be intercepting some groundwater moving from this area of the catchment towards Rostherne Mere.

4.3.51 In the current conditions, at least some of the groundwater within the zone of influence for the cuttings in the west of the Rostherne Mere catchment may, however, drain down the topographical gradient to the north-east. Groundwater discharge from the zone of influence could occur naturally at a spring in Bucklow Hill, although the flow might also be affected by the A556 drainage. However, groundwater flow to the spring may be restricted by lower permeability horizons in glacial till deposits. As a result, some groundwater in the Rostherne Mere catchment might, in theory, move towards Little Mere, the closest potential discharge location in The Mere, Mere sub-catchment.

4.3.52 The Technical note indicates that there is no evidence of discharges in the vicinity of Little Mere which could be a result of groundwater flow from the area of the Hoo Green cuttings. It seems unlikely therefore, that any groundwater from the zone of influence contributes to Little Mere although it is not possible to confirm this at present. In wetter conditions, groundwater may, perhaps, emerge in springs or might discharge through the base of Little Mere.

4.3.53 An assessment was, therefore, carried out to determine a theoretical maximum limit of impact of the Hoo Green cuttings on the water level of Little Mere. It was assumed in the assessment that all the potential recharge to the superficial deposits in the zone of influence within the Rostherne Mere catchment discharges in Little Mere. As a result, the theoretical limit would be substantially higher than any possible impact on the water level that might realistically arise from the presence of the Hoo Green cuttings. Furthermore, taking into account current evidence, the actual impact is more likely to be zero. Allowing, however, for the possibility of some recharge discharging in Little Mere, the impact might, at worst, be one or two orders of magnitude lower than the calculated theoretical limit.

4.3.54 No surface water outflow was occurring from Little Mere when visited at the end of July 2018. The assessment of impact indicated that, in periods in which there is no outflow from Little Mere, a maximum total, cumulative reduction in water level of approximately 270mm (0.27m) could theoretically occur. In contrast, the maximum theoretical impact on the water level when there is outflow from Little Mere would be minor, probably a few millimetres or less, similar to the impact calculated for Rostherne Mere. Details of the assessment calculations are provided in the Technical note.

4.3.55 The Technical note makes clear there are several reasons why this impact would not actually be expected to occur. Firstly, as the zone of influence of the Hoo Green cuttings is not in the surface water catchment for Little Mere, groundwater from the zone of influence may not contribute to Little Mere. If groundwater flow in the area follows the topographic gradient, it would discharge in the Rostherne Mere catchment downgradient of Little Mere. Alternatively, as discussed in the Technical note, it is possible the groundwater could discharge to surface water catchments to the north and south of the zone of influence, or via land drainage to Bucklow Hill. Secondly, in the event that some groundwater does discharge in Little Mere, the removal of this groundwater flow component would lead to some compensation by groundwater inflow from adjacent groundwater catchments, which would then discharge to Little Mere. Finally, if water levels in Little Mere were reduced, it is very likely that additional water would be drawn into Little Mere from the main body of The Mere by leakage through the ground. Hence, any change in water level would be distributed to some extent across the whole of The Mere, Mere water body.

4.3.56 Information from local sources, provided in August 2019, indicated that Little Mere had been dredged ‘in recent years’. If so, this could have removed substantial amounts of fine sediment which may previously have restricted the leakage of surface water through the mere bed in dry years. This could explain why there was no discharge over a few months in 2018, contrasting with the additional anecdotal evidence that, in previous extremely dry years such as 1976, discharge continued throughout the summer.

4.3.57 Assuming the dredging did give rise to significant leakage losses from Little Mere, the bed of the mere may be located above the water table in underlying superficial deposits in dry periods. The leakage from Little Mere would pass through an unsaturated zone in the top of the superficial deposits before reaching the water table. If this is the case, it is unlikely there could be any groundwater inflow to Little Mere in these periods. Hence, any change in groundwater flow in the catchment, following construction of the Proposed Scheme, could have no direct impact on water levels in dry conditions.

4.3.58 Overall, this evidence suggests that although an impact on water levels is unlikely, some uncertainty and the potential for a reduction in water levels remains. This cannot be dismissed and could conflict with the conservation objective to ensure no loss of [hydrological] connectivity (between lake and surrounding areas) (amongst others). Further assessment of the impact on the ecology of The Mere, Mere is required.

Ecological impacts of water level changes at Rostherne Mere and The Mere, Mere

4.3.59 The assessment of purely hydrological impacts above has confirmed that changes in water levels at Rostherne Mere are likely to be a few millimetres (5mm at most in dry or very dry conditions). In terms of The Mere, Mere, calculations suggested that a maximum theoretical reduction in groundwater inflow could give rise to a total, maximum reduction in water level of approximately 270mm in Little Mere. This theoretical maximum reduction in water level was calculated during dry periods in which there is no outflow from Little Mere. However, several reasons were provided to explain why this impact would not occur. As already indicated (see 4.3.55), the actual impact is more likely to be zero, taking into account current evidence, or, at worst, one or two orders of magnitude lower than the calculated theoretical limit. Ecological impacts of water level changes at Rostherne Mere and The Mere, Mere are discussed in turn below.

4.3.60 Given that the qualifying feature for Rostherne Mere includes the fringing swamp/marsh/fen community, the ecological impact of a change in water levels would be greatest in the margins where either:

- the distribution of submerged and exposed areas could change; and/or
- the proportionate change in depth would be greatest.

4.3.61 The lateral changes in shoreline were calculated for a combined, maximum reduction in water level of 5mm resulting from the cuttings to the north of Rostherne Mere and the set of cuttings to the west of The Mere, Mere. Using Environment Agency data, the approximate lateral movement of the water line of Rostherne Mere, in response to a maximum water level change of 5mm resulting from all cuttings, was calculated to be between 80mm and 267mm.

4.3.62 Drawing on existing bathymetry survey data, this indicates that for a reduction of 5mm, the loss of lake area would be approximately 0.05ha or 0.1%, and about 2.6% of the shelf area above the 1m depth of water. The existing habitat type lost would represent about 1.5% of the 3.3ha of the current extent of the swamp/marsh/fen currently present. The calculations do not, however, allow for any new areas of the habitat which might establish in the resulting marginally shallower water at the edge of the shelf, although this is very unlikely to compensate entirely for the loss of habitat.

4.3.63 The NVC report (2010)[36] describes the main body of water at Rostherne Mere as 'extremely species-poor'. The lack of macrophyte species is attributed to a combination of lake depth, poor water quality and turbidity (the latter a consequence of increased pelagic algal growth due to phosphate loading for which the presence of blue-green algal blooms provided additional evidence). Survey data shows a consistently species-poor aquatic macrophyte flora. This suggests that 'Favourable Condition' requirements are not met at Rostherne Mere.

4.3.64 In contrast, the same report describes the margins of Rostherne Mere as supporting a 'good range of swamp, mire, and wet woodland communities' supporting S4 *Phragmites australis* swamp, S7 *Carex acutiformis* swamp, S13 *Typha angustifolia* swamp, S15 *Acorus calamus* swamp, S24 *Phragmites australis–Peucedanum palustris* tall-herb fen, S25 *Phragmites australis-eupatorium cannabinum* tall-herb fen and S26 *Phragmites australis-Urtica dioica* tall-herb fen NVC communities, amongst others. The characteristic species are found growing in shallow water or above the water line on the damp margins of the mere although in places extended

[36] JBA Consulting (2010), *Rostherne Mere NNR – National Vegetation Classification* - Final Report.

tens of metres into the open water. The current overall Water Framework Directive (WFD) assessment is 'Bad' reflecting the failure to meet both biological and physio-chemical parameters. As with the NVC survey above, this was considered to be caused by excessive phosphate loading within the mere.

4.3.65 However, it should be noted that measures to improve water quality within the catchment and the water bodies is underway which in time can be expected to reduce the overall nutrient status of both meres.

4.3.66 Similar outcomes were reported in macrophyte surveys carried out by the Environment Agency in 2007, 2012, 2015 and 2018 with only between four and six species recorded in in each, although these were found to colonise water down to 3.5m depth (reflecting 'moderate' turbidity).

4.3.67 The subsequent 2019 NVC survey[37] essentially endorsed these findings, identifying that the fringing swamp vegetation comprised NVC communities S4a S4 *Phragmites australis* sub-community, S6 *Carex riparia* swamp and S13, suggesting only modest change in species composition, abundance and distribution. *Phragmites* and *Typha* spp. continued to form the dominant species.

4.3.68 The same survey was able to confirm that the raised bog community of Gale Bog has been lost and replaced with fen, marsh and swamp, and wet woodland. However, unlike the woodland of Harpers Bank Wood and Mere Covert, its position within the vegetation zonation, provides grounds for it to be considered as a component of the swamp/marsh/fen feature and it is included in that assessment accordingly.

4.3.69 Gale Bog provides important diversity amongst the fringing vegetation of Rostherne Mere. Once representing an area of raised bog (and described in the citation), it appears to have been swamped by the rising (eutrophic) water level in the mere prompting the establishment of mature wet woodland. The 2010 NVC noted the presence of a mosaic of W1-W2-W2a-W6b (*Salix cinerea-Galium palustre*, *Salix cinerea-Betula pubescens-Phragmites, Alnus glutinosa-Urtica dioica)* wet woodlands. An area of swamp vegetation remains with S7, S7-14 *Sparganium erectum* swamp, and S25-26-S28 *Phalaris arundinacea* tall-herb fen communities. Though dominated by purple loosestrife and meadowsweet, also supports a population of purple small-reed (also noted in the SSSI citation) as a regionally uncommon species and a key component of the marginal habitat. However, small changes in water levels are unlikely to have an adverse effect on the status of this species as it is a robust rhizomatous perennial with an affinity with habitats subject to winter flooding.

[37] High Speed Two Ltd (2022), High Speed Rail (Crewe - Manchester), Background Information and Data, *Ecological baseline data - National Vegetation Classification and ancient woodland,* BID EC-004-00001. Available online at: https://www.gov.uk/government/collections/hs2-phase-2b-crewe-manchester-environmental-statement.

4.3.70 Similar characteristics are displayed by other components of the marginal communities along the perimeter of the lake reflecting the zonation and the ability to adapt to modestly changing water levels in natural circumstances. However, the potential loss of 2.6% of the shelf area represents a considerable decline in the amount of substrate available for colonisation and this would represent a direct challenge to the achievement of the conservation objectives.

4.3.71 Even when set in the context of an annual variation in water levels of about 600mm (suggested by Natural England with evidence to support this found by HS2 Ltd) and a range of 960mm recorded by HS2 Ltd (between an extended hot, dry spell in July 2018 and very wet conditions in October 2019 when surface water would have extended across Gale Bog), a reduction in water level of a few millimetres will result in a loss of this qualifying feature.

4.3.72 A bathymetric survey in 2004 identified three zones: less than 1m depth able to support fringing emergent vegetation such as common reed, 1m–3.5m potentially suitable for colonisation by submerged macrophytes, and greater than 3.5 deep with macrophytes generally absent with production dominated by pelagic algae. These extended across approximately 5%, 10% and 85% of the mere respectively.

4.3.73 However, despite the evidence gained from recent surveys, the distribution, abundance, species composition and the status of the marginal vegetation remains only partly understood, especially in relation to the extent and profile of the surrounding shelf as the 2004 study only extrapolated data across the shelf; depending on the time of year, even very small changes in water level could have some effect on the amount of habitat available for colonisation and growth. Consequently, the effect on species composition, abundance and distribution and the structure and function of the overall marginal macrophyte communities cannot be predicted with certainty.

4.3.74 In terms of The Mere, Mere, these issues are less well defined though in 2020, an NVC survey recorded the following. Surrounding vegetation comprises W10 *Quercus robur-Pteridium aquilinum-Rubus fruticosus* woodland and W6d *Alnus glutinosa-Urtica dioica Sambucus nigra* sub-community. Several small areas of swamp were identified comprising vegetation typical of S23 'other water-margin vegetation' or S28 *Iris pseudacorus-Filipendula ulmaria* mire. Elsewhere, fringing swamp resembled both *Phragmites australis* swamp and reedbed or a transition community between S4 and S7 *Carex acutiformis* swamp (or a similar mire community) or S12 *Typha latifolia* swamp. In addition, small, fragmentary stands of S19 *Eleocharis palustris* swamp and OV26b *Epilobium hirsutum-Phragmites australis-Iris pseudacorus* sub-community were recorded. Another small stand of dense, tall-herb wetland vegetation was observed (S23), distinctive because of the abundance of yellow loosestrife and was considered to be more widespread but restrictions on access prevented closer inspection of this and other fringing and aquatic communities, although floating mats of white water-lily resembling A7 *Nymphaea alba* community was observed. Separately, an area of short, tussocky grassland with attributes of the MG6 *Lolium perenne-Cynosurus cristatus* community was present along with a sward dominated by *Holcus lanatus*, *Festuca rubra* and

Anthoxanthum odoratum. Although the hydrological Technical note provides reasons why impacts on water levels are unlikely, harmful effects on the marginal and aquatic vegetation and macroinvertebrate communities, and, in particular, the red-eyed damselfly population cannot be ruled out with any certainty.

4.3.75 Overall, adverse effects on the integrity of both sites cannot be ruled out beyond reasonable scientific doubt.

4.3.76 Therefore, adverse effects from cuttings on the integrity of Rostherne Mere and The Mere, Mere cannot be ruled out beyond reasonable scientific doubt. Mitigation is therefore required.

4.4 Mitigation for the impact of cuttings

4.4.1 Mitigation is required because there is a risk that the Millington, Rostherne and Hoo Green cuttings could lead to a reduction in water levels which could conflict with the conservation objectives of Rostherne Mere. In addition, there is a risk that the Hoo Green cuttings could lead to a reduction in water levels which could conflict with the conservation objectives of The Mere, Mere. Because it has not yet been possible to explore this further by detailed ground investigations, the precautionary principle demanded that adverse effects on the integrity of both Rostherne Mere and The Mere, Mere could not be ruled out.

4.4.2 The management of groundwater flows may form a component of large-scale infrastructure developments and engineering solutions can be employed to maintain groundwater flows in catchment areas. In addition, there needs to be a reasonable degree of confidence that mitigation will be effective, timely, resilient, and deliverable in the long-term. The mitigation schemes proposed in relation to Rostherne Mere and The Mere, Mere are summarised below, and are explained more fully in the Technical note.

4.4.3 In terms of the Millington and Rostherne cuttings, filtered drainage water from an area of the cuttings extending a considerable distance outside the Rostherne Mere catchment could be discharged to Rostherne Mere via a recharge trench. The approximate section of the cuttings contributing to the mitigation drainage scheme and the location of the recharge trench north-east of Rostherne Mere are shown in Figure 5. The timing of the discharge from the cuttings to the recharge trenches may be different to the timing of any natural groundwater discharge in the area above Gale Bog. However, the additional discharge from the extended area of the cuttings would mean that the total discharge is likely to exceed the natural groundwater discharge in the area.

4.4.4 Because the proposed location of the recharge trench lies on glacial till which is likely to be of low permeability, recharge wells may be constructed in the base of the trench, through the upper clay layer and into the lower sandy deposits underlying the area. Infiltration could then take place to the lower sandy deposits through these wells. A recharge scheme might also restore or increase discharges from some seepages in the slopes north-east of Gale Bog which could otherwise be affected by the Proposed Scheme although there could be no guarantee that the current seepage conditions would be replicated closely across any of the slopes.

4.4.5 If there is a risk that any groundwater in the vicinity of Rostherne Mere could drain away through the bedding material for the carrier drains, concrete dams or geomembrane could be installed across the lower section of the trench just downgradient of points of significant groundwater inflow. In addition, the backfill material above the drains could be varied to prevent groundwater draining away along the trench. Any groundwater would then be expected to re-establish a flow path through the trench backfill or bedding material.

4.4.6 For the area to the north-west of The Mere, Mere, drainage from sections of the cuttings extending across and outside the Rostherne Mere catchment could be pumped to recharge trenches in the superficial deposits to the east of the zone of influence of the Hoo Green cuttings. The approximate sections of the cuttings contributing to the mitigation drainage scheme, and also the provisional location of the recharge trenches to which the drainage water will be discharged, are shown on Figure 6. The geological mapping indicates that glaciofluvial deposits comprising permeable sands and gravels are likely to be present at the location of the recharge trenches.

4.4.7 As with the Millington and Rostherne cuttings, the recharge trenches provided to address the impact of the Hoo Green cuttings should produce a contribution which exceeds the natural recharge in the area of the zone of influence. Again, there may be differences in precise timing between recharge through the trenches and the natural groundwater throughflow. However, taking into account the distance of the recharge scheme from Rostherne Mere or The Mere, Mere, (if some groundwater does flow towards the latter) a slight variation in the timing of recharge should make no significant difference to the timing of groundwater discharge in the catchment.

4.4.8 The proposed recharge scheme does not take into account any impact caused by the A556 or drainage patterns in the area. The A556 scheme is likely to have cut through much of the sands in the southern half of the outcrop of glaciofluvial deposits. Potentially, therefore, the A556 drainage might be intercepting some groundwater moving from this area of the catchment towards Rostherne Mere. However, the mitigation included in the design will provide mitigation for the potential additional impact on groundwater flow from the Proposed Scheme.

Figure 5: Recharge trenches north of Rostherne Mere

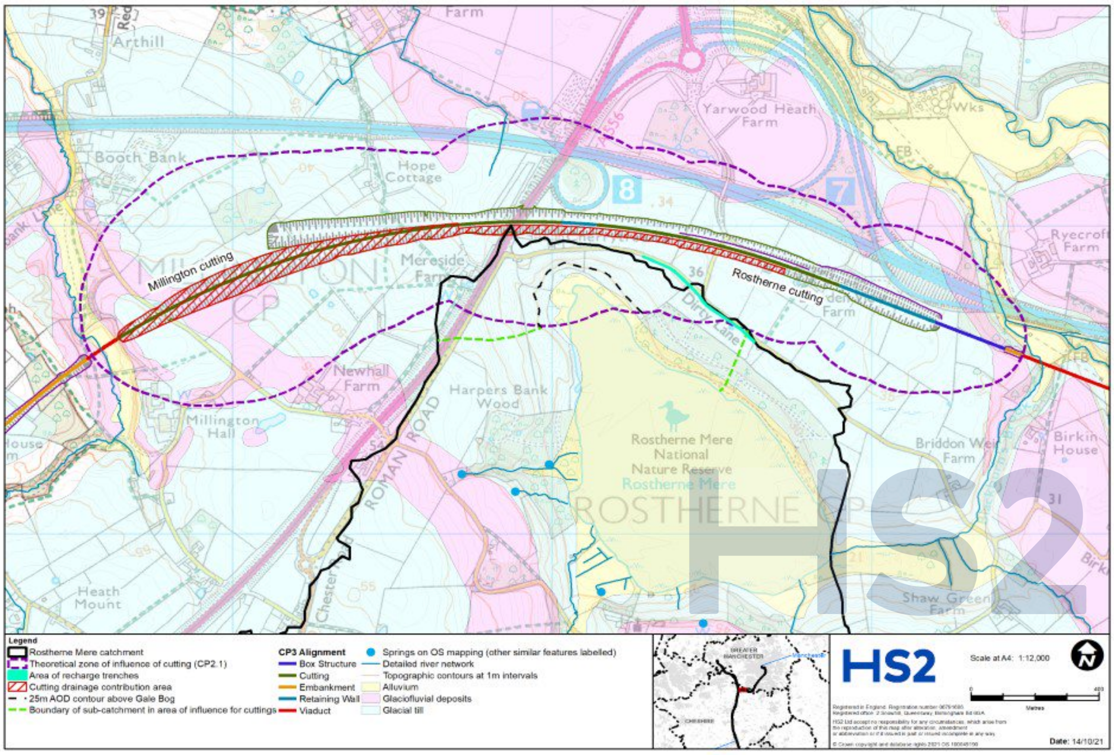
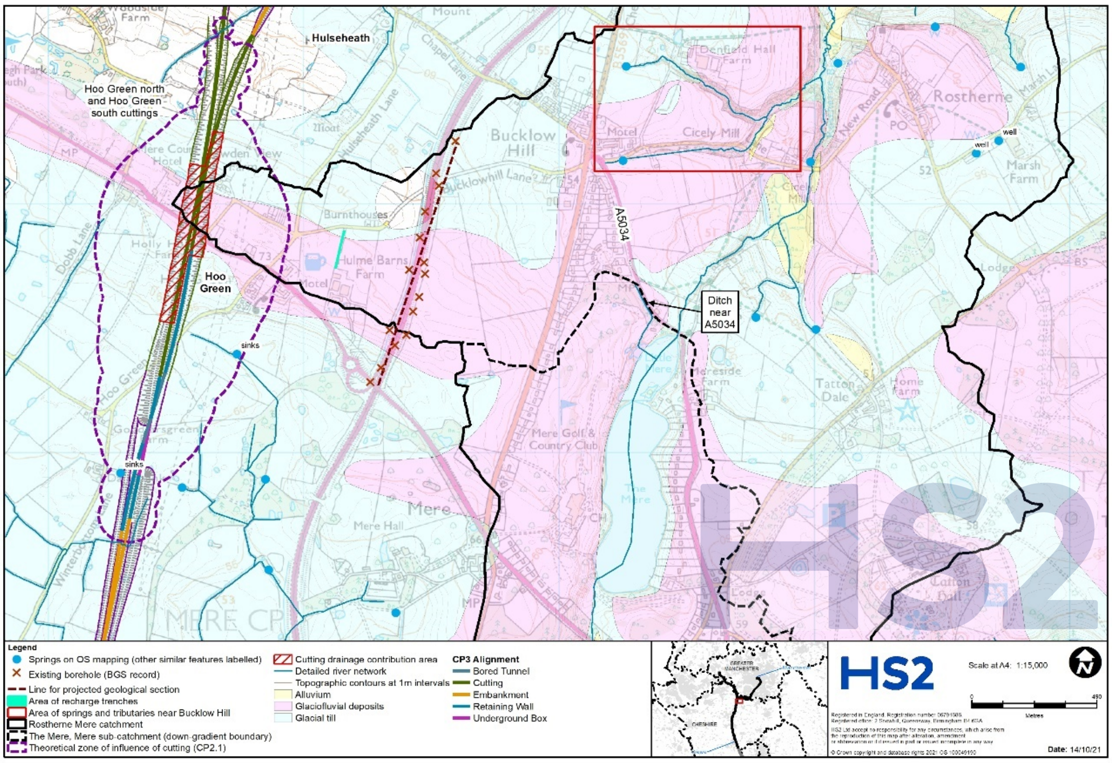


Figure 6: Recharge trenches west of Rostherne Mere



4.4.9 On the basis of the considerations set out above, the mitigation proposed is considered to provide reassurance beyond reasonable scientific doubt that there would be no reductions in water levels in Rostherne Mere. With this mitigation it is expected that Gale Bog, and both the marginal and aquatic vegetation would remain unaffected by the Proposed Scheme.

4.4.10 The springs and seepages above Gale Bog lie outside, and do not represent qualifying features of the Ramsar site. This means that even though the vegetation communities of the springs and seepages comprise some elements of the fringing swamp communities, their future species composition, abundance and distribution cannot be considered a factor when assessing impacts on the floristic conservation objectives of Rostherne Mere and any impacts do not require mitigation.

4.4.11 This forms the basis of the approach to mitigation of the Millington and Rostherne cuttings. This seeks to maintain the overall water balance but does not aim, and is unable to guarantee, that either the timing of discharges from the springs and seepages or their location and vegetation composition will remain unchanged. Overall, this is not considered to conflict with the conservation objectives allowing adverse effects to be avoided.

4.4.12 A similar rationale underpins the approach to mitigation in relation to The Mere, Mere. Uncertainty remains about the scale of a fall in water levels, to the extent that it is considered unlikely there would be any fall in levels at all. However, regardless of any actual impact, the adoption of mitigation measures is considered to provide, beyond reasonable scientific doubt, the necessary confidence that there would be no resulting reductions in water levels in The Mere, Mere. It is expected that there will be no measurable effect on the extent, distribution and composition of the qualifying features and, consequently, there would be no conflict with the conservation objectives for the site Therefore, it is considered that an adverse effect on the integrity of the site can be avoided.

4.4.13 The implementation of the recharge schemes would be preceded by detailed site and ground investigations to refine the design or, indeed, to establish whether the schemes are actually required or not. If necessary, the recharge schemes would be subject to careful management, operation and maintenance to ensure they remain functional throughout the lifetime of the Proposed Scheme. This would be supported by a suitable groundwater level monitoring programme to confirm that the recharge schemes are operating as planned; if required this would also allow remedial action to be taken. Both the monitoring programme and recharge scheme would, if necessary, be developed in consultation with Natural England.

4.4.14 Therefore, in terms of hydrological impacts, it is concluded, beyond reasonable scientific doubt, that with allowance for implementation of the proposed mitigation measures, adverse effects on the integrity of Rostherne Mere and The Mere, Mere can be ruled out alone. Consequently, there is no need for an in-combination assessment.

5 In-combination assessment

5.1 Need for assessment

5.1.1 The possible need for an in-combination assessment is addressed by Regulation 63. If required, this would evaluate the cumulative effect of those impacts which are not significant or adverse alone but when combined with the impacts of the Proposed Scheme could make those effects more likely, more significant or more adverse.

5.1.2 Because this HRA has shown that adverse effects have been avoided alone in terms of impacts from construction activities, and hydrological change on both Rostherne Mere and The Mere, Mere, the potential for adverse effects to arise in combination can also be ruled out. Therefore, it is considered there is no need for an in-combination assessment.

5.1.3 The evaluation of air pollution represents the single exception to this. To be consistent with the Wealden decision the in-combination effects of air pollution have already been considered in the screening assessment. Therefore, no further assessment of air pollution is required.

5.1.4 Therefore, and mindful of case law (Foster and Langton), with the exception of air pollution where this additional consideration is built into the assessment process, it is considered there is no need for any further in-combination assessment.

5.2 Impacts on other components of the Midland Meres and Mosses Phase 1 Ramsar site

5.2.1 It is recognised that as the Ramsar site comprises multiple components, should the Proposed Scheme, following an appropriate assessment, cause adverse effects to arise on one, this could require the consideration of whether the Proposed Scheme or other plans or projects had caused adverse effects to arise on other components. The cumulative impact of these could result in a greater adverse effect. However, as it is considered that adverse effects have been ruled out at The Mere, Mere and, in separate HRAs for two other components of the Ramsar site, Tatton Meres and Wybunbury Moss, which were considered at risk from air pollution, there is no potential for any cumulative impact with any other plans or projects. Therefore, it is considered there is no need for any further assessment.

6 Integrity test

6.1.1 The Proposed Scheme has been subjected to an appropriate assessment for the purposes of Regulation 63 of the Habitats Regulations 2017 as amended. It is considered that the competent authority is able to ascertain that an adverse effect on the integrity of the European site can be ruled out alone or in-combination.

7 Conclusions

7.1.1 This document provides all relevant information to enable a HRA to be carried out for the purposes of Regulation 63 of the Habitats Regulations 2017, as amended, should one be required. The outcomes allow the following conclusions to be drawn:

- nitrogen deposition: it is considered there is no credible risk that nitrogen deposition, during either construction or operation of the Proposed Scheme, alone or in combination with other plans or projects, could undermine the conservation objectives of Rostherne Mere or The Mere, Mere. Therefore, it is considered that likely significant effects alone or in-combination can be ruled out and there is no need for an appropriate assessment (alone or in-combination);
- construction related activities: it is considered that the mitigation proposed is effective, reliable and deliverable, and allows the appropriate assessment to ascertain, beyond reasonable scientific doubt, that adverse effects on the integrity of Rostherne Mere and The Mere, Mere will be avoided alone. It is considered there is no need for an in-combination assessment; and
- changes to the hydrological regime: it is considered that the mitigation proposed is effective, reliable and deliverable, and allows the appropriate assessment to ascertain, beyond reasonable scientific doubt, that adverse effects on the integrity of Rostherne Mere and The Mere, Mere will be avoided alone. It is considered there is no need for an in-combination assessment.

Annex A: Natural England advice 2019

Annex A: Natural England advice 2019

HS2/NE Work Request Response	
Title	**Formal Advice on qualifying Ramsar features and grassland management at Rostherne Mere Ramsar site**
NE Reference	HS200058
Date of Advice	18 February 2019.
Request Originator	Jon Riley, MWJV (Mott MacDonald WSP Joint Venture)
Date of Request	5 February 2019
Phase	☐ Phase 1 ☐ Phase 2a ☒ Phase 2b ☐ OIMD
Request	Information required to prepare an Appropriate Assessment of potential hydrological and air quality impacts arising from the construction of HS2 Phase 2b on Rostherne Mere Ramsar site, a follows: • Confirmation of the features that form the basis for designation of the Ramsar site. The 2012 screening report for the HS2 Phase 2 states that the key qualify features are – standing open water habitat: natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation; and – fen, marsh and swamp habitat (edge component of the above standing open water): water-fringe vegetation. However, the 2016 SSSI Favourable Condition Table (which also identifies the Ramsar features) lists only the following: – naturally eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation In contrast, the Ramsar Information Sheet identifies the feature as: – Rostherne Mere is one of the deepest and largest of the meres of the Shropshire-Cheshire Plain. Its shoreline is fringed with common reed Phragmites australis. Consultation with NE for the 2012 screening report established that birds listed as noteworthy fauna and those listed under the SSSI designation do not form part of the qualifying interest of the Ramsar. However, subsequently NE has referred to additional features; geology and remnant raised bog that may also contribute to reasons for designation of the Ramsar site. HS2 therefore requests Natural England's formal advice on the qualifying features of the Ramsar site to enable a robust and comprehensive HRA to be carried out. In addition, we seek NE's opinion on the sensitivity (including critical loads if possible and failing that informed opinion) of the final list of features to nitrogen deposition and increased acidity – the sensitivity of Ramsar features is typically poorly described on APIS and can hinder assessment by struggling to provide the objective information required.

HS2/NE Work Request Response	
	• Information on the management of grassland in Rostherne Mere NNR that surrounds the Ramsar site, particularly in terms of inputs of fertilizer, slurry and any other nutrients that require consideration in assessing the impacts of nitrogen deposition from HS2 construction activities on the integrity of the SSSI/Ramsar.
Response	**Ramsar qualifying features** The correct interpretation of the Ramsar qualification features at Rostherne Mere is that Rostherne Mere is designated under criterion 1 where, "A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region." At Rostherne this includes both the standing open water element but also the fringing fen, marsh and swamp habitat. Whilst the Favourable Condition Table (FCT) appears to concentrate on the standing open water element of the Ramsar feature it goes on, in the extent attribute, to say that this feature includes the fringing fen, marsh and swamp habitat. A loss in extent of the fringing habitats could affect site condition. Shoveler and Pochard are mentioned in the February 1999 version of the Ramsar Information sheet but were removed from the June 2008 version as the population numbers were below the Ramsar selection threshold. Peat bog (Gale Bog) was also referred to in the February 1999 information sheet and contributed to the habitat designated under criterion 1. However, the bog element of the fringing habitat has reduced in extent due, we think, to subsidence and changes in water level. The remnants of Gale Bog should be treated as part of the fringing habitat mosaic extent. In the HRA for the A556 construction no special consideration was required for bog habitat and this approach should also be taken for the HS2 HRA/AA. The salt karst is a SSSI feature does not require consideration under the HRA/AA process but would need to be considered when impacts on the SSSI are being looked at. **Sensitivities to air pollution** The Air Pollution Information System (APIS) does not include site specific information for Ramsar sites. Searching for Rostherne Mere SSSI only returns information for duck species feature. In the absence of specific site information for the habitat features at Rostherne we recommend the use of data within the APIS Habitat/Pollutant impact Database. Information on Sensitivities and critical loads (where available) should be used for the following habitat types; • Fen, marsh and swamp • Standing Open water and Canals It is difficult to specify appropriate critical load/levels for standing open waters and the approach generally taken is to apply the relevant loads/levels from associated terrestrial habitat so in the case of Rostherne Mere those relevant to Fen, marsh and swamp should be used when assessing impact. **Grassland Management at Rostherne Mere NNR** This should be read in conjunction with the compartment map attached at the end of this advice.

<table>
<tr><th colspan="2">HS2/NE Work Request Response</th></tr>
<tr><td></td><td>In summary, NE has permitted low levels of grazing between approx. 7 April and 31 Oct on the fields surrounding Rostherne Mere SSSI, with no fertiliser inputs. This management is delivered through a supplementary Nature Reserve Agreement, agri-environment scheme prescription or consent.
Further detail is provided below.

Supplementary Nature Reserve Agreement areas – compartments 24, 4, 3 and part of 2.
Grazing between 1 May to end September only.
Low stocking May to June. Low stocking is generally considered to be 0.6 Lu/ha.
Increased in grazing levels July until September – higher stocking rate of 2 Lu/ha.
If heifers are grazed (heifers up to 2 years of age) these are considered to be 0.6 Lu/ha.

Compartments 2, 1, 25, 22 and 21 – these compartments have the same landowner as above, but are not in the supplementary NRA. Grazing may be at higher levels and for a longer period than specified. Grazing management is being discussed with this owner. We would only consent grazing at the levels and timings above, with no fertiliser inputs.

HLS Agreement AG00458797 - Compartments 5, 6, 7, 11, 12, 13, 14, 15 and 16
Option HK15 Maintenance of grassland for target features:
From year 1 onwards, manage the sward by grazing between 7 April and 31 October or cutting to achieve a sward height of between 5cm and 15cm during April and May (unless the land has been shut for hay) and between 5cm and 15cm in November.
Remove livestock between 1 November and 6 April.
Do not cut hay or silage before 15 July, always leaving at least 10% uncut in any one year (which need not be the same 10% each year). All cuttings that could damage the sward must be removed.
Do not apply fertilisers, organic manures or waste materials (including sewage sludge)

Consent 240216 - Compartments 17, 18, 19, 20
Low intensity grazing with cattle or sheep from 7th April to 31st October, to achieve sward height of 5cm – 15cm throughout the growing season.
No application of fertilisers, organic manures or waste materials.</td></tr>
<tr><td>Deadline of response</td><td>Tuesday 12th February 2019 for clarification of Ramsar qualifying features and NNR land management agreements. Tuesday 19th February for information on sensitivity of the final list of qualifying features to nitrogen deposition and increased acidity.</td></tr>
<tr><td>Nature of response: e.g. Meeting (telephone/face to face), formal/informal advice, site visit</td><td>Formal advice (follow up meeting may be necessary).</td></tr>
<tr><td>NE contact
(if known)</td><td>Chris Hogarth</td></tr>
</table>

Annex B: Rostherne Mere and The Mere, Mere – Impact of cuttings on the water environment and ecology

Contents

Tables

Figures

1 Summary

1.1 Rostherne Mere site summary

1.1.1 Rostherne Mere Ramsar site and Site of Special Scientific Interest (SSSI) is a natural eutrophic lake, occupying a depression in the topography approximately 5km north of Knutsford in Cheshire. Rostherne Mere is one of many meres located in the Cheshire and north Shropshire area.

1.1.2 Rostherne Mere Ramsar site and SSSI is located in the catchment of the River Bollin just to the south of the M56. The Proposed Scheme is in cuttings in the area between Rostherne Mere and the M56 in the Hulseheath to Manchester Airport area (MA06) and also in the catchment area upstream of Rostherne Mere and to the west of The Mere, Mere SSSI (which forms part of the Manchester Meres and Mosses – Phase 1 Ramsar site) in the Pickmere to Agden and Hulseheath area (MA03).

1.1.3 The purpose of this current Technical note is to:

- provide an assessment of the potential impact of drainage in the cuttings on water resources in and around Rostherne Mere and The Mere, Mere, including water levels in Rostherne Mere;
- use the results of the water resources assessment to determine the potential impact of the Proposed Scheme on the ecology of Rostherne Mere;
- provide technical information on the hydrology and ecology of the sites to supplement Habitats Regulations Assessments of the potential impacts of the construction of the Proposed Scheme; and
- discuss mitigation measures which might, if needed, be implemented in the catchment.

1.1.4 This Technical note includes the assessment of the flow monitoring data for 2018 and the discussion of the hydrological conditions in the catchment. The water resources assessment approach is used to assess the potential impacts for conditions in 2018, a reasonably dry year and also in very dry or drought conditions as occurred in 1976 and 1996. In these years, flows in the catchment and mere water levels are likely to have been particularly low.

1.1.5 A detailed assessment of the hydrogeology is also presented for the area of the cuttings to the north of Rostherne Mere. The assessment is based mainly on information from existing borehole logs and water level monitoring data from a highway construction site investigation in 1991[1].

1.1.6 Discussion of the potential impact on The Mere, Mere of cuttings to the west of The Mere, Mere is included. The Mere, Mere comprises two waterbodies: The Mere and Little Mere,

[1] British Geological Society (2021), *Borehole records*. Available online at: https://www.bgs.ac.uk/information-hub/borehole-records/.

which are contiguous and separated by a bund. It is uncertain whether there could be any impact from the Proposed Scheme on The Mere, Mere as a whole, or just on Little Mere, the part of the site which is closest to the Proposed Scheme. However, a very approximate assessment is provided of the theoretical maximum limit for the impact of the Proposed Scheme cuttings on the water level in Little Mere. This theoretical value would be substantially greater than any impact which may occur and there may actually be no impact at all.

1.1.7 Any changes to catchment hydrology may affect the ecology of Rostherne Mere and The Mere, Mere, including the protected habitat features and associated species. Sections on the aquatic ecology of Rostherne Mere describe the data made available for the study by the Environment Agency and Natural England, and the results of a vegetation survey carried out on behalf of HS2 Ltd in 2019[2]. The assessment of the potential impact due to the cuttings on the water levels on the aquatic ecology and the water dependent flora and fauna in and around Rostherne Mere is included in this report.

1.1.8 Data on the ecology of The Mere, Mere has been provided by the Environment Agency and a summary of the data is included in this Technical note. A vegetation survey was carried out in August 2020 to provide additional details to supplement the ecology data. A detailed assessment of the ecology data is provided in the Document to inform a Habitats Regulations Assessment for Rostherne Mere Ramsar site and Midland Meres and Mosses Phase 1 Ramsar site.

1.1.9 The assessments of the potential impacts of the cuttings on water resources in the catchment and the effects on aquatic ecology for Rostherne Mere lead on to a discussion of possible mitigation. The mitigation could comprise infiltration in recharge trenches or through recharge wells using drainage water from the cuttings.

1.1.10 The need for further monitoring and site investigations is discussed following the technical assessments.

[2] High Speed Two Ltd (2022), High Speed Rail (Crewe – Manchester), *Background Information and Data, Ecological baseline data – National Vegetation Classification and ancient woodland*, BID EC-004-00001. Available online at: http://www.gov.uk/government/collections/hs2-phase-2b-crewe-manchester-environmental-statement.

2 Purpose of this Technical note

2.1 Technical note overview

2.1.1 The purpose of this Technical note is to:

- provide an assessment of the potential impact of the Proposed Scheme on water resources in and around Rostherne Mere and The Mere, Mere including water levels in Rostherne Mere;
- use the results of the water resources assessment in considering the potential effect of the Proposed Scheme on the ecology of Rostherne Mere;
- provide technical information on the water resources and ecology to supplement HRA of the potential impacts of the construction of the Proposed Scheme on Rostherne Mere and The Mere, Mere; and
- discuss mitigation measures which might, if needed, be implemented in the catchment.

2.1.2 This Technical note takes into account the Proposed Scheme and includes:

- an assessment of the potential impacts of the cuttings, located in or close to the Rostherne Mere catchment, on water resources in the catchment. This includes a water balance approach to the assessment of the potential impacts on water levels in Rostherne Mere, together with the analysis of geological logs and groundwater level data from existing borehole records;
- discussion of the potential impact on The Mere, Mere of the cuttings located to the west of The Mere, Mere, namely Hoo Green north and Hoo Green south cuttings. These are referred to in this Technical note as the Hoo Green cuttings;
- a very approximate calculation of the theoretical limit of impact of the Hoo Green cuttings on the water level in Little Mere, the part of The Mere, Mere site located closest to the cuttings in the Rostherne Mere catchment;
- discussion and analysis of baseline ecological data obtained from the Environment Agency, Natural England and on behalf of HS2 Ltd;
- an assessment of the ecological tolerances of and potential impact on habitats and species relevant to the designation of Rostherne Mere Ramsar site and SSSI;
- outline plans for the mitigation proposed in relation to Rostherne Mere and The Mere, Mere, in the event that mitigation is required; and
- monitoring proposals for water resources and ecology.

2.1.3 The Technical note also takes account of:

- comments received from Natural England and the Environment Agency; and
- information provided by local parish councillors at a meeting with HS2 Ltd on 2 August 2019 and in a subsequent telephone conversation with one of the councillors.

3 Site setting for the Rostherne Mere catchment

3.1 Topography and drainage

3.1.1 Rostherne Mere is located in the catchment of the River Bollin. It is a natural eutrophic lake, occupying a depression in the topography about 5km north of Knutsford in Cheshire. Rostherne Mere extends over an area of approximately 46 hectares (ha) and has a maximum depth of approximately 35m. The outflow from the mere discharges to Blackburn's Brook which contributes to Birkin Brook near the M56. Birkin Brook joins the River Bollin to the north of the M56. Rostherne Mere is one of many meres located in the Cheshire and north Shropshire area.

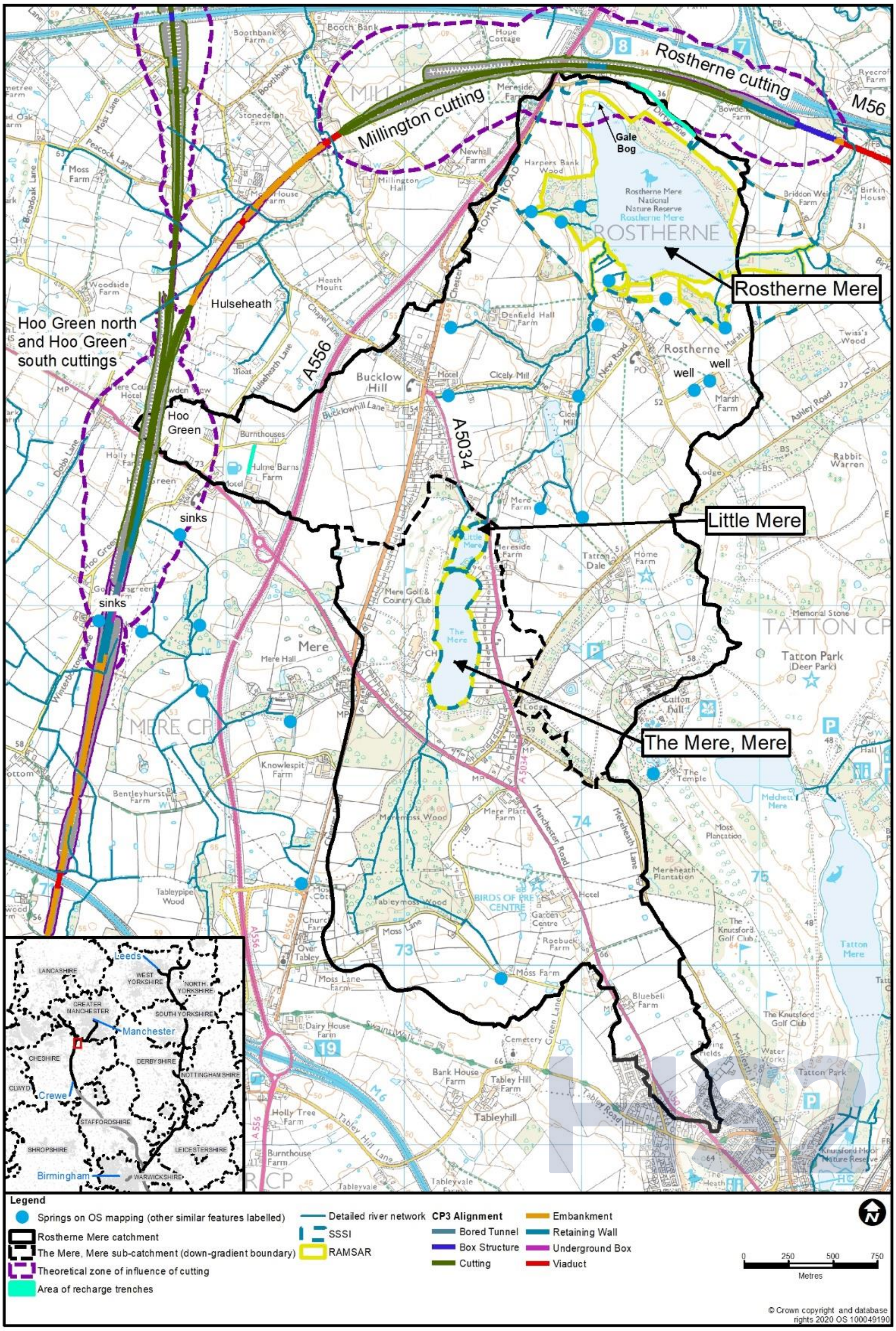
3.1.2 Figure B1 shows the Rostherne Mere surface water catchment based on topography, the route of the Proposed Scheme and construction features. The total catchment area to the outflow from Rostherne Mere is approximately 10km^2.

3.1.3 The Rostherne Mere SSSI and Ramsar site is located further downstream in the same catchment as The Mere, Mere SSSI (a constituent of the Midland Meres and Mosses Phase 1 Ramsar Site). Rostherne Mere and The Mere, Mere are connected by Rostherne Brook. Other features of interest for water resources shown on the map in Figure B1 comprise:

- springs shown on Ordnance Survey (OS) topographical mapping at 1:25 000 or more detailed scales. Note that some other groundwater-related features such as wells and sinks are shown with the same symbol (blue circle) on the map. Several watercourses, many fed by springs from superficial deposits, discharge into Rostherne Brook and the meres; and
- the sub-catchment boundary for The Mere, Mere. The Mere, Mere SSSI comprises two waterbodies, The Mere in the upstream area and Little Mere at the downstream end of the site. The SSSI citation indicates that Little Mere is separated from The Mere by a spillway.

3.1.4 The catchment boundaries shown on Figure B1 were drawn using ground level contouring at one metre intervals derived using digital terrain modelling and contouring shown on 1:25,000 scale OS mapping. A combination of automated and manual methods were applied in determining the location of the catchment boundaries from the contours.

Figure B1: Rostherne Mere catchment



3.1.5 The catchment includes an elevated outlying area of possible internal surface water drainage to the south of The Mere, Mere and west of Tatton Mere around Bluebell Farm. The area, which varies by only a few metres in elevation, comprises a series of shallow basins. Despite the proximity of Tatton Mere to the east, the area declines overall in elevation to the north. However, there is no watercourse connecting these ponds to The Mere, Mere.

3.2 Description of the Proposed Scheme

3.2.1 The components of the Proposed Scheme in the area of the Rostherne Mere surface water catchment are shown in Figure B1 and are described in Section 2.1 of the Document to inform a Habitats Regulations Assessment for Rostherne Mere Ramsar site and Midland Meres and Mosses Phase 1 Ramsar site. This assessment will focus on the following components:

- the Hoo Green cuttings on the HS2 West Coast Main Line (WCML) connection and the HS2 Manchester spur to the west of The Mere, Mere. These are the Hoo Green South cutting retaining wall, Hoo Green box structure, Hoo Green tunnel, Hoo Green North cutting retaining wall and the Hoo Green North cutting (hereafter known as Hoo Green cuttings). The retaining walls, box structure and tunnel extend over substantial lengths just to the south of the Rostherne Mere catchment. However, within the Rostherne Mere surface water catchment, the Hoo Green North cutting is an open cutting with a maximum depth of approximately 13.7m (from the current ground level to the base of cutting drainage) in the catchment. The Hoo Green North cutting on the HS2 WCML connection deepens further to the north to a maximum depth of approximately 23.8m. However, this increased depth of the cutting occurs approximately 2km from the Rostherne Mere catchment;
- the HS2 Manchester spur between the Hoo Green cuttings and the Millington and Rostherne cuttings comprises embankments with two short viaducts;
- parts of the Millington and Rostherne cuttings on the HS2 Manchester spur are located near to Rostherne Mere. At its closest location, Millington and Rostherne cuttings are approximately 170m to the north of Rostherne Mere Ramsar site. The cuttings have a maximum depth of approximately 13m (to the base of cutting drainage);
- the A556 Chester Road overbridge is to be constructed close to the eastern end of the Millington cutting, at the northern tip of the Rostherne Mere surface water catchment. The section of cutting beneath the bridge is approximately 40m long. Piling will be required to support the overbridge;
- the Rostherne and Millington cuttings are located either side of a partly retained cut (the Rostherne cutting retaining wall west), with a length of approximately 110m. The retaining wall is supported by piles and is located on the north side of the cutting, close to an existing slip road between the M56 and A556 Chester Road. The south side of this section of the cutting is an open cut;

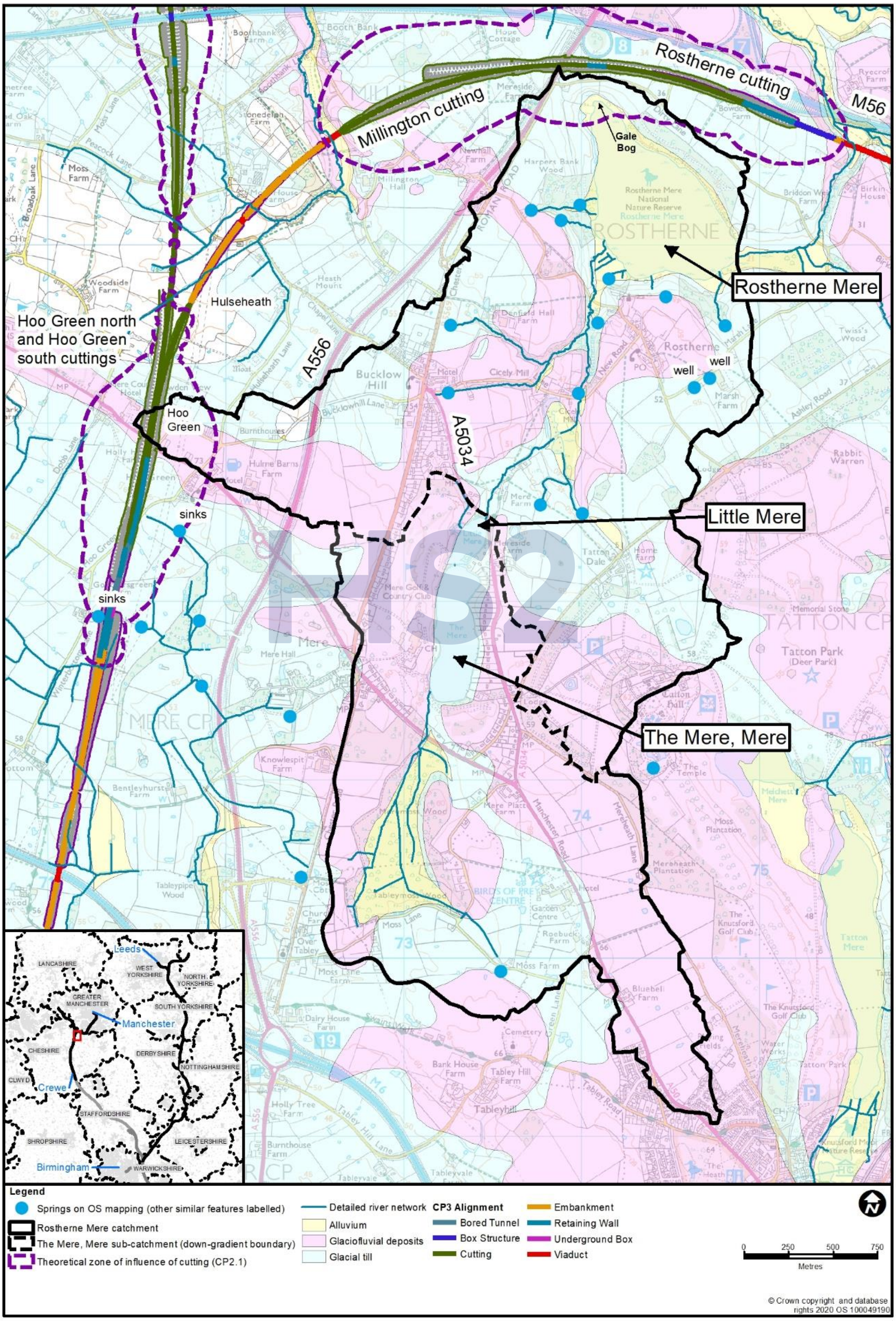
- a retaining wall (the Rostherne cutting retaining wall east) is also located in the cutting to the north east of Rostherne Mere near Bowden Farm. With the exception of the overbridge and retaining wall sections, both sides of the Millington and Rostherne cuttings are in open cut throughout;
- the Rostherne cutting retaining wall east connects to a box structure and embankment on the west side of the Blackburn's Brook viaduct crossing; and
- two sealed carrier drainage pipes and connecting manholes have been included below the Rostherne cutting and filter drainage, to convey drainage water to a discharge point on Blackburn's Brook.

3.2.2 In terms of impacts on groundwater, the sections of the Proposed Scheme in cuttings are of main interest for this assessment. If the depth to the water table is above the base of cutting drainage, the discharge of groundwater to the cutting would give rise to a reduction in groundwater levels over the area surrounding the cutting.

3.3 Geology, springs and groundwater

3.3.1 The superficial geology of the Rostherne Mere catchment comprises mainly glacial till and glaciofluvial deposits (sand and gravel), with both formations covering major areas of the catchment. Some alluvium is also present around Rostherne Mere and in other low-lying wetland areas. The superficial geology of the catchment is shown on Figure B2. The glaciofluvial deposits to the north and east of Rostherne Mere are described by the British Geological Survey (BGS) as glaciofluvial sheet deposits. However, both the glaciofluvial deposits in the Rostherne catchment and the glaciofluvial sheet deposits comprise mainly sand and gravel.

Figure B2: Superficial geology of the Rostherne Mere catchment



3.3.2 The Hoo Green cuttings to the west of The Mere, Mere are located in glacial till and glaciofluvial deposits in the Rostherne Mere catchment and are likely to drain groundwater from these formations. The parts of the Hoo Green cuttings which include retaining walls and box structure, located over substantial lengths just to the south of the Rostherne Mere catchment, may also affect groundwater flows and drainage in the area. The cuttings also intercept the Mercia Mudstone Group (MMG) below the superficial deposits in several sections, and in an area to the north west of The Mere, Mere where superficial deposits are absent.

3.3.3 The Rostherne and Millington cuttings are located mainly in glacial till, with a band of glaciofluvial deposits intercepted in the Millington cutting to the north west of the Rostherne Mere catchment. Piling for the A556 Chester Road overbridge will go through the superficial deposits and into the underlying MMG over a length of approximately 40m. The piling will form a barrier in superficial deposits along the section of track beneath the overbridge. For the retained cut to the south of the existing slip road, only a partial retaining wall is likely to be constructed where space is constrained by the slip road.

3.3.4 The substantial number of springs in the Rostherne Mere catchment indicates that groundwater is likely to play a major role in supporting base flows in streams particularly in dry periods and therefore, in maintaining water levels in Rostherne Mere. As a result, it is important to understand the relative contributions to the meres of springs and watercourses particularly during drier months in the period June to September. Many of the springs shown on Figure B1 and Figure B2 are located within the glaciofluvial deposits or close to the contact between the glaciofluvial deposits and the glacial till. Hence, much of the groundwater in the catchment may emanate from sand and gravel deposits.

3.3.5 At Rostherne Mere, the groundwater supplying springs is likely to be located within the relatively shallow superficial deposits comprising sands and gravels or more permeable horizons within glacial till. With shallow groundwater it is reasonable to assume that in many areas, the groundwater catchment coincides approximately with the topographical surface water catchment.

3.3.6 However, if a relatively flat-lying area within the surface water catchment extends out into adjacent surface water catchments, it is possible that the shallow groundwater would drain along shorter groundwater flow paths to the adjacent catchments. The variations in the water table would be expected to form a subdued version of the topography, possibly with groundwater discharge in the directions of overall steeper gradients in adjacent catchments. One example is likely to be the elevated drainage area which forms part of the Rostherne Mere catchment but is located near Tatton Mere, discussed in Section 3.1. In this case, some of the groundwater may drain either to the Tatton Mere catchment to the east, or possibly to the Tabley Mere catchment to the south-west, as a result of the steeper topographic gradients in the adjacent catchments.

3.4 Zones of influence of cuttings

3.4.1 Figure B2 shows the likely maximum zones of influence on groundwater from permanent dewatering or drainage in the Millington and Rostherne cuttings to the north of Rostherne Mere and the Hoo Green cuttings to the west of The Mere, Mere. Assessments of the likely maximum zones of influence from dewatering of cuttings have been made using Sichardt's formula. The methodology is set out in the Environmental Impact Assessment Scope and Methodology Report (SMR) (see Volume 5: Appendix CT-001-00001). For the assessments, cuttings are assumed to be open throughout. Permanent below-ground engineering works, such as retaining walls, are not taken into account and as such the zone of influence is considered to be a conservative assessment.

3.4.2 Based on the assumptions made in the calculations, including the assumption that groundwater levels are at current ground level, the zones of influence are likely to be overestimated. If actual groundwater level data and permeability information was available, the drawdown in the cuttings and in turn, the zones of influence, might be reduced significantly. However, this precautionary approach, giving likely maximum zones of influence, is considered appropriate for this stage of the assessment.

3.4.3 Figure B2 indicates that the zone of influence for the Millington and Rostherne cuttings includes the area in the north of the Rostherne Mere catchment between the cuttings and Rostherne Mere. The zone of influence takes into account the elevation of the base of the filter drainage system, comprising trenches which are open at the surface and backfilled with filter material, located below the base of the cuttings. The lowest point in the open filter drainage system in the Millington and Rostherne cuttings is approximately 24.8 metres above ordnance datum (mAOD). Gale Bog, an area of wet woodland and swamp in the north of the Rostherne Mere Ramsar site shown on Figure B1, is at an elevation of about 21mAOD. As this is below the lowest possible level of dewatering in the cutting (24.8mAOD), in practice the zone of influence of the cuttings could not extend as far as Gale Bog or the open water of Rostherne Mere.

3.4.4 The zone of influence for the Hoo Green cuttings includes an area of the Rostherne Mere catchment which extends out to the west and across a part of the route of the Proposed Scheme. However, the zone of influence is located outside the sub-catchment of The Mere, Mere.

3.5 Existing hydrological information

3.5.1 During the site visit in May 2018, Natural England indicated that the Environment Agency has carried out spot flow gauging by current meter on Rostherne Brook upstream of the Rostherne Mere and on Blackburn's Brook downstream of the Rostherne Mere. During the July 2018 visit, a gauge board was found on the Cherry Tree Lane bridge arch over

Blackburn's Brook indicating that level readings and possibly flow measurements have been made there at some time.

3.5.2 Natural England staff indicated they have never been aware of inflows in Rostherne Brook or outflows in Blackburn's Brook drying up. The current warden has been on site since 2009 but also knew the warden who had been on site in the severe drought in 1976. When contacted, the previous warden could not confirm whether or not inflows or outflows to and from Rostherne Mere had dried up in 1976. However, he thought that, had the Rostherne Brook inflow dried up in 1976, he would have been made aware of this by residents in Rostherne village.

3.5.3 A meeting was held with local councillors on 2 August 2019. In this meeting, a local councillor of the Rostherne parish council who farms land adjacent to Blackburn's Brook showed a video recorded in the past week of flow reversal in Blackburn's Brook taken from the bridge on Cherry Tree Lane. The video showed a strong flow of brown, sediment-laden water, probably several cubic metres per second, towards Rostherne Mere.

3.5.4 In a subsequent telephone call[3], the local councillor stated the flow reversal had lasted for approximately three days. There had also been a further flow reversal in August 2019, making a total of three such events up to that time in 2019. He indicated that the flow reversals occur as a result of water levels rising by several feet in Birkin Brook further downstream. He also indicated that he had never seen Blackburn's Brook dry up or to have no flow in it. This included the drought year 1976 when he had been working during the summer at the farm on Rostherne/Cherry Tree Lane.

3.5.5 In response to a request for data from HS2 Ltd, the Environment Agency provided spot flow data taken in Blackburn's Brook on a total of seven occasions in 1991, 1995, 1996, 2006 and 2007. The data is shown in Table B1. The grid references for the flow monitoring indicate that the measurements were carried out at sites upstream and within approximately 60m of the Cherry Tree Lane bridge over Blackburn's Brook.

Table B1: Environment Agency flow data - Blackburn's Brook

Date	Location	Flow (l/s)	Area of flow (m^2)	Average velocity (m/s)
08/6/2007	375250 383950	56	0.47	0.12
17/08/2006		38	0.30	0.13
26/9/1996		32	0.37	0.09
21/6/1996		42	0.37	0.12
30/08/1995		12	0.19	0.06
28/08/1991	375300 384100	26	0.32	0.08
21/08/1991		14	0.38	0.04

[3] Personal communication, 7th August 2019.

3.5.6 Natural England also indicated that water level records for Rostherne Mere might extend back to the 1970s, although the previous site warden did not have any of the records. However, he did provide some information on the management of Blackburn's Brook up to 1988, as well as on periods in which a reversal in flow has been seen in Blackburn's Brook.

3.5.7 Although not a complete record, the information indicates that this unusual phenomenon, with flow temporarily reversed towards rather than draining out of Rostherne Mere, occurred in many years in the main period of record from 1972 to 1992. Flow reversal was noted on five occasions in 1981, the maximum number recorded in a single year.

3.5.8 Gauging station data for the River Bollin catchment indicates that these flow reversals coincided with periods of high flow elsewhere in the catchment.

3.6 Water dependent ecology

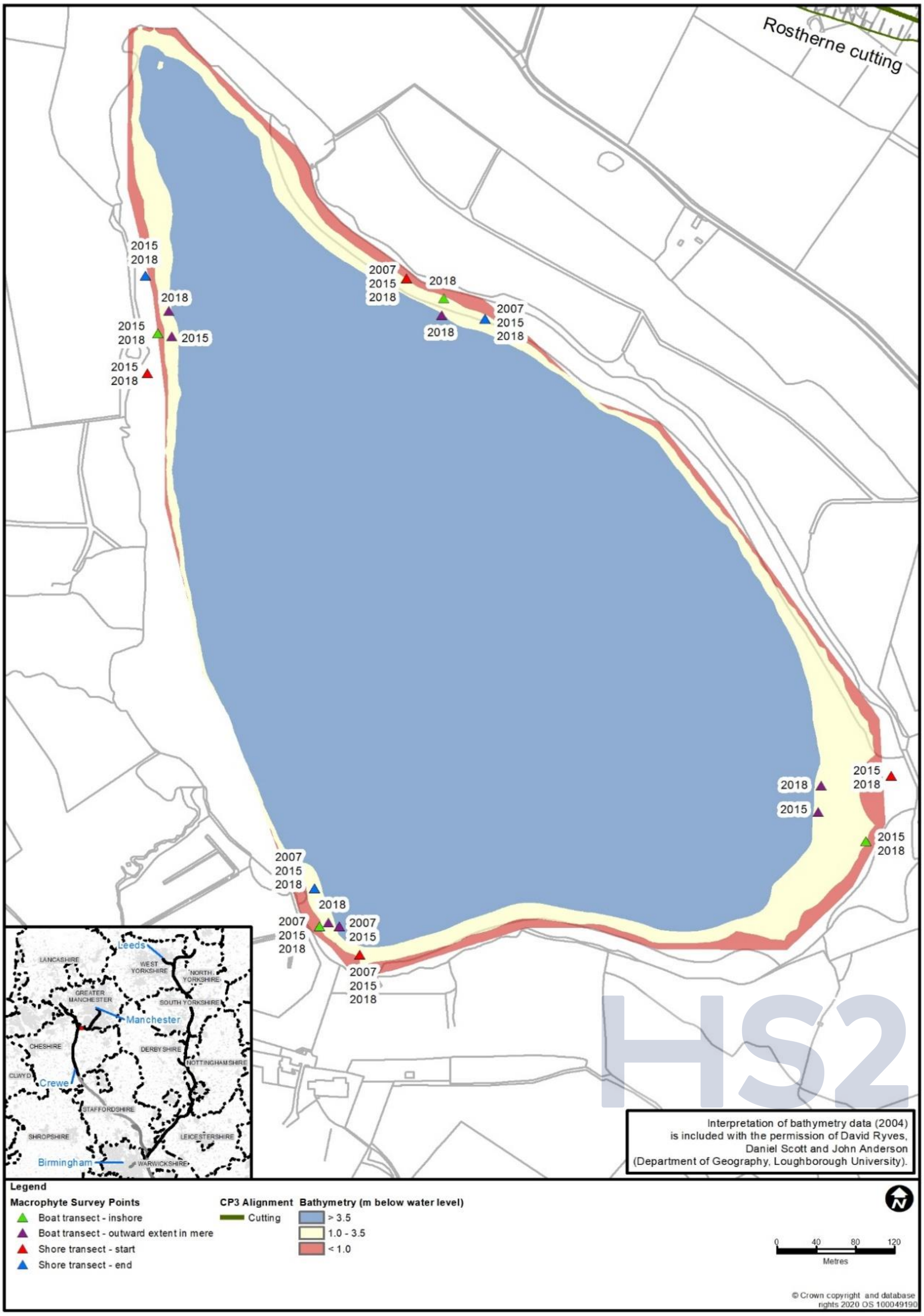
Existing ecological and related data

3.6.1 The Environment Agency provided several datasets relating to Rostherne Mere as detailed in Table B2. Summaries of Environment Agency macrophyte and macroinvertebrate data are included in Appendix A. The location of macrophyte survey transects are shown in Figure B3.

Table B2: Rostherne Mere - ecological and chemical datasets

Waterbody	Data/survey type	Years of survey
Rostherne Mere	Macrophytes	2007, 2015, 2018
Rostherne Mere	Diatoms	Annual, 2007 to 2016
Rostherne Mere	Macroinvertebrates (family)	Spring/summer/autumn 2004, spring 2009
Rostherne Mere	Surface water quality data	2012 to 2019
Rostherne Brook	Macrophytes	2014

Figure B3: Rostherne Mere – location of macrophyte surveys



3.6.2 Natural England appointed JBA Consulting to carry out a comprehensive National Vegetation Classification (NVC) survey of the habitats at Rostherne Mere to provide an accurate baseline of current terrestrial and marginal wetland vegetation communities, and to inform future reserve management[4]. The results have been used to:

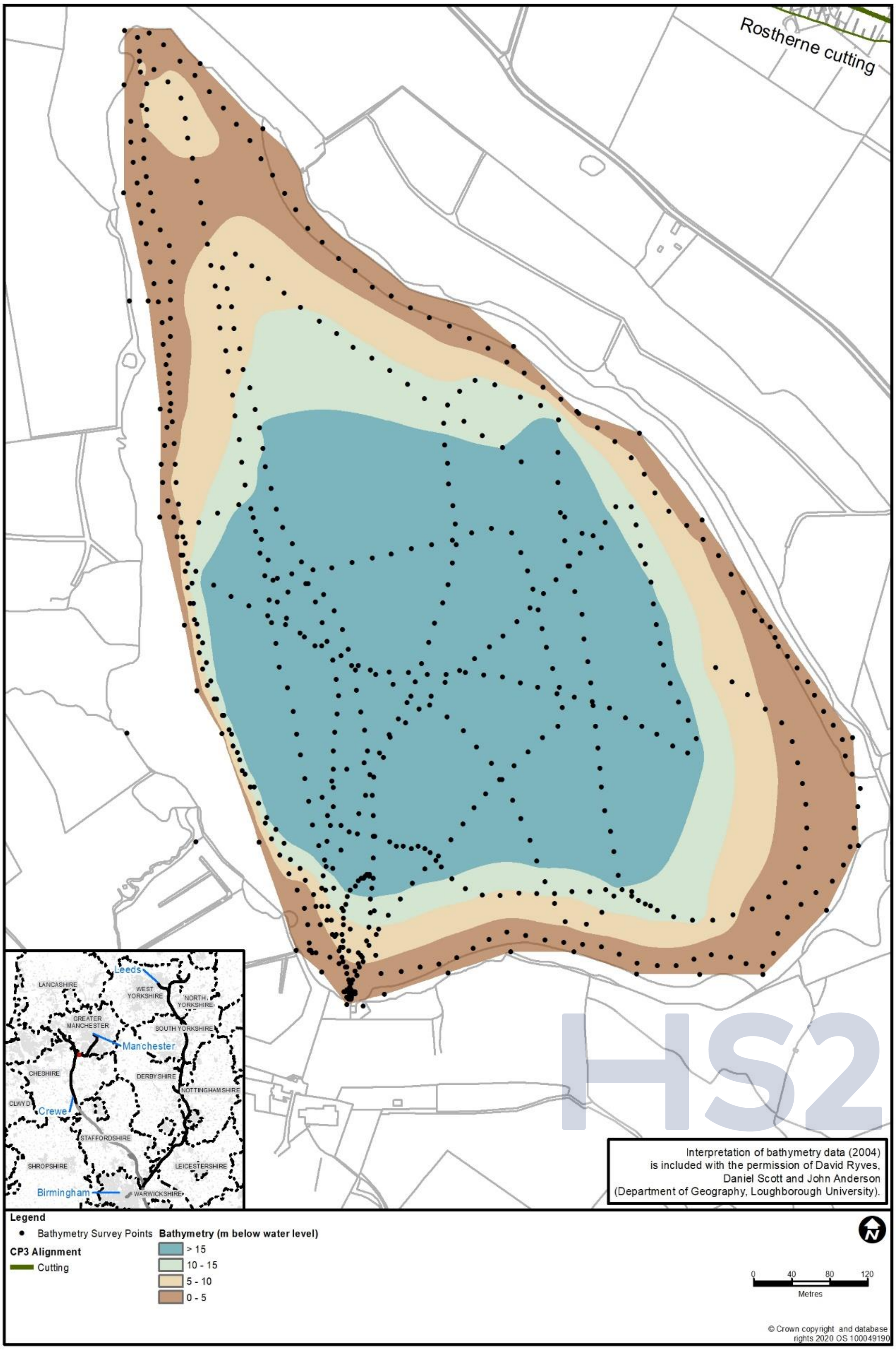
- corroborate findings of surveys carried out on behalf of HS2 Ltd in July 2019[2]; and
- provide data in areas where access constraints meant surveys could not be carried out in 2019.

3.6.3 A bathymetry survey was undertaken for Rostherne Mere in 2004 by the Department of Geography at Loughborough University[5]. Interpretation of the bathymetry data has been included with the permission of Department of Geography, Loughborough University. The depth measurements from the survey were used to determine lake bed topography and the lake bed contours shown in Figure B4.

[4] JBA Consulting (2010), *Rostherne Mere NNR – National Vegetation Classification (NVC), Final Report*.

[5] Department of Geography, Loughborough University (2004), *Rostherne Mere bathymetric survey*.

Figure B4: Rostherne Mere – bathymetry data points



3.6.4 The SSSI citation[6] for The Mere, Mere, which comprises The Mere and Little Mere (see Figure B1), includes some information relating to the condition of these waterbodies and their ecological sensitivities. Data on the ecology of The Mere, Mere has also been provided by the Environment Agency.

Rostherne Mere habitats and designations

3.6.5 Rostherne Mere is a natural eutrophic lake which occupies a natural depression in topography. Eutrophic Standing Waters were listed as a UK Biodiversity Action Plan (UKBAP) Priority Habitat. They continue to be listed as a Habitat of Principal Importance under Section 41 of the Natural Environment and Rural Communities Act 2006. Anthropogenic nutrient inputs are believed to limit the diversity of aquatic vegetation in Rostherne Mere, although a narrow shelf around the lake allows reedswamp to extend around much of the lake perimeter. The waterbody experiences substantial, seasonal variations in water levels.

3.6.6 Rostherne Mere is one of the largest and deepest meres in Cheshire. It is designated as a Wetland of International Importance (a Ramsar site) and is notified as a SSSI. The SSSI is also designated as a National Nature Reserve (NNR).

3.6.7 The qualifying features of the Ramsar site include the waterbody and its associated fringing reedswamp vegetation. The Ramsar site extends over almost 80ha, encompassing areas of surrounding woodland, although the woodland is not a qualifying feature. In turn, the Ramsar site sits within the larger SSSI (153ha). Qualifying features of the SSSI comprise the waterbody and reedswamp, but also include wintering pintail (*Anas acuta*) and pochard (*Aythya farina*) populations. The SSSI boundary encompasses the surrounding woodlands and also extensive pasture, although none of these areas represent qualifying features.

3.6.8 Rostherne Mere is also a Water Framework Directive (WFD) waterbody[7].

Rostherne Mere condition

3.6.9 Information relating to site designations and Favourable Condition are available within the Favourable Conditions Table (FCT) for designated features of interest supplied by Natural England. Rostherne Mere constitutes a ‘standing water’ habitat type. The specific designated interest features relating to this habitat type are a 'naturally eutrophic lake’ with *Magnopotamion* or *Hydrocharition*-type vegetation, including fen, marsh and swamp as a fringing element (NVC communities S4, S13, S26), and aggregation of pintail and pochard.

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[6] Natural England (1985), *SSSI Citation of The Mere, Mere*. Available online at: https://designatedsites.naturalengland.org.uk/PDFsForWeb/Citation/1001818.pdf.

[7] Environment Agency (2017), *The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017 (SI 2017 No. 407)*.

3.6.10 The SSSI unit which includes the mere is classed as being in the condition of 'Unfavourable – no change'[8]. The classification is attributed to suppression of aquatic macrophyte diversity through excessive phosphorus loading, and encroachment of the non-native aquatic plant Canadian pondweed (*Elodea canadensis*). The excessive nutrients give rise to blooms of blue-green and filamentous algae. Apparent loss of pintail, and reduced numbers of pochard and shoveler (*Spatula clypeata*), are also mentioned in the context of site condition, although the reductions are linked to changes in climate and regional habitat availability.

3.6.11 The FCT indicates that productivity in the mere is dominated by pelagic algae, with macrophytes restricted to relatively marginal areas where depth is no greater than 3.5m. The maximum depth of macrophyte colonisation may be limited by turbidity, itself a consequence of increased pelagic algal growth due to phosphate loading. Figure B4 is based upon a bathymetry survey undertaken in 2004, and divides Rostherne Mere into three ecological zones. These are:

- <1m depth – able to support fringing emergent vegetation such as *Phragmites australis*, comprising approximately 4.5% of the mere;
- 1m to 3.5m deep – could, potentially, be colonised by submerged macrophytes, approximately 10% of the mere; and
- >3.5m deep – macrophytes generally absent, with production dominated by pelagic algae, comprising approximately 85% of the mere.

3.6.12 The 2010 NVC report[4] describes the main body of water at Rostherne Mere as 'extremely species-poor'. No floating or submerged macrophyte species were observed directly or retrieved by grapnel, with the exception of a large quantity of filamentous algae in the south-west corner of the mere. The lack of macrophyte species is attributed to a combination of lake depth and poor water quality, for which the presence of blue-green algal blooms provided additional evidence.

3.6.13 Macrophyte surveys were commissioned on Rostherne Mere by the Environment Agency in 2007, 2012, 2015, and 2018, although the 2012 data were not available when preparing this Technical note. The survey data shows a consistently species-poor aquatic macrophyte flora. Between four and six 'aquatic' species were recorded in each survey for which data was available.

3.6.14 The surveys also provide an indication of turbidity as at least one measurement of secchi depth was required for each survey. The maximum depth of macrophyte colonisation was also observed. Secchi depths of between 0.75m and 1.31m were recorded in 2015 and 2018, as shown in Table B3, indicating a moderate level of turbidity. Macrophytes were observed to colonise depths of up to 3.5m (see FCT), indicating light penetration at this depth for at

[8] Natural England (1984), *SSSI Citation Rostherne Mere.* Available online at: https://designatedsites.naturalengland.org.uk/UnitDetail.aspx?UnitId=1020554&SiteCode=S1003353&SiteName=rostherne&countyCode=&responsiblePerson=.

least part of the year. However, with lake depths of up to 35m, macrophyte growth is still limited to the marginal areas of the lake.

Table B3: Secchi depth and maximum depth of macrophyte colonisation

Year	Number of sections	Secchi depth (m)	Maximum depth of colonisation (m)
2018	4	1.31	2.60
		1.31	2.50
		1.31	2.70
		1.31	2.30
2015	3	0.75	2.50
		0.80	3.00
		0.80	1.10
2007	1	Not recorded	1.50

3.6.15 The 2010 NVC report[4] describes the margins of Rostherne Mere as supporting a 'good range of swamp, mire, and wet woodland communities'. These were mostly represented by *Phragmites australis*-dominated communities (S4, S24, S25, S26), though lesser reedmace *Typha angustifolia* (S13), and sweet flag *Acorus calamus* (S15) communities were also present. The *Phragmites australis*-dominated communities are described as being especially dense in the eastern and south eastern parts of the mere and extending into the mere for tens of metres. The FCT contains an estimate of 3.3ha for the area occupied by marginal reedswamp.

3.6.16 The current overall and element-level status classifications for the Rostherne Mere WFD waterbody[9] are included in Table B4, indicating that the overall classification for the waterbody is 'Bad'. This is due to the 'Bad Ecological Status', reflecting the failure of both biological and physico-chemical quality elements. The classifications are consistent with the view that excessive phosphate loading has directly influenced macrophyte and algal communities, consequently impacting dissolved oxygen levels. The WFD classifications also suggest that the current hydrological and morphological condition of the lake should support natural communities in the absence of this nutrient pressure.

Table B4: WFD 2015 current status classification and 2019 status data for Rostherne Mere

Classification item	2015 current status	2019 data
Overall water body	Bad	Bad
Ecological	Bad	Bad
Biological quality elements	Bad	Bad

[9] Environment Agency (2021), *Catchment data explorer*. Available online at: https://environment.data.gov.uk/catchment-planning/.

Classification item	2015 current status	2019 data
Macrophytes and Phytobenthos combined	Bad	Bad
Chironomids (CPET)	Good	Good
Phytoplankton	Moderate	Poor
Hydromorphological supporting elements	Supports good	High
Hydrological Regime	Supports good	High
Morphology	High	High
Physico-chemical quality elements	Moderate	Moderate
Salinity	High	High
Acid Neutralising Capacity	High	High
Ammonia (Phys-Chem)	High	High
Dissolved oxygen	Poor	Poor
Total Phosphorus	Bad	Bad
Specific pollutants	High	-
Chemical	Good	Fail
Priority substances	Good	Good
Other Pollutants	Good	Good
Priority hazardous substances	Good	Fail

The Mere, Mere

3.6.17 The Mere, Mere SSSI citation[6], which includes The Mere and Little Mere, provides some information as to the condition of these waterbodies and their ecological sensitivities. The citation states that the SSSI supports 12 species of submerged macrophyte, the largest number known in any of the Cheshire meres. In common with Rostherne Mere, *Callitriche hermaphroditica* is listed in the citation for The Mere, Mere SSSI. However, the list of submerged macrophytes also include a number of other species which would be expected in a natural eutrophic lake, such as:

- the pondweed *Potamogeton berchtoldii*, perfoliate pondweed (*Potamogeton perfoliatus*), and broad-leaved pondweed (*Potamogeton natans*);
- yellow water-lily (*Nuphar lutea*); and
- stands of emergent vegetation such as *Phragmites australis*, *Typha latifolia* and *Typha angustifolia*.

3.6.18 Of particular note are plants such as six-stamened waterweed (*Elatine hexandra*), and needle spike-rush (*Eleocharis acicularis*), which are often found in marginal habitat such as wet mud and could be sensitive to changes in water level.

3.6.19 The citation also describes the aquatic invertebrate community as diverse, highlighting the presence of the red-eyed damselfly (*Erythromma najas*) which has a restricted distribution in Great Britain.

3.6.20 The information on ecology received from Environment Agency includes data for:

- chironomidae (surveys in 2006, 2007, 2015 and 2018);
- diatoms (surveys for 2007 to 2018);
- macrophytes (surveys in 2008, 2011, 2014 and 2018); and
- phytoplankton, zooplankton and water quality (surveys in 2005 to 2008).

3.6.21 The overall WFD status classification for The Mere is 'Poor', and 'Moderate' for Little Mere[9]. The WFD classification indicates that The Mere is considered a shallow lake (mean depth 2.8m). Bathymetry data has not been obtained, although there are some water depths associated with the macrophyte surveys.

3.6.22 As with Rostherne Mere, nutrient enrichment has and continues to be a concern for The Mere, Mere.

4 Surveys and monitoring in 2018/2020

4.1 Introduction

4.1.1 This section includes discussion of the flow monitoring and water levels in Rostherne Mere, in addition to:

- comments on flows in Mere Covert provided by a local parish councillor at the meeting on 2 August 2019;
- reference to Rostherne Mere water levels for July, September and October 2019;
- discussion of data from continuous monitoring of water levels from late October to late November 2019; and
- observations made by Natural England during a visit to the slopes behind Gale Bog on 18 November 2019.

4.1.2 A summary of results of the Rostherne Mere 2019 vegetation survey on behalf of HS2 Ltd[2], is provided, including a brief comparison with findings from the 2010 survey.

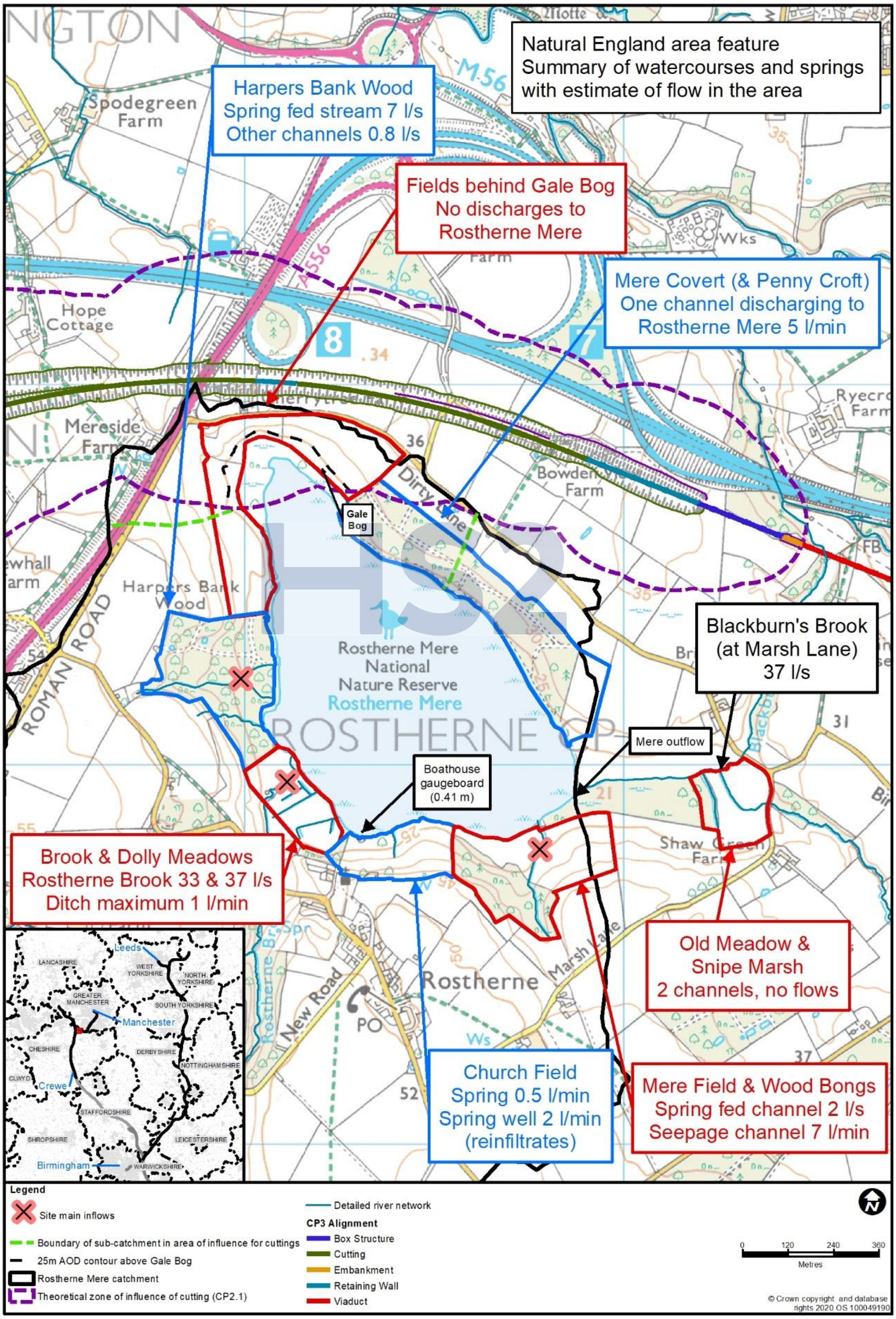
4.1.3 Survey results from the survey of The Mere, Mere in 2020, are also discussed.

4.2 Hydrological monitoring – Rostherne Mere SSSI

Site visits in 2018

4.2.1 An initial site reconnaissance visit on 24 May 2018 was attended by staff from Natural England, the Environment Agency and HS2 Ltd. During the visit, the group made a complete circuit around the mere starting and finishing at the Natural England car park in Rostherne village. The route taken was close enough to the mere shoreline to observe all discharges from streams, springs and seepages, with the exception of a section of approximately 400m in the north-western half of Mere Covert. Figure B5 shows the mere and includes names of woodland, wetland and other features within and around the SSSI.

Figure B5: Rostherne Mere – results of the site visit, 26 July 2018



4.2.2 At the end of the circuit of the mere, Old Meadow and Snipe Marsh were visited to check the watercourses in the downstream area of the SSSI.

4.2.3 During each subsequent visit in 2018, complete circuits were made around the mere, starting and finishing at the Natural England car park. This included the section in Mere Covert which was not covered on the visit in May 2018. In addition, there was more time available to check thoroughly all areas of the route around the mere and improve on some of the very approximate measurements taken on 24 May 2018. The route taken in July, August and September 2018 was close enough to the mere shoreline to observe all discharges from streams, springs and seepages.

4.2.4 On 26 July 2018, the flow in Blackburn's Brook and the channels in Old Meadow and Snipe Marsh were inspected. On 15 August and 7 September 2018, access was not permitted to these sites downstream of the SSSI. As a result, the field team did not proceed with monitoring the flow in Blackburn's Brook, or with inspecting the channels in Old Meadow and Snipe Marsh.

Flow measurement methods

4.2.5 On all visits in 2018 the field team made approximate estimates of larger flows using channel dimension measurements and floats for velocity measurements. The approximate estimates of flow were made at the following locations:

- main inflows to Rostherne Mere:
  - Rostherne Brook close to the mere shoreline in Brook Meadow and also, with the exception of the visit on 24 May 2018, in the tree-lined channel crossing the meadow;
  - the major spring fed channel in Harpers Bank Wood; and
  - the channel in Mere Field fed by spring flow from Wood Bongs.
- outflow from Rostherne Mere:
  - Blackburn's Brook at the Cherry Tree Lane bridge (24 May and 26 July 2018 only).

4.2.6 On the visit on 15 August 2018, the inflows to Rostherne Mere in the three main watercourses were also measured using current metering equipment to give more accurate flow values. Flow measurements by current meter were carried out at the two locations on Rostherne Brook.

4.2.7 On each visit a visual assessment of flows was also made on more than 10 additional small spring fed channels and seepages which discharge into Rostherne Mere around the SSSI. For some of the channels it was also possible to estimate flows by using very approximate channel dimensions and floats for velocity measurements, or from the time to fill a small measuring jug.

4.2.8 During each visit, a reading was also taken from the Rostherne Mere water level gauge board attached to the boathouse. An approximate, although reasonably accurate, level reading was possible on 24 May 2018 as the gauge board needed cleaning. The gauge board was cleaned on 26 July 2018 to allow accurate readings.

4.2.9 The very approximate nature of some of the assessments of minor flow needs to be taken into account when assessing the results. However, the flow values, which are summarised for different areas around Rostherne Mere in Table B5, provide a useful indication of the relative contributions of watercourses, springs and seepages to the mere. In addition to the flow data and analysis presented in Figure B5 and Table B5 shows:

- the areas around Rostherne Mere referred to in Table B5; and
- the results from the monitoring on 26 July 2018, which included a complete round of inflows to Rostherne Mere and an estimate for Blackburn's Brook.

4.2.10 For larger flows, field assessments were made in litres per second (l/s). For many of the small flows and seepages, the assessments were made in litres per minute (l/m) and then converted to l/s for the analysis presented in Table B5.

4.2.11 In Table B5 there is reference to an ochrous spring in Harpers Bank Wood. Water from this spring deposits a distinctive orange (ochrous) material, presumably an iron compound, in the spring discharge channel. The reason for the ochrous colour at this particular location is not known. It was not seen in any other discharge around Rostherne Mere.

Table B5: Rostherne Mere – estimated flows for watercourses, springs and seepages (2018)

Location	Method	Flow estimates								Comments
		Litres/minute				Litres/second				
		24 May	26 Jul	15 Aug	7 Sep	24 May	26 Jul	15 Aug	7 Sep	
Church Field										
Spring well	Approx.	1	2	2	2	0.02	0.03	0.03	0.03	Reinfiltrates in field
Spring/ watercourse	Approx.	1	0.5	2	1	0.02	0.01	0.03	0.01	
Dolls Meadows										
Seepages	Approx.	2	0.5-1	6	5	0.03	0.01	0.10	0.08	
Rostherne Brook (estimates)										
Upstream tree lined section	Approx.	-	-	-	-	-	33	-	31	Flow estimated at both sites on 26-July and 07-September, estimated at one site and gauged at both sites on 15-August
	Meter	-	-	-	-	-	-	35	-	
Downstream, in meadow	Approx.	-	-	-	-	50	37	36	33	
	Meter	-	-	-	-	-	-	33	-	
	Current metering/approximate estimate (%)							91%	-	
Average		-	-	-	-	50	35	34	32	

Location	Method	Flow estimates								Comments
		Litres/minute				Litres/second				
		24 May	26 Jul	15 Aug	7 Sep	24 May	26 Jul	15 Aug	7 Sep	
Harper Bank Wood										
Main ditch (below ochrous spring)	Approx.	-	-	-	-	10	7	3	3	
	Meter	-	-	-	-	-	-	4	-	
Other ditches		7	-	9	-	0.1	0.8	0.2	0.2	
Fields behind Gale Bog										
Seepages	Approx.	<2	0.5	0	-	0.03	0.01	0	0	Reinfiltrates in field (26 July)
Mere Covert										
Central channel	Approx.	<5	5	1.5	7	0.1	0.1	0.03	0.1	
Other seepages	Approx.	-	0	0	0	-	0	0	0	
Wood Bongs										
Spring fed stream below Wood Bongs	Approx.	-	-	-	-	4	2	-	4	Approximately flow not estimated on 15 August
	Meter	-	-	-	-	-	-	3	-	
Channel below Wood Bongs	Approx.	-	7	7	10	-	0.1	0.1	0.2	Channel not seen on 24 May
Total inflow – Rostherne Mere (estimates)						64	45	41	39	
Inflow to Rostherne Mere from behind Gale Bog and Mere Covert		<7	5	1.5	-	0.1	0.1	0.03	0.11	
		As % of total inflow to mere				0.1%	0.2%	0.1%	0.3%	
Old Meadow and Snipe Marsh	Approx.	-	0	-	-	0.5	0	-	-	No visit possible 15 August and 7 September
Outflow – Rostherne Mere (estimates)										
Blackburn's Brook	Approx.	-	-	-	-	80	37	-	-	No estimate possible 15 August and 7 September
Rostherne Mere – Gaugeboard level (m)						0.55	0.41	0.42	0.48	24 May approximate reading

Accuracy of flow monitoring

4.2.12 The approximate assessments of flows, including the assessment of the three main inflows and the outflow from the mere, are more accurate for the later visits in July, August and September 2018 than for the initial group reconnaissance visit on 24 May 2018. More time was available for the assessments on the later visits. The accuracy of the assessments was also improved by:

- the approximate measurement of flows at two locations on Rostherne Brook on 26 July and 7 September 2018;
- current metering on the three main inflows to Rostherne Mere on 15 August 2018. Current metering included two sets of measurements on Rostherne Brook at approximately the same locations as for the assessments on 26 July and 7 September 2018; and
- use of a measuring jug for timing some small discharges on 26 July, 15 August and 7 September 2018.

4.2.13 The following is noted from the flow measurements for Rostherne Brook included in Table B5:

- there was reasonable consistency between the two flow estimates made on 26 July (33l/s and 37l/s) and on 7 September 2018 (31l/s and 33l/s);
- there was consistency between the two measurements using current metering on 15 August 2018 (33l/s and 35l/s). Ten flow velocity measurements were taken in the upstream section, and seven measurements in the downstream section. These numbers of readings would be expected to produce quite accurate measurements of flow overall; and
- there was a 9% difference between the flow measurement by current metering and the flow estimate using channel dimensions and floats at the downstream location close to the mere shoreline in Brook Meadow on 15 August 2018.

4.2.14 The reasonable consistency between the flow estimate and flow measurements for Rostherne Brook on 15 August 2018 adds confidence regarding the accuracy of flow estimation in July and September 2018. There is also reasonable consistency between the flow estimate and flow measurements for the main channel below the ochrous spring in Harpers Bank Wood on 15 August 2018, as indicated in Table B5.

4.2.15 For Blackburn's Brook, it was not possible to find a reasonably uniform section of the channel for an accurate flow assessment. On 24 May 2018, the flow was estimated only very approximately using dimensions assessed visually and floats for a velocity measurement. The flow was estimated on 26 July 2018 using channel dimension measurements and floats for velocity measurements at the upstream end of the culvert beneath the bridge. Although the culvert section was reasonably uniform, flow was concentrated to one side of the channel by rubble and debris in the channel. Hence the estimate for flow is likely to be much less accurate than the estimates for Rostherne Brook.

Analysis of results

4.2.16 The sum of the three main inflows to the mere on 26 July 2018 was 44l/s which is indicated on Figure B5 and in Table B5. The inflows were estimated with channel dimension measurements and floats. The inflow from other minor sources was estimated to be of the order of 1l/s, giving a total inflow to the mere of approximately 45l/s. These figures are of a similar order to the outflow estimate for Blackburn's Brook (37l/s), bearing in mind the potential inaccuracy of the outflow measurements.

4.2.17 However, open water evaporation could be an important additional component of the water balance for the mere in the hot, predominantly dry weather which occurred in the week prior to and during the visit. A typical warm summer with an open water evaporation rate[10] of more than 3mm/d could give rise to average evaporation losses of at least 1,500m^3/d, equivalent to approximately 17l/s, from the open water and reedbed margins totalling approximately 0.5km^2 for Rostherne Mere. Changes in surface water storage in the mere that gives rise to changes in water level could also be a significant additional component of the water balance.

4.2.18 The sum of the three main inflows to the mere was 41l/s on 15 August and 39l/s on 7 September 2018, with inflows to the mere from other minor sources totally approximately 0.4l/s and 0.6l/s. In all monitoring, the three main inflows comprised 98% or more of the total inflow to the mere.

4.2.19 Rostherne Brook provides by far the most important single inflow to Rostherne Mere. Flow in the brook comprised approximately 80% of the total inflow to Rostherne Mere on 26 July, 15 August and 7 September 2018.

4.2.20 The estimate for the total inflow to Rostherne Mere on 26 July 2018 (45l/s) indicates a notable decline from the total of 64l/s for inflow estimated very approximately at the end of May. A decline in total inflow is likely to have resulted from the long dry period and a natural reduction in spring discharges through the early summer months. However, note that flow estimation was carried out more accurately on subsequent visits than during the initial reconnaissance on 24 May 2018.

4.2.21 There was little additional reduction in total inflow between 26 July, 15 August and 7 September 2018. The further declines, from 44l/s to 41l/s and then to 39l/s, were respectively approximately 8% and 12% of the total inflow on 26 July 2018.

Potential impact of Millington and Rostherne cuttings

4.2.22 The theoretical zone of influence for the Millington and Rostherne cuttings includes parts of Gale Bog, the fields behind Gale Bog, the northernmost part of the open water of Rostherne Mere and the northern corner of Mere Covert (see Figure B5). Boundaries to the sub-catchment area below the zone of influence in which groundwater flow is most likely to be affected are also shown on Figure B5. It is possible that groundwater supplying any seepages within or close to this sub-catchment area could be intercepted within the zone of

[10] Met Office (2019), *Hadley Centre observations datasets.* Available online at: https://www.metoffice.gov.uk/hadobs/hadcet/index.html.

influence and would discharge to the drainage in the cuttings. However, seepages in the area of fields to the south of the sub-catchment, located between Gale Bog and Harpers Bank Wood are unlikely to be affected. In addition, springs feeding watercourses in Harpers Bank Wood should not be affected. These springs are located well outside the zone of influence as can be seen in Figure B1.

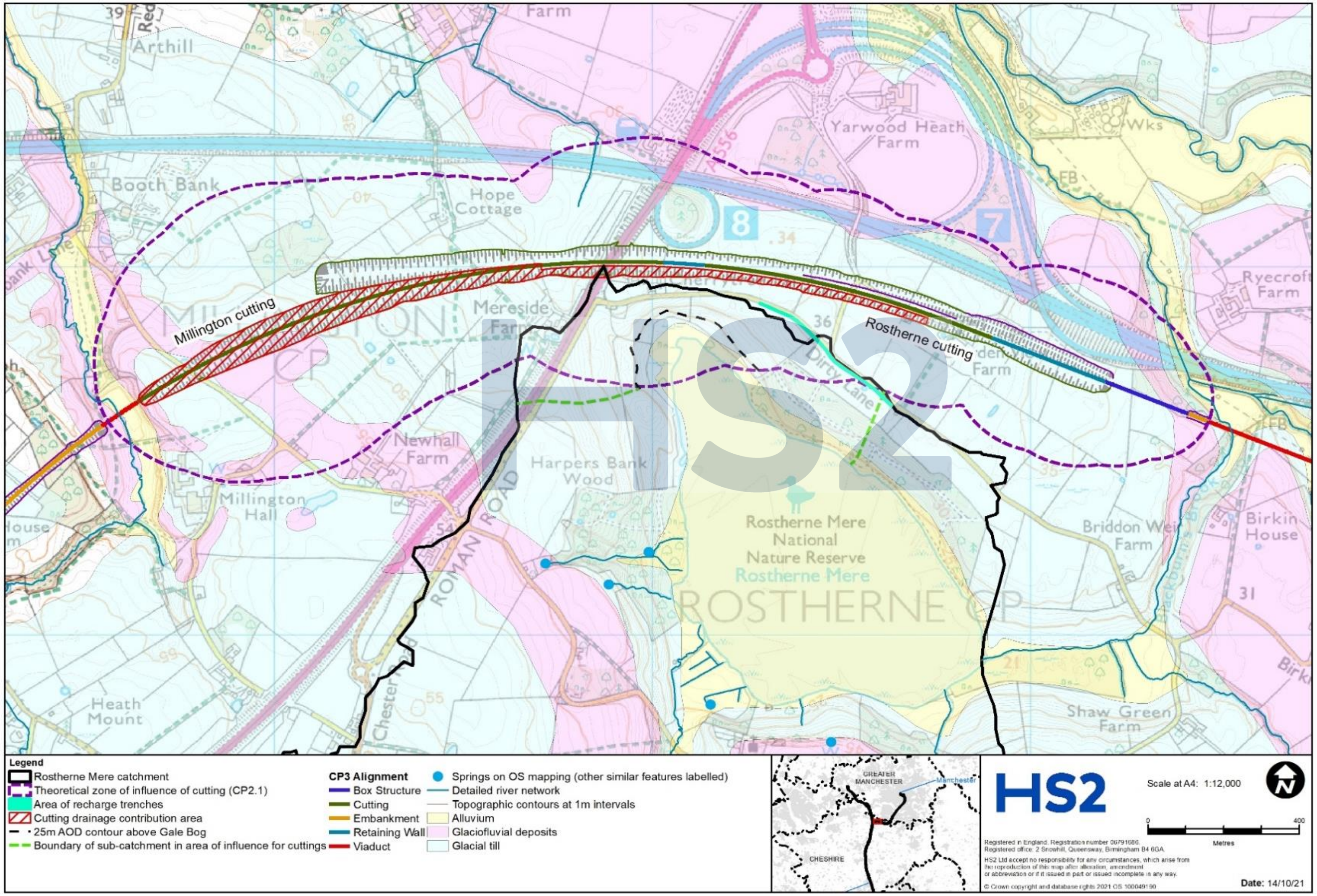
4.2.23 As already indicated in Section 3.3, the lowest level in the open filter drainage system below the tracks in the Millington and Rostherne cuttings is approximately 24.8mAOD, with Gale Bog at an elevation of approximately 21mAOD. As Gale Bog is below the lowest possible level of dewatering in the cutting, in practice the zone of influence of the cuttings could not extend as far as Gale Bog or the open water of Rostherne Mere. The maximum extent of the zone should be at approximately the 25mAOD contour in the fields behind Gale Bog.

4.2.24 The 25mAOD topographic contour is highlighted on Figure B5. The cuttings could intercept groundwater above 24.8mAOD which would otherwise discharge from seepages located between the 25mAOD contour and Rostherne Mere. However, the cuttings could not create a reversal in groundwater flow at or below the level of Rostherne Mere, which might cause water from Rostherne Mere to seep through the bed of the mere and flow towards the cuttings.

4.2.25 The zone of influence of the Millington and Rostherne cuttings includes a small area of the Rostherne catchment which is just within and up-gradient of the northern part of Mere Covert (see Figure B5). In theory, it is possible that all or some proportion of any seepages which discharge in this area of Mere Covert could be intercepted by the drainage in the cuttings.

4.2.26 The zone of influence also extends into an area near Mere Covert which is just outside the Rostherne Mere catchment around Bowden Farm. However, the 1m topographic contours on Figure B6 show that the area just outside the catchment, between the catchment boundary and the Proposed Scheme in the vicinity of Bowden Farm, is flat lying relative to the slopes around Rostherne Mere. In theory, some groundwater in this flat-lying area might discharge in Mere Covert rather than following the more subdued topographic gradient to the north.

Figure B6: Millington and Rostherne cuttings and detailed topography



4.2.27 Three seepage locations were seen in the fields close to or just above the boundary of Gale Bog during the reconnaissance visit in May 2018. A further three locations were identified in Mere Covert. These comprised:

- minor flow in a channel down the slope in the centre of Mere Covert;
- a seepage which was too small to be measured or estimated, and therefore considerably less than a litre per minute, in the southern part of the woodland close to the shoreline; and
- a further seepage, referred to by the Natural England Reserve Manager, present in the 400m section in Mere Covert not covered in the circuit around the mere. The seepage was understood to be of a similar size to the seepage seen in the southern part of the wood.

4.2.28 No seepages with any visible permanent flow were seen in the fields close to or just above the boundary of Gale Bog on 26 July, 15 August or 7 September 2018. Poor quality water discharging from a small, ponded area at the top of one field infiltrated into the ground in the slope of the field.

4.2.29 A minor flow was seen in the channel running down the slope in the centre of Mere Covert and discharging towards Rostherne Mere. The flow was estimated by channel size and float measurements to be approximately 5l/m on 26 July and 7l/m on 7 September. However, on 15 August, the flow was too small to attempt any measurement; a visual estimate indicated a flow of approximately 1l/m to 2l/m. No seepages, discharging to Rostherne Mere, were encountered in Mere Covert on 26 July, 15 August or 7 September.

4.2.30 The total discharge in areas below or close to the zone of influence of the Rostherne cuttings ranged from approximately 1.5l/m to 7l/m for the four monitoring visits. As indicated in Table B5, the total discharge equates to between 0.1% and 0.3% of the total inflows estimated for Rostherne Mere.

4.2.31 No attempt was made to access Gale Bog during the visits owing to the potentially soft and unpredictable ground conditions. However, Gale Bog was accessed by the HS2 Ltd ecology team during site work in late July 2019. The ecologists were briefed to note any indication of springs or groundwater seepages. No evidence of any discharges were seen, either as visible flows or in vegetation, which might indicate the presence of springs or groundwater seepages. However, the mere water level was higher than during visits in 2018 and standing water was present in parts of Gale Bog. The mere water level was higher still during a site visit by water resources staff at the end of September 2019. As a result, standing water was present in much of Gale Bog and no assessment could be made.

Seasonal variations in Rostherne Mere water level

4.2.32 On 26 July 2018, the water level on the gauge board in Rostherne Mere was 0.41m. This was the lowest level seen during the visits. Only an approximate reading of 0.55m was possible on the site visit at the end of May 2018 as the gauge board needed cleaning (see photograph in Figure B7). However, it was also possible to check the reading approximately by measurements of the position of the gauge board intervals and the water level on the photograph. The gauge board readings indicate a decline in mere water level of approximately 0.14m over the two-month period between late May and late July, equivalent to a net decline in level of approximately 2.2mm/d.

Figure B7: Rostherne Mere gauge board – 24 May 2018

4.2.33 The water level on 15 August was 0.42m, with no further significant overall change from 26 July. A reading of 0.48m on 7 September indicated a recovery in mere water level later in the summer.

4.2.34 During the site visit on 24 May 2018, Natural England indicated that the level of Rostherne Mere varied generally by approximately 2ft (approximately 0.6m or 600mm) between summer and winter.

4.2.35 On 23 July 2019 and 24 July 2019, the ecologists noted mere water levels of 0.58m and 0.60m. Overnight rain occurred in the period between the two readings. The water level was therefore nearly 0.2m higher than in the same period in 2018. On 26 September 2019 the water level was higher still at 0.74m. This was following several days of intermittent heavy rainfall. The water level was also high in Blackburn's Brook, preventing access for flow monitoring. There was evidence of eddies in the brook but no clear direction of flow, indicating that the brook was in or close to the condition of reversed flow referred to by the previous site warden (see Section 3.4).

4.2.36 There was a site visit to the boat house on 23 October 2019 to install a logger for continuous monitoring of the water level. The level on the gauge board was approximately 0.84m at the time, indicating a further overall increase from late September. A photograph of the gauge board on 23 October is shown in Figure B8. The logger was checked on 28 November 2019 when the water level on the gauge board was approximately 0.86m. However, the maximum water level recorded by the logger between these dates was equivalent to 1.37m on the gauge board (on 27 October 2019). In total, there were three major rainfall/runoff events between 23 October and 28 November 2019, possibly with some reversal of flow in Blackburn's Brook during the events. Flow reversal in the Blackburn's Brook was also observed on 28 November 2019.

4.2.37 Combining the observed low levels seen in the summer 2018 with the logger data for October/November 2019 indicates a range in Rostherne Mere water levels of approximately 0.96m (960mm).

Figure B8: Rostherne Mere gauge board – 23 October 2019

4.3 Hydrological conditions in 2018

Gauging station records

4.3.1 As indicated in Section 3, Rostherne Mere is located in the catchment of the River Bollin. Four gauging stations with variable periods of records are located in the Bollin catchment, either on the River Bollin or on a major tributary, the River Dean. Data for these sites are available from the National River Flow Archive (NRFA) website[11]. The locations of the gauging stations are shown in Figure B9. Summary information for the gauging stations is as follows, and is also included in Table B6:

- Bollington Mill gauging station is located on the River Bollin downstream of the confluence with Birkin Brook. The record for the station started in 2009 and is on-going;
- Dunham Massey gauging station was located approximately 600m downstream of Bollington Mill. Records are available from 1955, although the station was closed in 2002. The NRFA website indicates that for the gauging station 'Daily flow rating only approximate owing to very unstable bed and weed growth'. The accuracy of the flow record may therefore be questionable;
- there is a difference of more than 10% in the mean flows for the Bollington Mill and Dunham Massey gauging station shown in Table B6. In contrast, the difference in catchment areas is less than 0.5%. However, the periods for which mean flows were calculated were also different which may explain at least some of the difference in mean flow. The difference is not necessarily a simple indicator of the questionable accuracy of the record for Dunham Massey; and
- Wilmslow gauging station on the River Bollin and Stanneylands on the River Dean, a major tributary of the River Bollin, are located in the upper part of the Bollin catchment to the east of Rostherne Mere. Records for both stations start at the beginning of 1976, a year of extreme drought across the UK and are on-going.

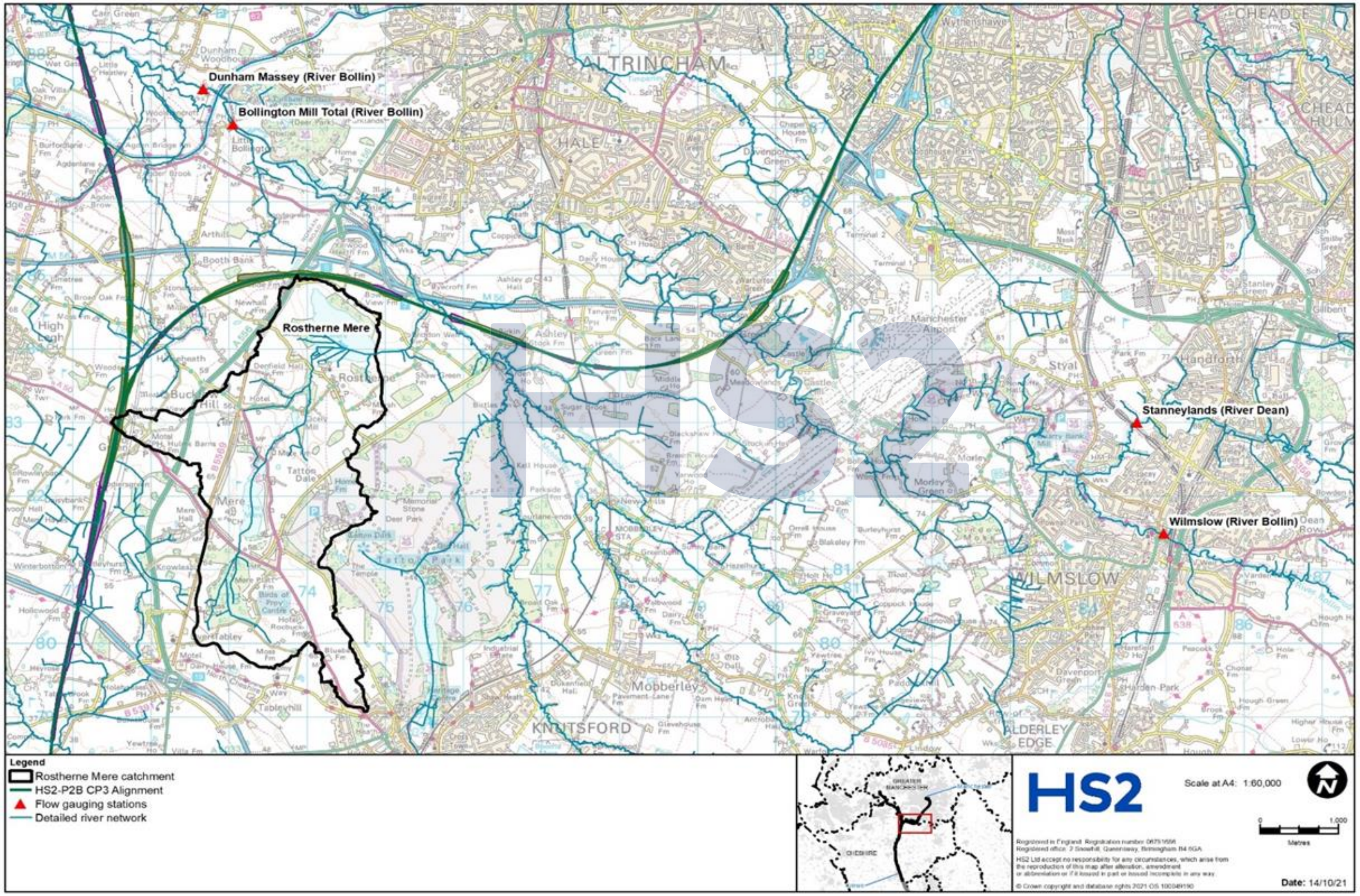
Table B6: Details for gauging stations

Gauging station name	Watercourse and NGR location	Catchment area	Years of flow record		Flow record (m^3/s)		Base flow index	Q95/ mean flow
		km^2	Commenced	Available to	Mean	Q95		
Bollington Mill Total	Bollin SJ73052 87054	257	2009	On-going	3.86	1.27	0.61	0.33
Dunham Massey	Bollin SJ72668 87533	258	1955	2002	4.33	1.18	0.57	0.27
Wilmslow	Bollin SJ84970 81491	73	1976	On-going	1.27	0.46	0.61	0.36

[11] NERC CEH (2021), *National River Flow Archive*. Available online at: https://nrfa.ceh.ac.uk.

Gauging station name	Watercourse and NGR location	Catchment area	Years of flow record		Flow record (m^3/s)		Base flow index	Q95/ mean flow
		km^2	Commenced	Available to	Mean	Q95		
Stanney-lands	Dean SJ84625 83001	59	1976	On-going	0.83	0.13	0.53	0.16

Figure B9: Location of the gauging stations in the River Bollin catchment



4.3.2 Figure B10 is a graph of the daily data for the continuous period of record of flows from 1976 to 2019 for the River Bollin at Wilmslow. Lower flows, less than $1.0m^3/s$, are included in the figure, as only the lower flows are of interest for the analysis of drier conditions in the spring to autumn period. Although extended periods of hot, dry weather occurred in the spring and summer in 2018, Figure B10 demonstrates that 2018 was drier than average, but not an exceptionally dry year in the Bollin catchment. The lowest recorded daily flows at Wilmslow were recorded in 1976, 1977 and 1996. In addition, there were approximately 10 other years in the record in which the minimum daily flow was lower than, or approximately equal to, the lowest flow in 2018.

4.3.3 Figure B11 includes the hydrographs of daily flows for the three gauging stations operating in the period May to September 2018. The flow estimates for Rostherne Brook and estimates of total inflows to Rostherne Mere are also shown on the figure. Figure B11 demonstrates that flows in the Bollin catchment declined steadily from early May to early July with few periods of increased flow due to rainfall or runoff events. There were regular rainfall or runoff events from early July to early September which produced more prolonged periods of increased flow. Following these events, flows returned to, or declined below, the flows seen in early July. The minimum daily flow occurred either in late July or early August at the three gauging stations.

4.3.4 The reconnaissance visit in late May took place following a period of approximately three weeks in which there were no significant increases in flow as a result of rainfall. Flows at the gauging stations showed a generally steady decline throughout the three weeks. This followed major rainfall events resulting in substantial increases in river flows at the end of April and the beginning of May (see Figure B11).

4.3.5 Late July was a particularly useful time for the monitoring visit as it followed an extended period of almost three months of generally dry weather. River flows at the gauging stations had declined significantly between the visits in late May and late July. Following a period of rainfall and increased runoff in mid-July, flows in the rivers declined again and were at their lowest level for 2018 in late July. As a result of the extended dry period, flows in the Rostherne Mere catchment were presumably dominated by groundwater discharges from springs in the catchment.

Figure B10: Flows at Wilmslow on the River Bollin (1976 – 2019)

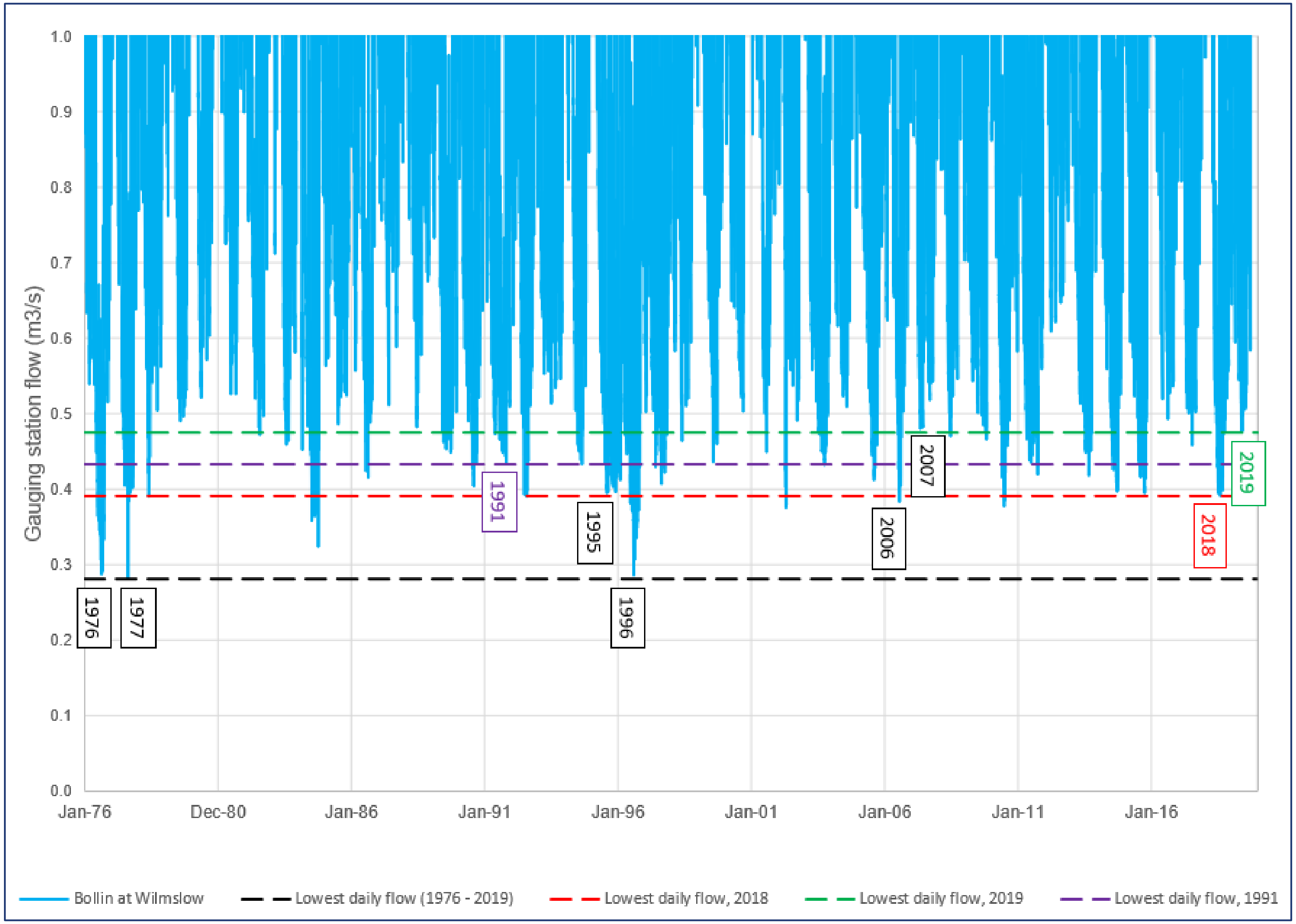
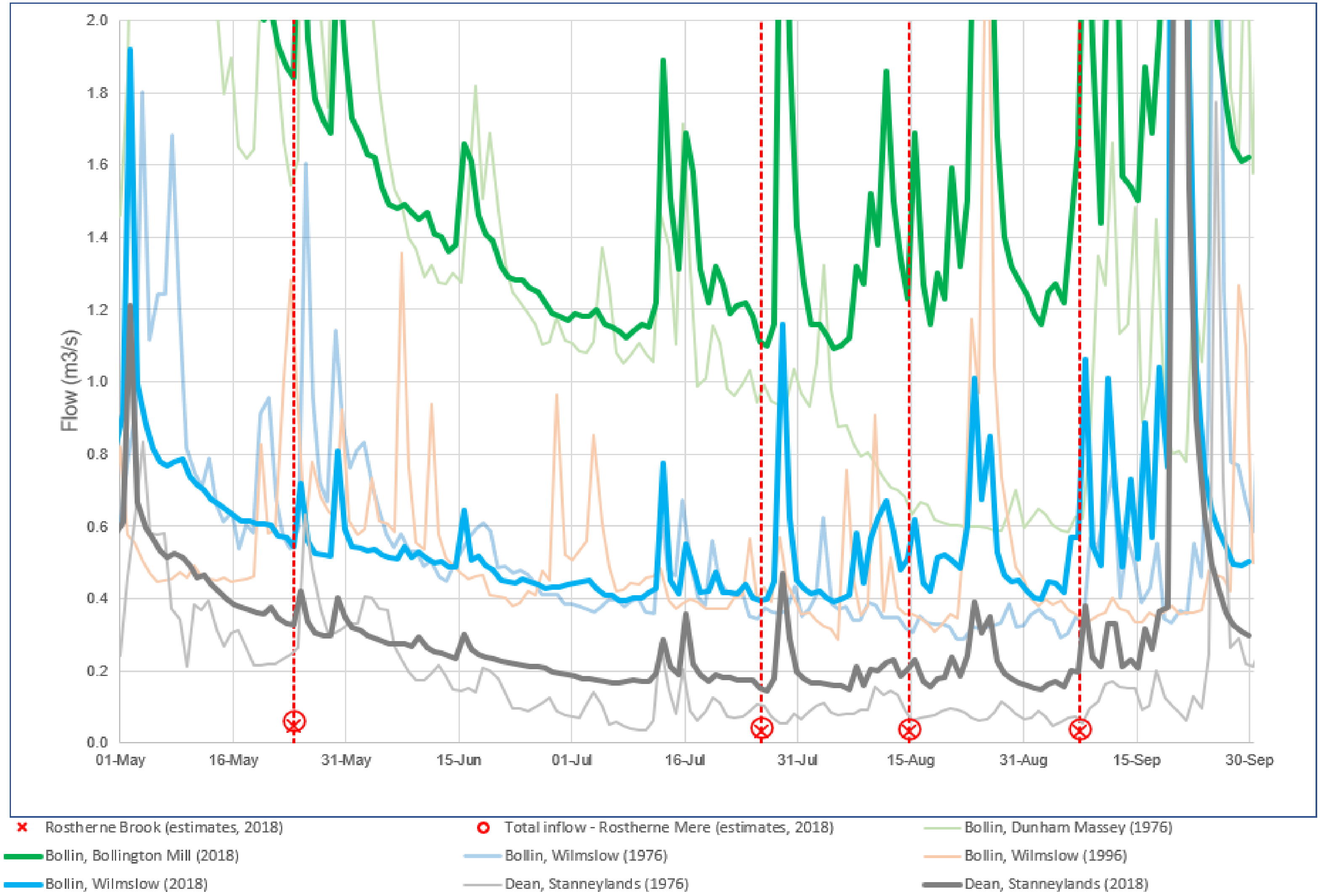


Figure B11: Daily flows – River Bollin (2018, 1996 & 1976)



4.3.6 There were periods of heavy rainfall in the three weeks between the site visits in late July and mid-August. Some rain was forecast in the week prior to the visit in mid-August. However, forecast conditions were dry for one to two days prior to the site visit. Conditions were also dry during the site visit. Figure B11 indicates that flows at the gauging stations had recovered slightly from the lowest levels in late July/early August but were nonetheless still at quite a low level.

4.3.7 At the time of the visit in September, flows had increased slightly from a further low level which occurred in the first few days of September. Flows were similar to the flows during the visit in mid-August in the upper catchment of the River Bollin at Wilmslow and the River Dean at Stanneylands, but higher than in mid-August further downstream at Bollington Mill.

Comparison of 2018 with previous drought years

4.3.8 Figure B11 also includes the 1976 hydrographs for the three gauging stations which were operating at the time, for comparison with the hydrographs for 2018. The following points are noted concerning flows in 1976:

- for the River Dean, 1976 was the year with the lowest daily flow on record;
- at Wilmslow on the River Bollin, the minimum flow was 2% lower in 1977 than in 1976. However, the single daily flow in 1977 which was lower than the minimum daily flow in 1976 resulted from an abrupt and questionable change in flow record. In a period of four days in August 1977, the recorded daily flow first declined by about 30% to the minimum for the year, and then recovered to about the same level as the flow prior to the decline. Such a sudden change in flow, following a ten-day period of otherwise reasonably constant base flow, is difficult to explain and assumed to be unreliable; and
- at Dunham Massey on the River Bollin, the minimum daily flow in 1959 was 3% lower than the minimum daily flow in 1976. Otherwise, the minimum daily flow in 1976 was lower than in any other year in the flow records for both Dunham Massey and Bollington Mill.

4.3.9 As a result, it can be seen that 1976 was a year of extremely low flow overall, although possibly not the year of very lowest flow in some areas of the catchment.

4.3.10 The hydrographs for Wilmslow are similar for much of 1976 and 2018. Base flows declined in a similar way from early May to early August. From early August, the hydrographs for 1976 and 2018 diverge as a result of rainfall events which increased river flows in August 2018. In contrast, river flows continued to decline in August 1976. The minimum daily flow in 1976 was 0.287m^3/s, approximately 73% of the minimum flow of 0.391m^3/s in 2018.

4.3.11 In contrast, flows were generally significantly lower in the River Dean in 1976 than in 2018. The minimum daily flow in 1976 was 0.036m^3/s, about 25% of the minimum flow of 0.146m^3/s in 2018.

4.3.12 There are some similarities between the hydrographs for the River Bollin at Dunham Massey in 1976 and at Bollington Mill in 2018 up to mid-July and, to a lesser extent, to early August. However, river flows declined substantially in dry conditions in August 1976, while rising overall as a result of rainfall events in August 2018. The minimum daily flow in 1976 was $0.584m^3/s$, approximately 54% of the minimum flow of $1.09m^3/s$ in 2018.

4.3.13 The decline in flow at Dunham Massey was particularly marked in August 1976. Flows diverged from the declining pattern seen from May to July 1976 to establish a much lower approximately constant flow of about $0.6m^3/s$. A similar pattern of flows was evident in 1959 with low flows of about $0.6m^3/s$ occurring from mid-August to mid-October. Within this time the record indicates an average daily flow of $0.651m^3/s$ on 25 days out of a continuous period of 29 days. The reasons for the apparent decline to near-constant flow levels in 1959 and 1976 are not known. However, these very low flow records appear questionable when also taking into account the comments on the gauging station on the NRFA website[11].

4.3.14 Figure B11 also includes the 1996 hydrograph for the Wilmslow gauging station on the River Bollin, for comparison with the hydrographs for 1976 and 2018. The following points are noted concerning flows in 1996:

- flows declined between mid-May and late July in 1996 in a similar way to the same periods in 1976 and 2018. However, the flow then declined sharply in 1996 to a minimum for the year on 5 August. The minimum flow for 1996 was marginally lower than the minimum flow for 1976; and
- the base flow in the rest of August 1996 was lower than in August 2018. After a major rainfall/runoff event in late August, low flows prevailed in much of September 1996 but at a slightly higher level than in early August.

4.3.15 Based on the gauging station records, minimum flows in Rostherne Brook are likely to have been lower in 1976 and 1996 than in 2018. The much smaller area of the Rostherne Mere catchment, approximately $10km^2$, as compared to the gauging station catchments included in Table B6, indicates there might have been greater variability in flows in the Rostherne Mere catchment between 2018 and 1976/1996. However, the presence of extensive areas of sand and gravel in the Rostherne Mere catchment could mean that inflows to the mere are maintained at a reasonable level even in drought conditions such as occurred in 1976 and 1996.

4.3.16 As discussed in Section 3, information from local sources indicates that there were continuous outflows from Rostherne Mere in Blackburn's Brook and probably continuous inflows in Rostherne Brook throughout 1976. Table B1 includes Environment Agency flow records for Blackburn's Brook in June and September 1996. Although not taken at what was potentially the time of lowest flow in August 1996, the measurements indicate reasonable flows for Blackburn's Brook in the 1996 summer drought period.

4.4 Catchment to the south of Rostherne Mere

4.4.1 Following the visit to Rostherne Mere on 26 July 2018, some sites in the catchment to the south of Rostherne Mere were also inspected from public access routes. These sites comprised:

- the watercourse along Cicely Mill Lane which drains the valley downstream of the spring to the east of Bucklow Hill (see Figure B1). Visual inspection of the watercourse from the bridge crossing on Cicely Mill Lane indicated a flow of a few l/s possibly of the order of 3l/s – 5l/s;
- the stream providing inflow at the southern end of The Mere, Mere, seen from the verge of the A50 at the culvert crossing downstream of Meremoss Wood. The discharge also appeared to be a few l/s; and
- the weir at the outlet from Little Mere, downstream of The Mere, Mere, into Rostherne Brook, seen from the verge of the A5034 Mereside Road. The weir, which has a height of approximately 1m – 2m in total, was dry. The water level in Little Mere was below the weir crest by the order of 0.1m.

4.4.2 As there was no outflow from Little Mere, the flow in Rostherne Brook of approximately 35l/s on 26 July comprised contributions from springs in mid-catchment between Little Mere and Rostherne Mere. Inspection of the watercourse which drains the valley downstream of one of the springs near Bucklow Hill indicated that there remained a significant discharge from this area even after prolonged periods of dry weather.

4.4.3 These observations confirm the importance of spring discharges in mid-catchment in maintaining inflows to Rostherne Mere and water levels in the mere in dry periods.

4.4.4 At the meeting on 2 August 2019, the parish councillors indicated that the outflow from Little Mere had never been known to dry up previously, not even in the extremely hot, dry summer conditions in 1976. However, the outflow weir was dry for approximately three to four months in the summer in 2018. The councillors added that Little Mere has been dredged out in recent years. Prior to the dredging, Little Mere was sediment-filled to within a few inches of the water surface.

4.5 2019 vegetation survey for Rostherne Mere

Survey dates and methods

4.5.1 NVC baseline survey[2] of water-dependent terrestrial habitats and lake-margins of Rostherne Mere was carried out to inform the assessment of impacts of construction of the Proposed Scheme on these habitats, particularly in respect to changes in groundwater flow and water levels.

4.5.2 The surveys were carried out by a surveyor experienced in NVC habitat surveys, on behalf of HS2 Ltd, on 23, 24 and 25 July 2019. Details of the standard methodology utilised for NVC surveys are provided in Technical note: Ecology and biodiversity – Ecological Field Survey Methods and Standards (FSMS) included in the SMR. Further information on survey methods and survey constraints arising from access limitations, seasonality and health and safety concerns are provided in the Rostherne Mere NVC baseline information[2].

Woodland and swamp communities at Gale Bog

4.5.3 Wet woodland at Gale Bog is dominated by grey willow (*Salix cinerea*) which is constant in the canopy, with frequent crack willow (*S. fragilis*) and goat willow (*S. caprea*). There is no understorey. Lesser pond sedge *(Carex acutiformis)* and reed canary grass *(Phalaris arundinacea)* are constant in the field layer. In the ground flora, common feather-moss *(Kindbergia praelonga)* is constant but at low abundances, and heart-leaved spear-moss *(Calliergon cordifolium)* is locally abundant and frequent. The species composition is characteristic of W1 *Salix cinerea-Galium palustre* woodland.

4.5.4 Within the woodland at Gale Bog is an area of swamp that is derived from the small area of bog in this area referred to in the citation for Rostherne Mere SSSI. Purple loosestrife *(Lythrum salicaria)* and meadowsweet *(Filipendula ulmaria)* are the only constant species, but they occur at moderate levels of abundance. Frequently occurring species include purple small-reed *(Calamagrostis canescens)* and lesser pond sedge which are locally dominant, plus less abundant yellow loosestrife *(Lysimachia vulgaris)*, reed canary grass, reedmace *(Typha latifolia)* and soft rush *(Juncus effusus)*. The species composition is a transition between S7 *Carex acutiformis* swamp and M27c *Filipendula ulmaria-Angelica sylvestris* mire *Juncus effusus-Holcus lanatus* sub-community. It also has affinities to *S24 Phragmites australis-Peucedanum palustris* tall-herb fen. However, the habitat is more characteristic of S7 NVC community due to the abundance of lesser pond sedge, compared to meadowsweet which is more frequent but less abundant. Purple small-reed is present at similarly high coverage as lesser pond sedge. However, from the SSSI citation[8], purple small-reed is likely to be a species left over from when the area was peat bog.

4.5.5 These results closely resemble those obtained in the 2010 vegetation surveys[4]. Both surveys report the same woodland community, and considerable variation in the swamp community present in open habitat within the woodland.

Lake-margin vegetation

4.5.6 A range of lake margin swamp communities were recorded during vegetation surveys carried out in 2019[2]. The swamp communities are largely continuous along the margins of Rostherne Mere, with the main exceptions, evident from aerial imagery, of the shoreline adjoining woodland at Gale Bog and Harpers Bank Wood.

4.5.7 Much of the mere's eastern margin with Mere Covert consists of a monospecific stand of common reed, with sparse bittersweet. The species composition is most characteristic of S4a *Phragmites australis* swamp and reed-bed, *Phragmites australis* sub-community. Further S4 swamp vegetation is present in small areas of the mere's eastern and southern boundary.

4.5.8 The predominant community along the mere's southern margin contains common reed as constant species at a high coverage. Other herbaceous species, typical of this community are also present including common nettle, cleavers (*Galium aparine*), meadowsweet, hemlock water dropwort *(Oenanthe crocata)* and gypsywort *(Lycopus europaeus)*. Himalayan balsam *(Impatiens glandulifera)*, a non-native invasive species, is also present. The species composition is most characteristic of S26 *Phragmites australis-Urtica dioica* fen community. Although common reed dominates, this community is more diverse than the S4 *Phragmites australis* swamp and reed-beds community, within which common reed is the only constant species.

4.5.9 A further area of S26 fen is present on the north western perimeter of Rostherne Mere and has variable species composition, perhaps due to reestablishment following woodland clearance in this area. Constant species include bittersweet, common reed, creeping bent, purple loosestrife, lesser pond sedge and reed canary grass. It is more species-rich than the adjacent stand of S4 swamp.

4.5.10 Narrow bands of S13 *Typha angustifolia* swamp community adjoin S26 fen along the southern boundary of the mere and to the southeast of woodland at Gale Bog, forming a transition from the fen community and open water. Lesser reedmace *(Typha angustifolia)* is dominant, with two other species, common reed and purple loosestrife, recorded at lower abundances within the stand. A further small area of this community is present in the southwest corner of the mere, along with a small stand of S12 *Typha latifolia* swamp.

4.5.11 The remaining swamp communities were recorded to the east of Rostherne Mere and are associated with Blackburn's Brook. S14d *Sparganium erectum* swamp *Phalaris arundinacea* sub-community is present along a ditch connected to the brook. Branched bur-reed *(Sparganium erectum)* is dominant and constant, with less abundant reed canary grass, and sparsely occurring water forget-me-not *(Myosotis scorpioides)* and water horsetail *(Equisetum fluviatile)*. Nearby, Shaw Green Willows contains an area of S7 *Carex acutiformis* swamp dominated by lesser pond sedge with abundant reed canary grass and a small number of wetland forbs (herbaceous flowering plants other than grasses).

4.5.12 The results of these surveys are broadly similar to the vegetation survey carried out in 2010[4]. Fen and swamp communities recorded in 2010, but not in 2019, are S25 *Phragmites australis-Eupatorium cannabinum* tall herb fen and S15 *Acorus calamus* swamp. Samples were often variable and affinities with wetland open vegetation communities were identified locally.

4.6 Observations by Natural England (November 2019)

4.6.1 Access was not possible to the slopes behind Gale Bog and Harpers Bank Wood during the ecological surveys in July 2019. However, a site visit was undertaken to these areas by Natural England later in the year. The visit, in November 2019, followed a period of very wet weather. As a result, the water level in Rostherne Mere was high, with standing water extending to the base of the slopes behind Gale Bog. Access was not possible to Gale Bog itself.

4.6.2 Communication from Natural England observed that:

- '… there is evidence for a significant number of drainage features on the northern and western slopes of the basin. These can be detected on the ground as shallow, sometimes sinuous valleys in the fields. In many places towards the bottom of the slope, upslope of the fringing vegetation surrounding the mere there were identifiable springs or seepages. Due to the wet weather in the days before the visit locations were found where springs had upwelled and flowed over the surface of the grassland.';
- 'At the base of slope, often at the lower ends of drainage features areas of wetland vegetation were present in a number of locations. In some places these were on flat areas which would have once formed part of the mere but have since transitioned into swamp and fen due to sedimentation and the development of peaty deposits. In other places the wetland vegetation was on more sloping ground indicating possible seepages. The wetland features in all cases were contiguous with the fringing vegetation around the mere.'; and
- 'Within Harpers Bank Wood all of which is within the Ramsar boundary there were large areas of swamp and carr vegetation. This was present not only on the fringes of the mere but on the slopes of the basin and on either side of the streams running through Harpers (Bank) Wood and into the mere. In addition to the streams there was evidence of ditches and drains taking water into and out of this swamp and carr area. The streams had eroded channels 2 – 3 feet below the surrounding surface within the swamp vegetation on the slopes suggesting that the swamp vegetation received its water supply from seepages in the surrounding basin slopes. These areas appear to be groundwater fed and so would be susceptible to drying out as a result of interception of groundwater.'

4.7 2020 vegetation survey for The Mere, Mere

4.7.1 An NVC baseline survey of lake-margins and open water of The Mere, Mere was carried out on the 12 August 2020 and seven samples were recorded, where access agreement and safety considerations allowed sampling to be carried out. Regular vegetation management meant that it was not possible to fully record some stands. The significant limitations on the extent of the survey means that an assessment of the impacts of changes in water level on

The Mere, Mere has been made on a precautionary basis without reference to this data. Survey methods are as described for Rostherne Mere in Section 4.5 above, and information on the communities present is summarised below:

- several small stands of swamp vegetation dominated by yellow iris. It is likely that more stands of this vegetation occur around The Mere, Mere. The vegetation is an example of NVC community S23 other water-margin vegetation but it may be possible to assign this vegetation to the S28 *Iris pseudacorus-Filipendula ulmaria* mire;
- several different stands of common reed dominated swamp situated around The Mere, Mere. A large area of this habitat is present in the south of approximately 0.5ha, other areas are much smaller (<0.1ha). Common reed is the dominant species in all cases. This vegetation resembles NVC community Phragmites australis swamp and reed-beds, in some samples it is transitional between the S4 community and NVC type S7 *Carex acutiformis* swamp (or another mire community). Classification to sub-community was not attempted;
- small, fragmentary stands of swamp vegetation including bulrush and other species. Certain areas contained frequent common spike rush *(Eleocharis palustris)* and all contained abundant bulrush. Individual stands are small and it is likely that this vegetation would be more extensive, but it is modified by regular management. Off-shore (out of safe reach) were a number of aquatic/floating species, including New Zealand pigmyweed *(Crassula helmsii)* and perfoliate pondweed which is a species mentioned on the SSSI citation. This vegetation is an example of NVC community S12 *Typha latifolia* swamp;
- a small area of vegetation (approximately 20m x 3m) dominated by great willowherb with frequent gypsywort *(Lycopus europeus)*, yellow iris, water mint *(Mentha aquatica)* and a range of other wetland species. This vegetation is an example of the OV26b *Epilobium hirsutum* community *Phragmites australis-Iris pseudacorus* sub-community and is likely to have been under-recorded due to access restrictions;
- a small area (approximately 20m x 5m) of dense, tall-herb, wetland vegetation at the edge of The Mere, Mere. Yellow loosestrife, purple loosestrife and yellow-flag iris are dominant with scattered alder saplings, frequent bramble and little bryophyte cover. The vegetation is an example of NVC type S23 other water margin vegetation. This vegetation is distinctive because it contains abundant yellow loosestrife which is rarely a constant species in NVC communities. It is likely to have been under-recorded; and
- floating mats of white water-lily *(Nymphaea alba)* covering approximately 0.5ha at the south of The Mere, Mere and in a second location on its west shore. This vegetation is in standing water and is not accessible. Other submerged and floating aquatic plant species are likely to be present in the mass of white water-lily. This vegetation is an example of NVC community A7 *Nymphaea alba* community.

5 Potential impacts on water levels – Rostherne Mere

5.1 Methods of assessment

5.1.1 As shown in Table B5, results from the four field visits in May to September 2018 indicate that the discharge from sources in the area of the sub-catchment between the Millington and Rostherne cuttings and Rostherne Mere equates to 0.1% – 0.3% of the total inflow to Rostherne Mere. If the discharge in the area between the cuttings and Rostherne Mere was lost as a result of construction of the cutting, it is assumed, therefore, that total inflows to the mere would be reduced by up to 0.3%. However, in order to assess the impact on the ecology of the mere, it is necessary to assess what impact this change in inflow would have on the mere water level.

5.1.2 An approximate water balance model was developed for Rostherne Mere, using data for 2018, in order to assess the potential impact of the reduction in inflow resulting from the construction of cuttings. The model takes into account inflows and outflows to and from the mere, together with open water evaporation and changes in storage within the mere. The water balance model has been used to approximately determine the impact on water levels in drought years (1976 and 1996).

5.2 Water balance model

Set up and approximate calibration for 2018

5.2.1 The following calculations and assumptions were made in the set up and approximate calibration of the model:

- the model was run with a daily timestep from the end of January to the end of September 2018. This included, therefore, the late spring and summer in which extended hot, dry periods occurred;
- total daily inflows to Rostherne Mere were derived using the daily flows for the gauging station on the River Bollin at Wilmslow. Catchment data available on the NRFA website indicates that the part of the Bollin catchment upstream of Wilmslow is likely to have higher rainfall than the Rostherne catchment. However, BGS mapping includes extensive areas of glaciofluvial deposits and river terrace deposits in the catchment. Groundwater conditions may therefore be similar to the conditions in the Rostherne Mere catchment;
- the daily flows were correlated approximately with the assessments of total inflows to Rostherne Mere made in May to September 2018 as indicated in Figure B12. The correlation was then used to estimate daily inflows to Rostherne Mere from January to September 2018;

- no data set was available for evaporation for 2018. As a result, approximate open water evaporation values were derived for the area for each half month period using an evapotranspiration data set[12] which includes data for 1976, together with maximum daily temperature data for central England which includes 1976 and 2018. The open water evaporation for 1976 was determined by multiplying the available potential evapotranspiration values over well-watered grass by a factor of 1.25. The factor is used in hydrology as broadly applicable throughout the year. Plotting open water evaporation[13] against maximum daily temperature for 1976[14], using the half monthly data sets, produced an approximate linear relationship shown on Figure B13. The linear equation fitted to the data was then applied to the maximum daily temperature data for 2018 to produce an approximate half monthly open water evaporation data set for 2018;
- the maximum half monthly open water evaporation value in 1976 was 5.1mm/day, compared to a maximum derived value of 4.3mm/day in 2018. Both maximum values occurred over the first half of July. In both years, half monthly open water evaporation values equalled or exceeded 3.0mm/day over the three month period from June to August, averaging 4.0mm/day in 1976 and 3.6mm/day in 2018;
- the half monthly open water evaporation values for 2018 were then applied for each day within the half monthly periods. Daily changes in mere storage were calculated based on the difference between inflows and open water evaporation;
- the discharge from Rostherne Mere was determined from calculations of flow over a V-shaped (V-notch) weir using the mere water levels determined as part of the water balance, taking into account changes in storage. The discharges were assessed for a weir which is largely submerged on the downstream side. This should represent more closely than for a free flowing weir the conditions in a narrow outflow channel with low gradient. The free-flowing discharge over a weir, calculated using a standard V-notch weir equation, was adjusted for submergence using the Villemonte formula[15]. The formula is valid up to a submergence of 90%;
- the mere outflow channel is crossed by a boardwalk bridge located about 20m to the east of the open water of the mere. The channel at the boardwalk is approximately 5m wide and reed-filled (see photographs in Figure B14). As the view was restricted by reeds, it's not known how the channel might vary in size away from the boardwalk. However,

[12] Robinson, E.L., Blyth, E., Clark, D.B., Finch, J. and Rudd, A.C. (2015), *Climate hydrology and ecology research support system potential evapotranspiration dataset for Great Britain (1961-2012) [CHESS-PE]*, NERC Environmental Information Data Centre. Available online at: https://doi.org/10.5285/d329f4d6-95ba-4134-b77a-a377e0755653.

[13] Open water evaporation values based on dataset from: Robinson EL, Blyth E, Clark DB, Finch J, Rudd AC, (2015), *Climate hydrology and ecology research support system potential evapotranspiration dataset for Great Britain (1961-2012) [CHESS-PE], NERC Environmental Information Data Centre*. Available online at: https://doi.org/10.5285/d329f4d6-95ba-4134-b77a-a377e0755653.

[14] *Maximum daily temperature values based on data from: Met Office, (2019), Hadley Centre observations datasets*. Available online at: https://www.metoffice.gov.uk/hadobs/hadcet/index.html.

[15] Villemonte, J. R. (1947), *Submerged weir discharge studies*, Engineering News Record.

using the mere water level data collected in 2018, it was possible to adjust the angle of the V-notch weir such that the changes in water level, in particular the change of approximately 140mm from late May to late July 2018, was simulated reasonably accurately. Hence the weir formula should simulate quite closely the water level changes in periods of low flows as encountered during monitoring. However, the V-notch weir formula may not represent accurately the control on outfall from Rostherne Mere in all conditions, particularly in winter;

- the water balance model operates by assuming outflow from the mere equals the net inflow (total inflow minus open water evaporation) in the first timestep, and then back-calculates the mere water level using the outflow. In each subsequent daily time step, total inflow is added to the storage, with open water evaporation and outflow (from the previous step) subtracted from the storage. The revised mere level, taking into account the change in storage in the time step, is then used to calculate the outflow for the current time step;
- approximate calibration of the water balance model was undertaken by varying the angle of the V-notch weir. It was found that a 54o weir (with 90% submergence) best simulated the change in water level from late May to late July 2018. The results of the model run are compared with field data collected in 2018 in Table B7 and Table B8. Model inflows and outflows and water levels are shown in Figure B15. In Figure B15, the model water levels are adjusted to gauge board levels by taking into account the difference between the simulated and actual levels at the time of the site measurement in late May 2018. The simulated change in level from late May to late July 2018, 140mm, is the same as the approximate actual change;
- the change in level from late July to mid August 2018 is also simulated reasonably accurately. However, the major rise in level from 15 August to 7 September 2018 is poorly simulated. A rise in level occurs in the water balance, although this is only about a third of the actual rise. The rainfall/runoff events in the Bollin catchment in the second half of August, evident in the simulated inflow hydrograph, may also have given rise to substantial direct rainfall on the mere which could also have raised the water level. However, no rainfall record is currently available for the area for 2018. Hence it was not possible to simulate a direct rainfall component;
- the maximum range in simulated water levels from late January to late September 2018 is 441mm, with a maximum level of about 0.85m recorded on the gauge board in February 2018. Although the model may only be very approximate for simulation in the winter period, this maximum range is equivalent to almost 75% of the general range in water levels of 600mm indicated by Natural England. 2018 was neither an exceptionally dry year through the summer months, nor a particularly wet year in the winter and spring. As a result, a range in levels might be expected which is lower than the approximate actual range indicated by Natural England;
- the staining on the gauge board shown in the photograph in Figure B7 indicates that the maximum water level may generally be about 880mm. This is very similar to the

maximum simulated level in February 2018, although whether the staining on the gauge board resulted from water levels in early 2018 or in a previous winter is not known;

- Figure B15 indicates that, from January to April 2018, inflows exceed outflows in periods of high rainfall and runoff, accompanied by major increases in water levels. The reverse occurs between major rainfall events when outflows exceed inflows and water levels decline. From the beginning of June, outflows decline steadily below total inflows as open water evaporation becomes an increasingly important component of the water balance; and
- Figure B15 includes the site estimates of total inflow to Rostherne Mere, and the outflow in Blackburn's Brook on 24 May and 26 July 2018. As the total inflows were used in calibration of the water balance model, the values are approximately equal to the simulated inflow on the same day. In contrast, the outflows were only very approximate estimates as discussed in Section 4, and do not align with the simulated outflow hydrograph. Nonetheless, for late July, the estimate for an actual outflow which was lower than total inflow aligns with the model results showing that open water evaporation was having a major impact on the water balance for the mere. The difference between the approximate total inflow and outflow was 8l/s on 26 July, compared to a simulated difference of 14l/s.

Table B7: Comparison of site level data for 2018 with water balance results

Date	Site data			Water balance	
	Mere water levels			Modelled mere water levels	
	Water level on gauge board	Change from day of previous site measurement		Change from day of previous site measurement	Maximum variation in water level (2018)
	m	m	mm	mm	mm
24-May-18	0.55				
26-Jul-18	0.41	-0.14	-140	-140	
15-Aug-18	0.42	0.01	10	12	
7-Sep-18	0.48	0.06	60	20	
2018					441

Table B8: Comparison of site flow data 2018 with water balance results

Date	Estimated flows (l/s)			Modelled flows (l/s)		
	Approximate total inflow	Approximate outflow (Blackburn's Brook)	Outflow minus inflow	Inflow	Outflow	Outflow minus inflow
26-Jul-18	45	37	-8	39	26	-14

Figure B12: Correlation of inflows to Rostherne Mere with River Bollin flows (2018)

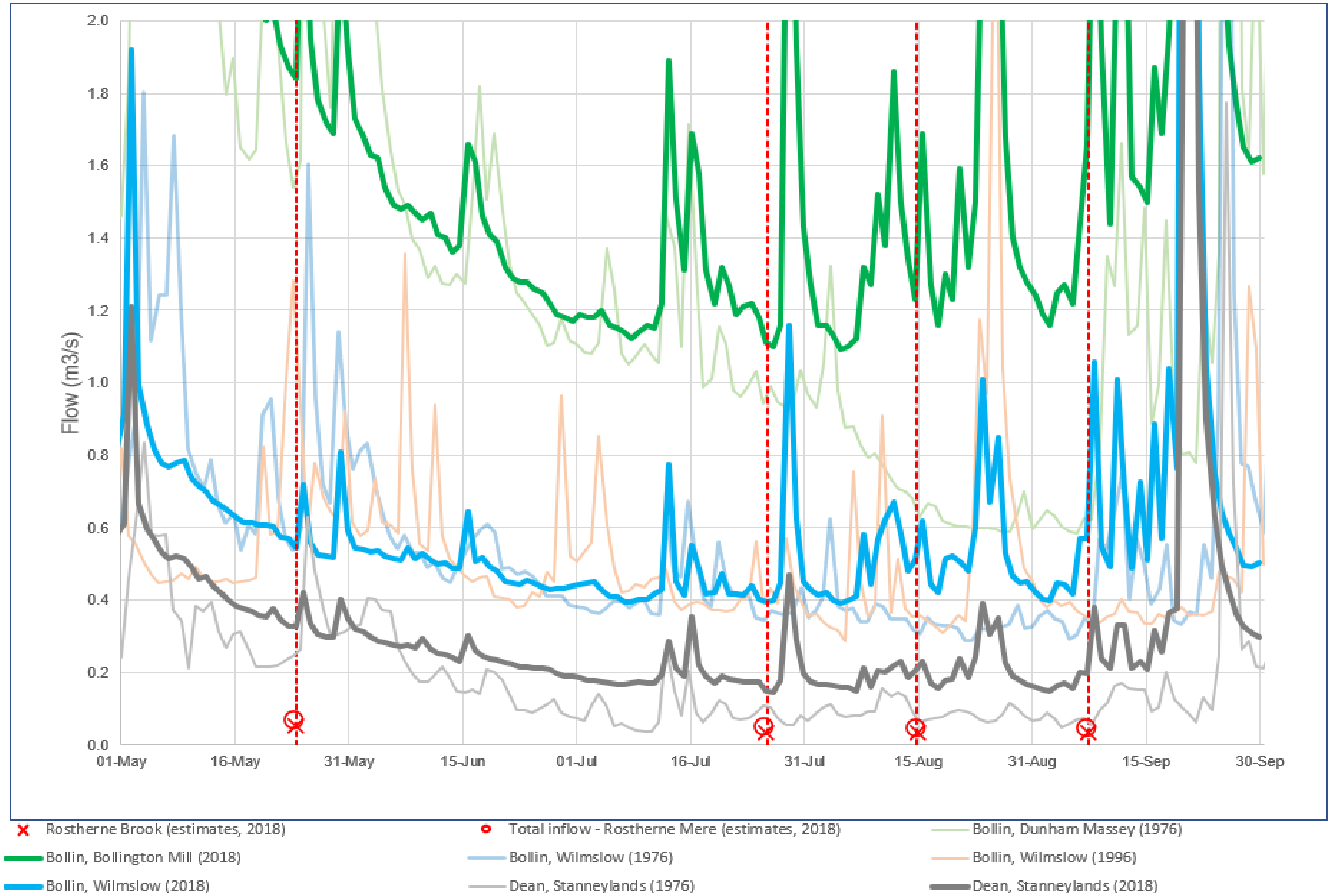


Figure B13: Correlation between maximum temperature and open water evapotranspiration (1976)

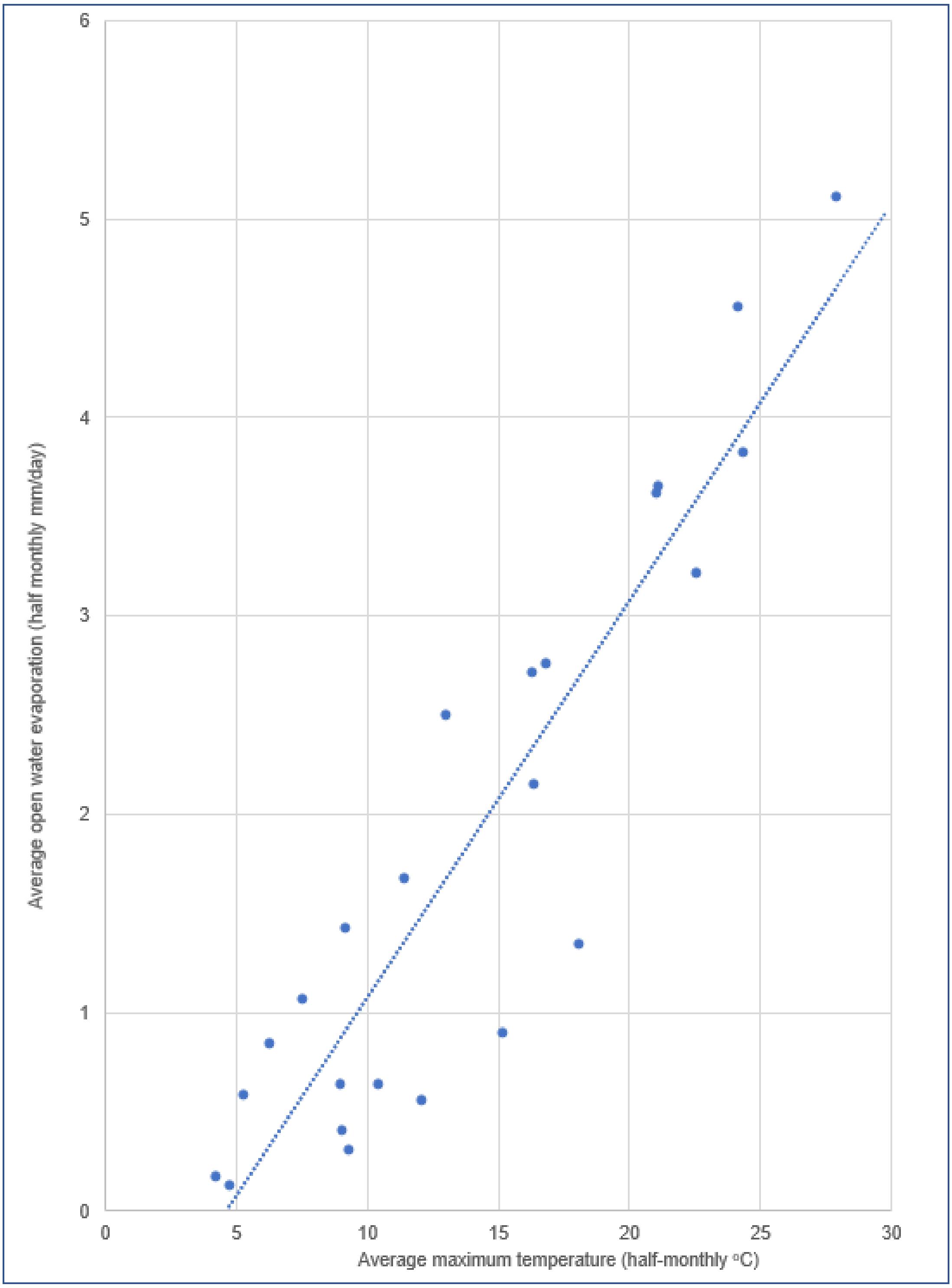
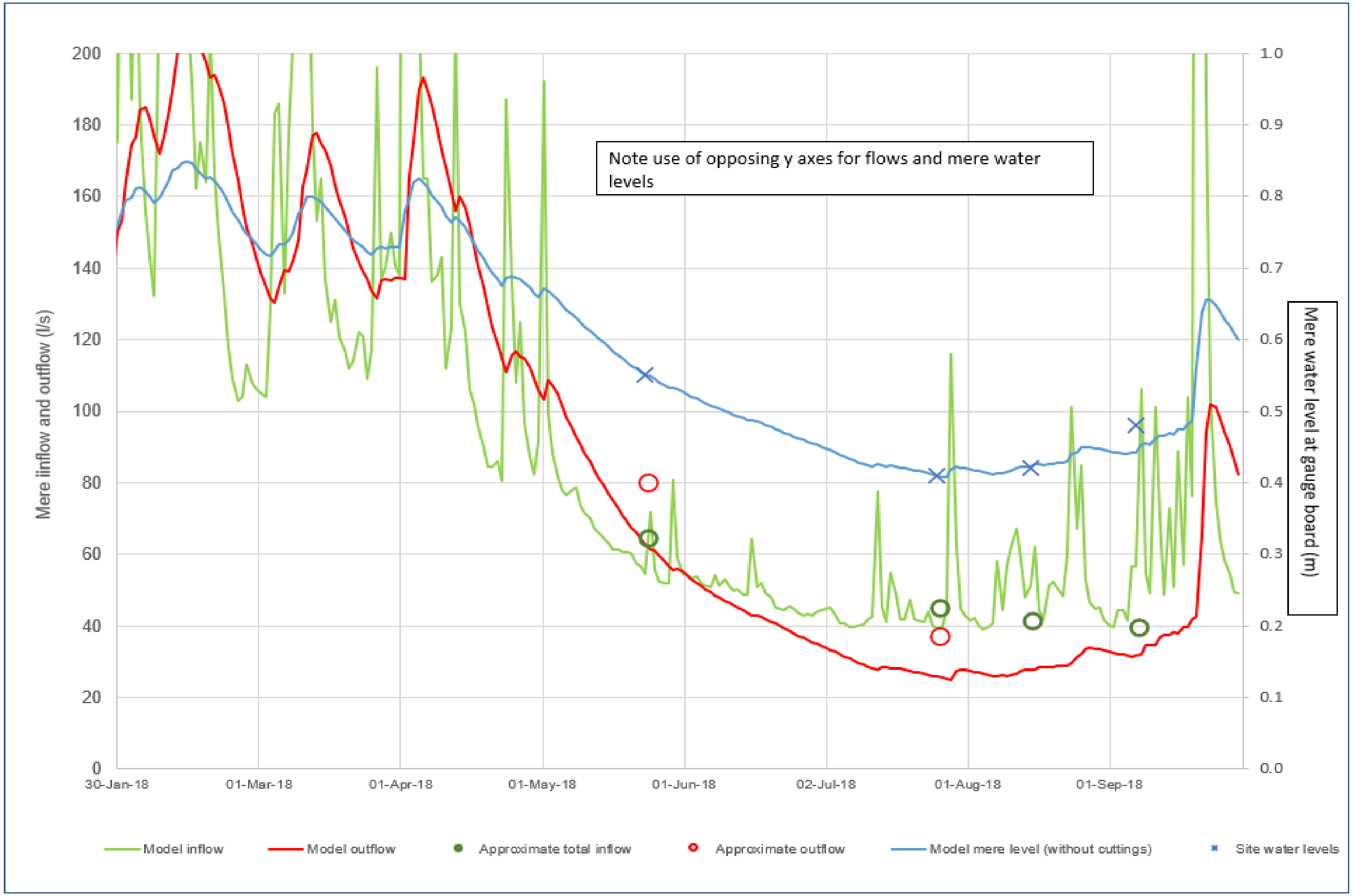


Figure B14: Rostherne Mere at boardwalk bridge over outflow

Figure B15: Water balance model results (2018)



Modelling for other years

5.2.2 Using the flow data for Blackburn's Brook provided by the Environment Agency it was possible to check the accuracy of the model for some other years. Water balance simulations were therefore undertaken for all the years for which the flow data is available. Daily flow data for the Wilmslow gauging station was again used to derive inflows to Rostherne Mere. The simulations include approximate daily open water evaporation values derived using the evapotranspiration data set available for each of the years[2].

5.2.3 As indicated in Table B1, two flow measurements were made in 1991 and 1996. The results of water balance simulations for these years are shown in Figure B16 and Figure B18.

5.2.4 The outflow simulation in 1991 is poor when compared to the flow values provided by the Environment Agency. Gauged flows are much lower than simulated. However, the following observations indicate that the actual flow measurements were not particularly accurate in 1991:

- the second flow measurement (26l/s) was taken a week after the first (14l/s), with a near doubling of the flow in the intervening seven days. The flow monitoring was in August 1991 when only major rainfall events could, potentially, create large variations in mere levels and outflow. However, the modelled inflow hydrograph, which is based on actual flow data in the Bollin catchment, indicates there were unlikely to have been any major rainfall events in August 1991 which could have created large variations in outflow from Rostherne Mere;
- the flow measurements were made at the same location on Blackburn's Brook and the areas of the flow section included in the Environment Agency's data are quite similar, as indicated in Table B1. However, the average velocity calculated for the second flow measurement is double the average velocity for the first measurement. This change in velocity seems very unlikely for two measurements in low flow conditions separated by a period of only a week; and
- as can be seen from Figure B10, 1991 was not a year of particularly low flows in the River Bollin catchment. The minimum daily flow in 1991 at the Wilmslow gauging station was above the minimum daily flow in 2018. In addition, it was substantially higher than the minimum daily flow in 1996, a year of very low flow, in which the average for the Environment Agency's flow gauging data (for late June and late September 1996) is almost double the average for the flows in 1991.

5.2.5 In contrast, the actual flow data for 1996 fits well with the hydrograph of simulated outflow from Rostherne Mere, as shown in Figure B18. This adds considerable confidence in the approximate model simulation of inflows and outflows in years of very low flow.

5.2.6 The single flow measurement on the Blackburn's Brook in 1995, shown in Figure B17, also looks to be unrealistically low when compared to the measurements for 1996. In contrast, the single flow measurement in 2006, another year of notably low flows, is quite close to the hydrograph of simulated outflow from Rostherne Mere as shown in Figure B19. The single flow measurement in 2007 (Figure B20) is about 15% higher than the simulated outflow, in a year of higher summer flow and mere water level conditions.

5.2.7 It has also been possible to check the accuracy of the model for conditions in 2019. Although no flow measurements were made in the catchment in 2019, mere water levels are available for the following periods, as discussed in Section 4.2:

- readings from the gauge board on 23 and 24 July, 26 September, 23 October and 28 November 2019; and
- continuous monitoring of the water level by logger from 23 October to 28 November 2019.

5.2.8 The water balance was also assessed for the period January to November 2019 (Figure B21). Daily flow data for the Wilmslow gauging station was used to derive inflows to Rostherne Mere. As only maximum temperature data, and not evaporation data, is available for 2019, open water evaporation was derived for 2019 by the same method as described for 2018.

5.2.9 The following comments relate to the simulated and observed water levels for 2019:

- comparison of Figure B15 and Figure B21 indicates that inflows and water levels were generally much higher in 2019 than in 2018. The conditions were very different in 2019 to the drier period in 2018 for which the water balance model was calibrated;
- the overall rising trend in mere water levels is simulated for the period in which gauge board readings were taken in July, September and October 2019, although the modelled water levels are below the levels from the gauge board. The modelled water levels are more accurate at the time of the gauge board reading in late November 2019; and
- overall, there is a reasonably accurate simulation of water levels of up to about 1.0m based on logger data in October and November 2019. However, the peaks in mere water levels in late October and November 2019 are simulated less accurately. As indicated on Figure B21, reversed flow was observed in Blackburn's Brook on 5 November 2019. As reverse flow events are not simulated by the model, the actual inflow could have been much greater than the simulated inflow, and the model would not be expected to simulate the peak in water level at the time. Nonetheless, the timing and rates of increase and decrease in mere water levels are simulated well in late October and November 2019.

5.2.10 The water balance was also simulated for the 1976 drought year (Figure B22). The simulated outflow is lower in the summer of 1976 than in 1996 and declines below 20l/s from late August to mid-September. Simulated mere water levels also drop below 0.40m in the same period, in contrast to 1996 when the minimum level is 0.40m.

Figure B16: Water balance model results (1991)

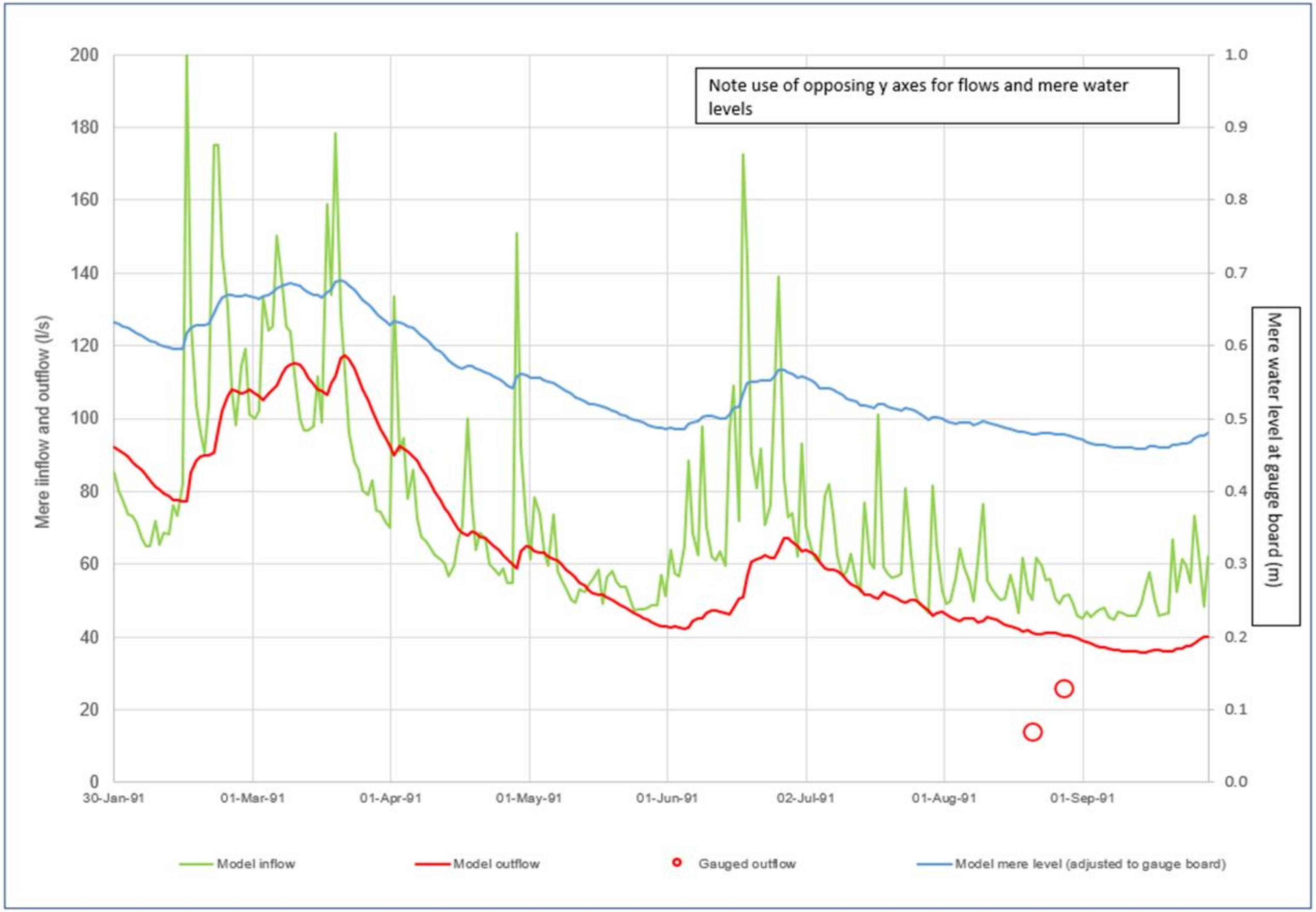


Figure B17: Water balance model results (1995)

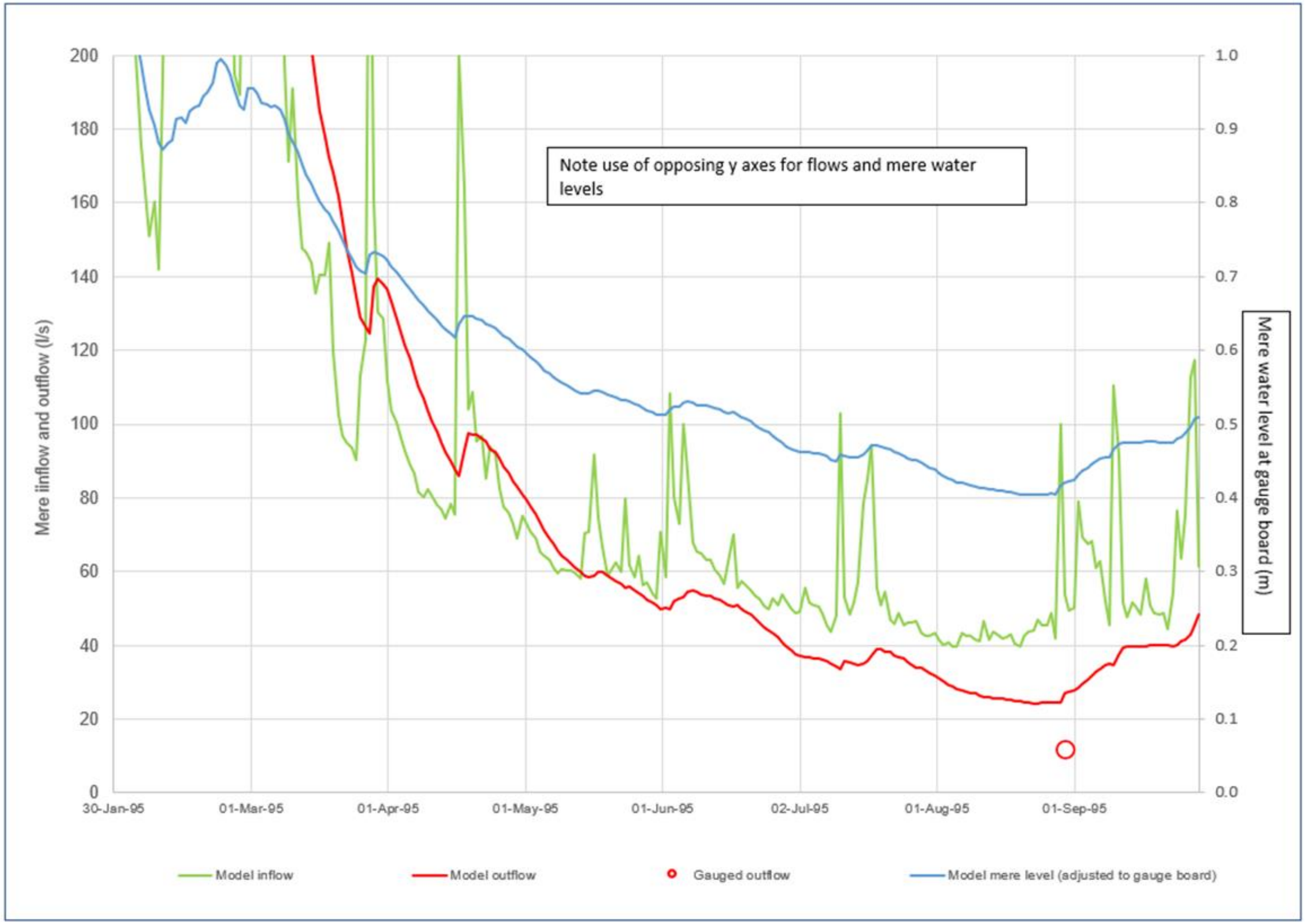


Figure B18: Water balance model results (1996)

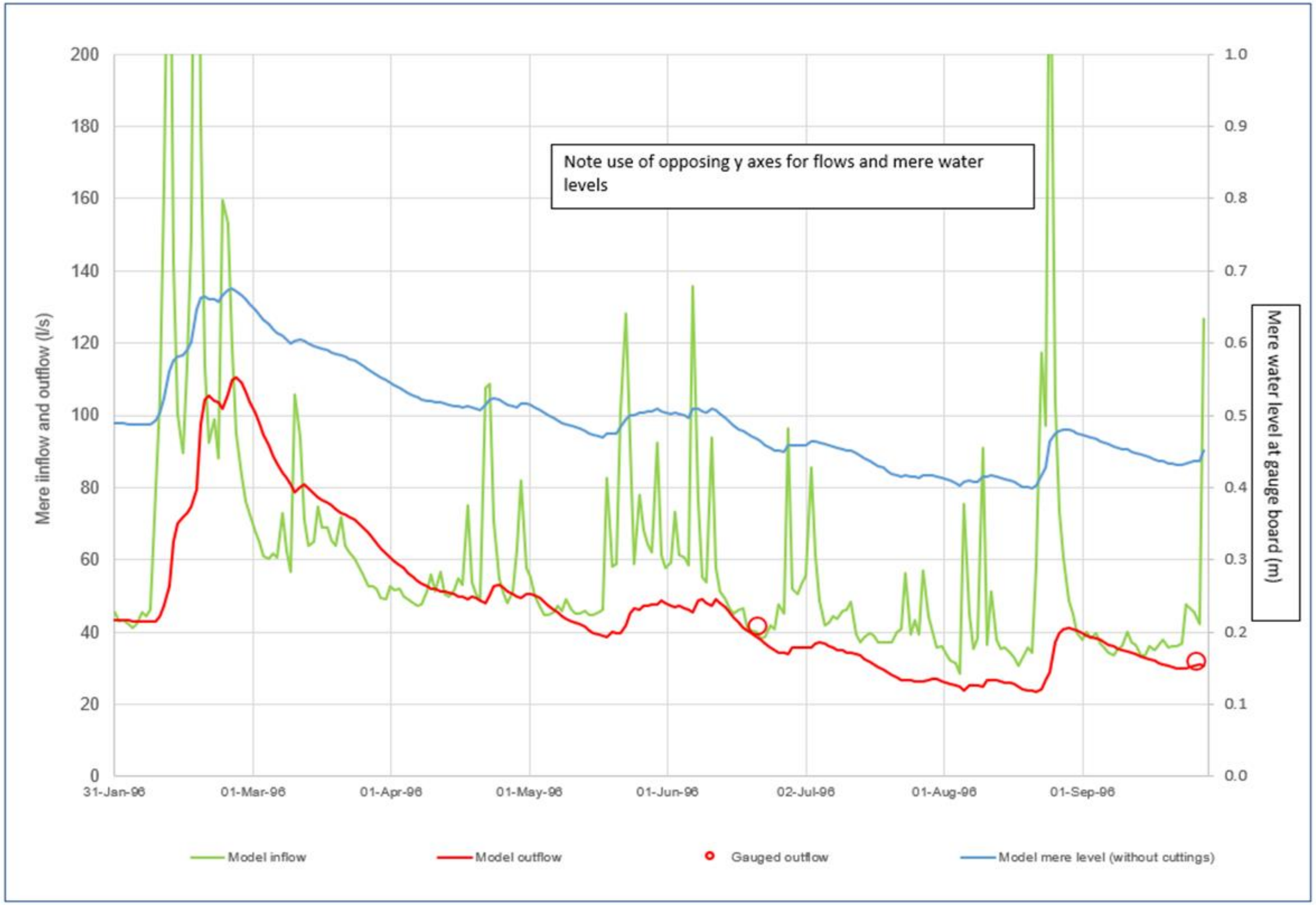


Figure B19: Water balance model results (2006)

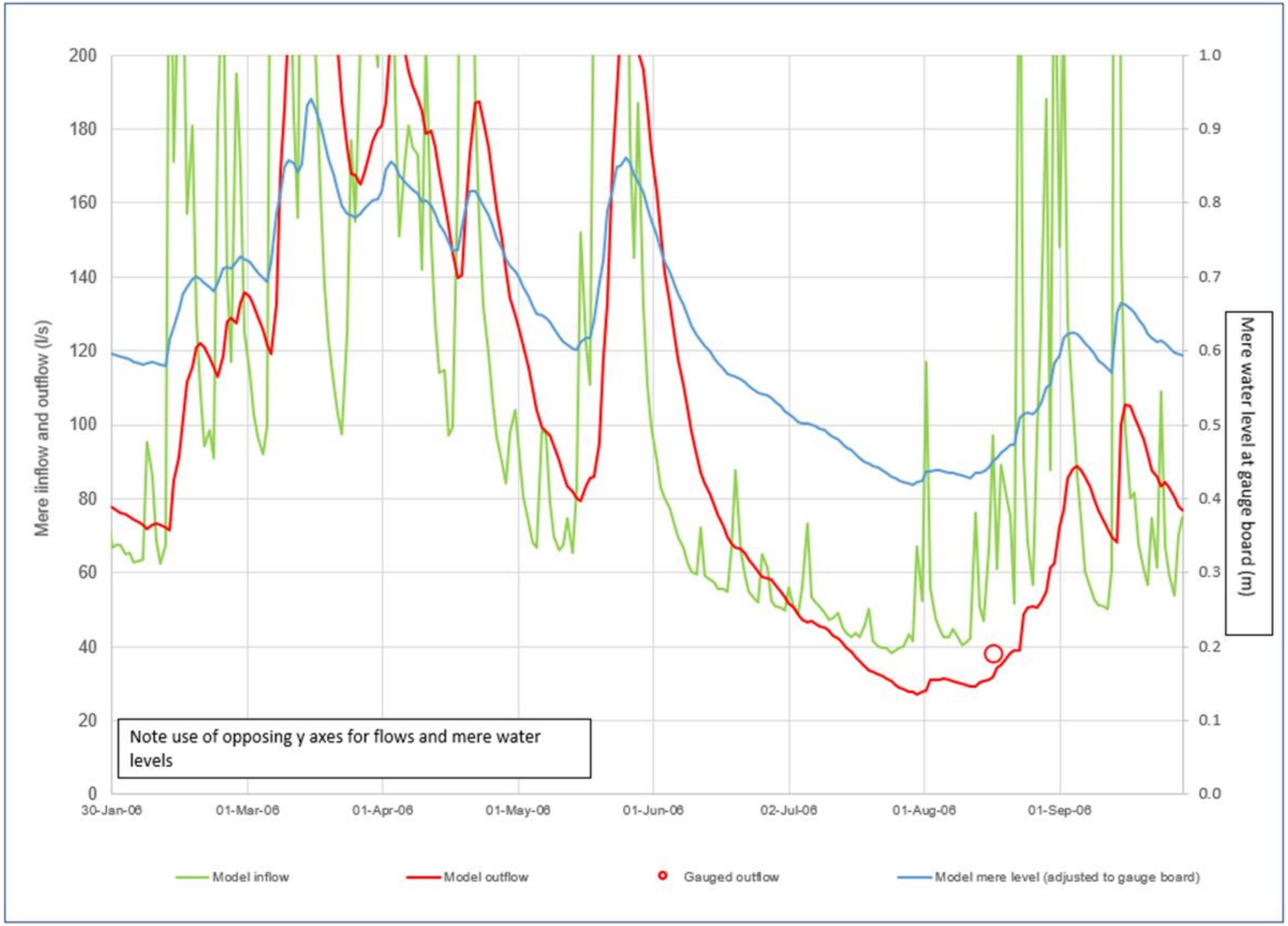


Figure B20: Water balance model results (2007)

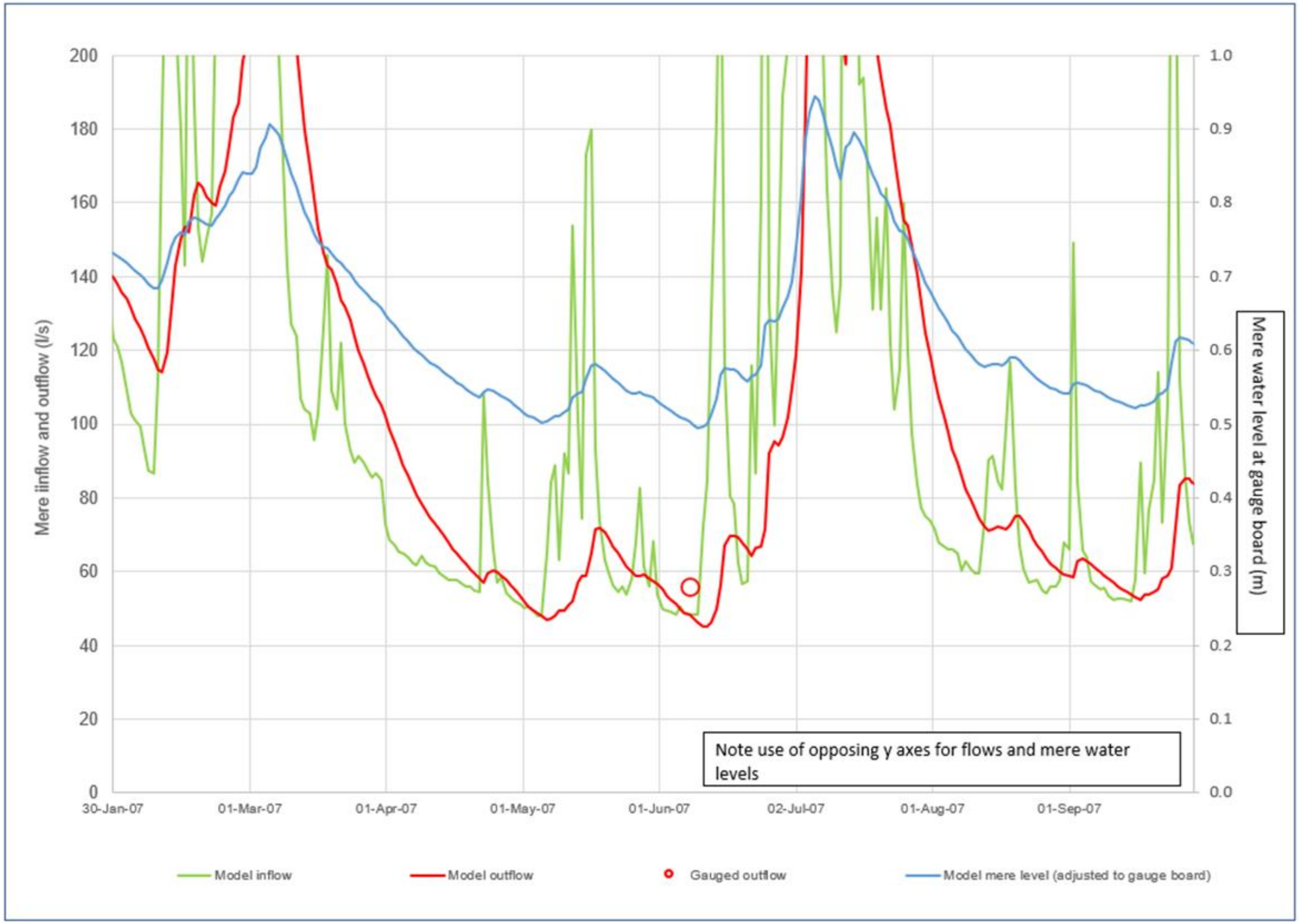


Figure B21: Water balance model results (2019)

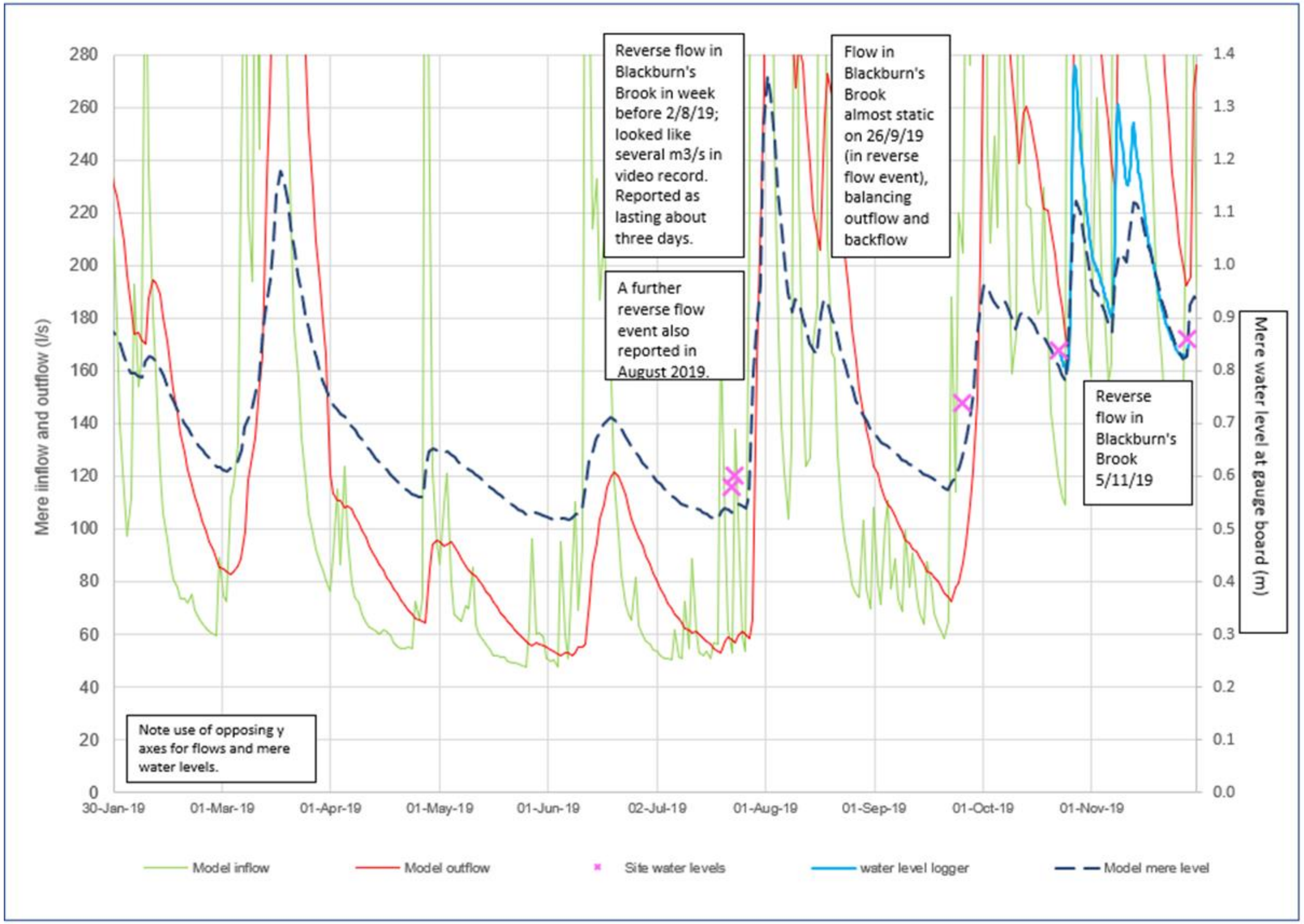


Figure B22: Water balance model results (1976)

Assessment of the impacts of the Proposed Scheme

5.2.11 Little data was available for the calibration and checking of the water balance model, and some variable results were obtained. However, the calibration is based on the actual variation in water levels in Rostherne Mere between late May and late July 2018, which also gives rise to a reasonably accurate simulation of flow data in 1996 in a period of particularly low flow. This combination of factors provides reasonable confidence that the model can be used effectively to assess the impacts of small changes in total inflows on mere water levels in dry conditions. In addition, the accurate simulation of lower water levels during the summer and autumn 2019, in very different conditions to 2018, adds substantially to the confidence in the water balance model.

5.2.12 It is recognised that the use of formulae for a submerged V-notch weir does not necessarily provide an accurate simulation of actual conditions in the outflow channel from Rostherne Mere. However, use of the formulae led to a calibration for 2018 which then indicates an accurate simulation of outflows in some other periods of low flow, in particular in 1996. Therefore, use of the formulae as a proxy for natural conditions appears acceptable at least in low flow conditions.

5.2.13 Regardless of the assumptions made in the model in relation to inflows, evaporation and outflows, assessment of the impacts of the Proposed Scheme is based on the comparison of conditions with and without the Proposed Scheme in place. The actual values taken from individual model runs are not used for this assessment. The same assumptions and inaccuracies are implicit in the conditions with and without the Proposed Scheme in place and, therefore, comparison of the results should, to a large extent, cancel out the potential sources of inaccuracy in the model. In addition, taking into account the calibration in low flow conditions in 2018, there can be reasonable confidence in the assessment for periods of low flows, and low water levels, based on the comparison of model results.

5.2.14 Following the approximate calibration and checking, the water balance model was run for scenarios with the Proposed Scheme cuttings in place. To simulate the impacts of the cuttings, the following changes were made to model inputs:

- a percentage reduction in total inflow was made to the baseflow component of the simulated total inflow hydrograph to take account of the impact that cuttings would have on groundwater throughflow. An approximate baseflow separation was applied to the simulated inflow hydrograph by linking periods of lower and more consistent flows separated by periods of high flow likely to be produced by rainfall/runoff events. For 2018, the estimated baseflow component amounted to 77% of the total flow in the period from late January to late September; and
- the remaining rainfall/runoff component of the hydrograph was reduced taking into account:

- the area of the cuttings within the surface water catchment boundary, as a proportion of the overall catchment area; and
- any area within the catchment boundary which would be separated from the main part of the catchment by the cuttings.

Reduction in water level due to Millington and Rostherne cuttings

5.2.15 A worst-case reduction of 0.3% of the total baseflow to Rostherne Mere was assumed in 2018. This reduction was based on the maximum estimated total discharge of about 7l/min (0.12l/s) in May to September 2018 in the area between the cuttings and Rostherne Mere, and the estimated total inflow to Rostherne Mere of 39l/s on 7 September 2018. However, the reduction is considered to be a worst-case potential impact for the following reasons:

- a much lower flow was seen in the channel in the centre of Mere Covert in August (about 1l/min – 2l/min) than in either July or September 2018. The variation in flow in summer months is likely to indicate that the water is from a shallow source with small and variable discharge which can decline between rainfall events in dry conditions;
- water quality data, collected during the site visits in August and September, showed that the overall salinity of the water in the channel in Mere Covert is significantly lower than the salinity of the water in other watercourses in the area. Results for electrical conductivity, which is indicative of the overall salinity of various watercourses contributing to Rostherne Mere, are shown in Table B9. The lower salinity of the main seepage in Mere Covert is also likely to indicate the water is from a shallow source which dries up relatively quickly;
- the zone of influence of the cuttings extends into the Rostherne catchment over the area which includes only the northern corner of Mere Covert. As a result, the cuttings may not actually affect the main discharge which occurs in the centre of Mere Covert; and
- at the meeting on 2 August 2019, a local parish councillor indicated that the flow in the centre of Mere Covert comprises near-surface drainage which responds rapidly to rainfall and reduces very quickly after rainfall. He indicated there is solid clay about two feet below the soil layer in the fields above Mere Covert and the water drains quickly above this clay layer. Water can be seen running off down furrows during rainfall. It seems unlikely therefore that the small flows seen in the centre of Mere Covert originate as groundwater and would therefore not be affected at all by the presence of the cuttings.

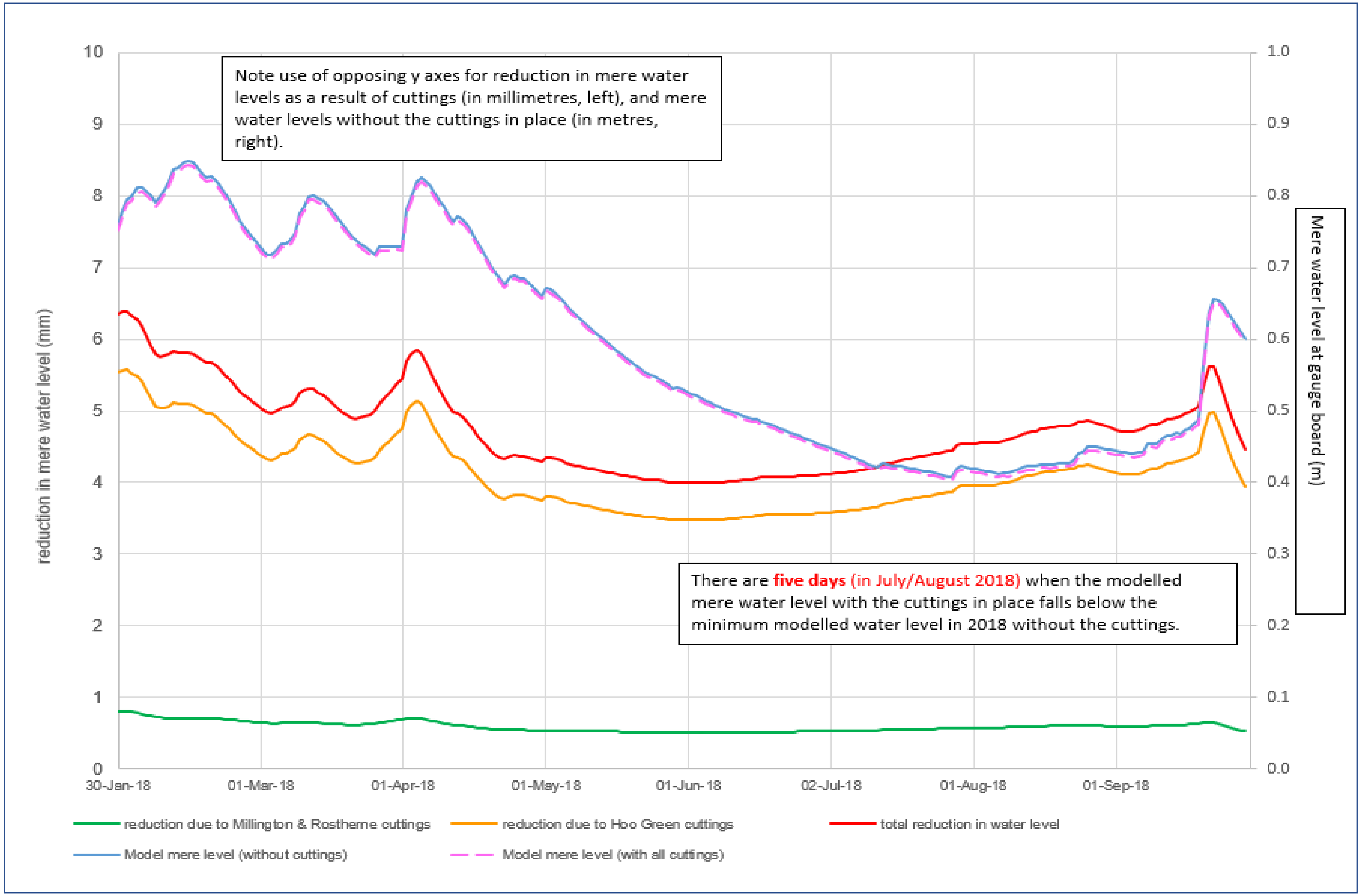
Table B9: Water quality data in 2018

Watercourse location	Electrical conductivity (uS/cm)		
	15 Aug	7 Sep	Average
Discharge in Mere Covert	250	260	260
Rostherne Brook (downstream)	620	610	620
Main stream in Harpers Bank Wood	650	640	650
Tributary stream in Harpers Bank Wood	580	570	580
Stream below Wood Bongs	540	560	550

5.2.16 For very dry conditions, it would therefore be reasonable to assume a loss of inflow of only 0.1% as seen in August 2018, or possibly even zero if discounting the flow in the centre of Mere Covert entirely. As already discussed, the seepages seen in the slopes behind Gale Bog in May 2018 had dried up in July and August 2018. In addition, the two seepages referred to in Mere Covert in May 2018 are likely to be too small to be affected by the zone of influence of the Rostherne cutting. They had, anyway, dried up by the time of the visit in July 2018.

5.2.17 The water balance model was, however, run with the total baseflow reduced by 0.3%. The rainfall/runoff component of inflow was reduced by about 0.01% to allow for the very minor area of catchment within the extent of the cuttings. The results are included in Figure B23 in which the reduction in water level as a result of the reduction in total inflow is plotted against the left hand y axis. The Rostherne Mere water levels are plotted against the right hand axis. The results indicate that water levels decline by about 0.6mm from April onwards through the late spring and summer months as a result of the presence of the Millington and Rostherne cuttings, increasing slightly in the winter period when inflows and water levels are higher.

Figure B23: Impacts of cuttings on water levels – Rostherne Mere (2018)



Reduction in water level due to Hoo Green cuttings

5.2.18 The potential zone of influence of the Hoo Green cuttings to the west of The Mere, Mere in the catchment of Rostherne Mere is shown in Figure B1. This zone of influence intersects approximately 2% of the area of the Rostherne Mere catchment downgradient of The Mere, Mere sub-catchment.

5.2.19 The area of the catchment to the west of The Mere, Mere extends out between the catchments to the south of Hoo Green (Tabley Brook) and to the north towards Hulseheath (Millington Clough). Some groundwater in this area may contribute to the adjacent catchments rather than following a more extended groundwater flow path and direction within the Rostherne catchment. However, in the telephone conversation following the meeting with local councillors on 2 August 2019, a local parish councillor said he had been discussing with a farmer in the area the drainage in the Rostherne catchment where it extends out to the west to the Hoo Green cuttings. From the conversation, he understood there is a drainage system with an 18" pipe which underlies the area near the Hoo Green cuttings in the Rostherne Mere catchment. The pipeline route was to the north east, with discharge into the watercourse on Cicely Mill Lane near Bucklow Hill in the Rostherne Mere catchment.

5.2.20 The local parish councillor indicated that the farmer has a map of the drainage system. However, it may be difficult to determine how much of the potential recharge to groundwater is actually intercepted by the drainage system. In addition, he did not know whether the pipeline route has changed as a result of recent construction for the A556 improvement scheme.

5.2.21 Locations of some of the boreholes along the new alignment of the A556 Chester Road in the Rostherne Mere catchment are shown on Figure B24. A geological section produced using the borehole logs is presented in Figure B25. The section has been simplified to show the base of predominantly sandy deposits, described in the geological logs on the BGS records[1]. The sandy deposits align generally with the area of glaciofluvial deposits indicated by BGS mapping. However, the sands extend further to the north than indicated by the mapping. In addition, the superficial deposits are very variable. Gravel is present with the sand in several boreholes, but silty or clayey layers also occur occasionally within the sands. The clay underlying much of the area shown by BGS as glacial till is frequently sandy, silty or contains gravel.

5.2.22 Figure B25 indicates that the sandy deposits are very variable in thickness, between about 1.5m and 7m in boreholes in the Rostherne Mere catchment. In some locations, however, projection of the geological logs onto the section exaggerates the variability. For example, the two boreholes which are near the southern boundary of the catchment are shown within a few metres of each other on Figure B25 (BGS reference SJ78SW322 and SJ78SW323) but are actually about 70m apart. Nonetheless, the variability in thickness of sandy deposits is considerable, although the actual composition of the superficial deposits may not vary so markedly between the two locations. One of the two borehole logs describes slightly gravelly, sandy clay above the bedrock mudstone at 4m depth, hence no sandy deposits are indicated at the location in Figure B25. The other log describes a mixture of sandy gravel, very sandy clay (thickness 0.9m), gravelly clayey sand, sandy silt and sandy gravel above the bedrock mudstone at 7.9m depth, hence these are shown as sandy deposits on the geological section.

5.2.23 A minimum base level for the sandy deposits of about 62mAOD may be present. The section also indicates that the sandy deposits extend more than 80m, and possibly up to about 180m, to the north of the glaciofluvial deposits contact with the glacial till shown in the BGS mapping.

5.2.24 An estimated section produced using design levels along the newly constructed A556 Chester Road, taken from the publicly available documents for the A556 Knutsford to Bowdon improvement scheme, is also included in Figure B25. The design levels indicate that the A556 scheme is likely to have cut through much of the sands in the southern half of the outcrop of glaciofluvial deposits. Potentially, therefore, the A556 Chester Road drainage might be intercepting some groundwater moving from this area of the catchment towards Rostherne Mere. However, for the current analysis, it is assumed the whole of the potential zone of influence, comprising 2% of the catchment, contributes groundwater to Rostherne Mere down-gradient of The Mere, Mere sub-catchment.

5.2.25 The water balance model was run with the total baseflow reduced by 2%. The rainfall/runoff component of inflow was reduced by 0.4% to allow for the area of catchment within the extent of the cuttings, together with the area within the catchment to the west of the cuttings which would be separated from the main catchment area. The results are also included in Figure B23. They indicate that water levels decline by about 3.5mm – 4.0mm from April onwards through the late spring and summer months as a result of the presence of the Hoo Green cuttings. The simulated decline in water level is greater in the winter months, increasing to more than 5mm when inflows and water levels are higher. The water level decline also increases in the rainfall/runoff events occurring from mid-September.

Figure B24: Detailed topography to the west of The Mere, Mere

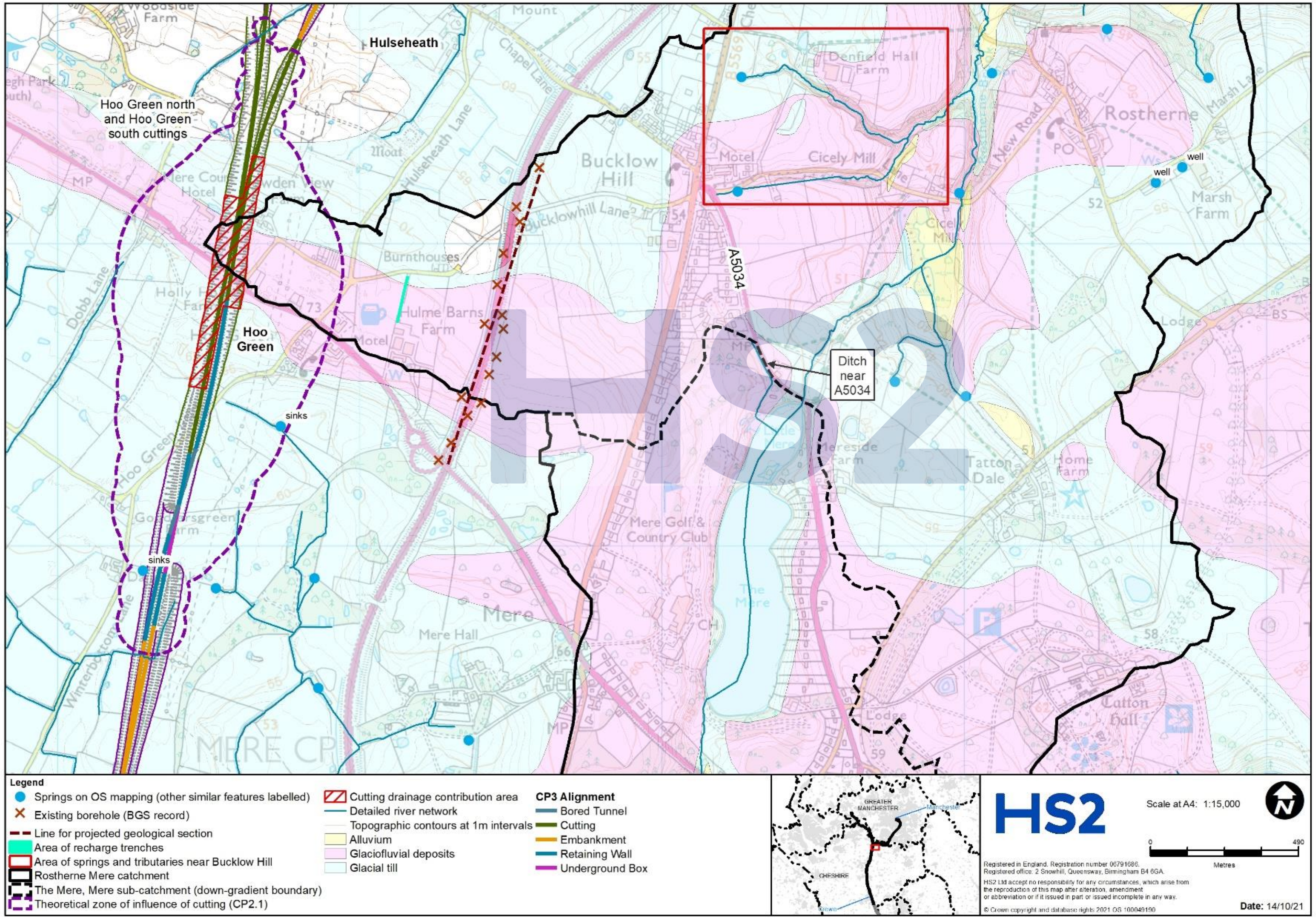
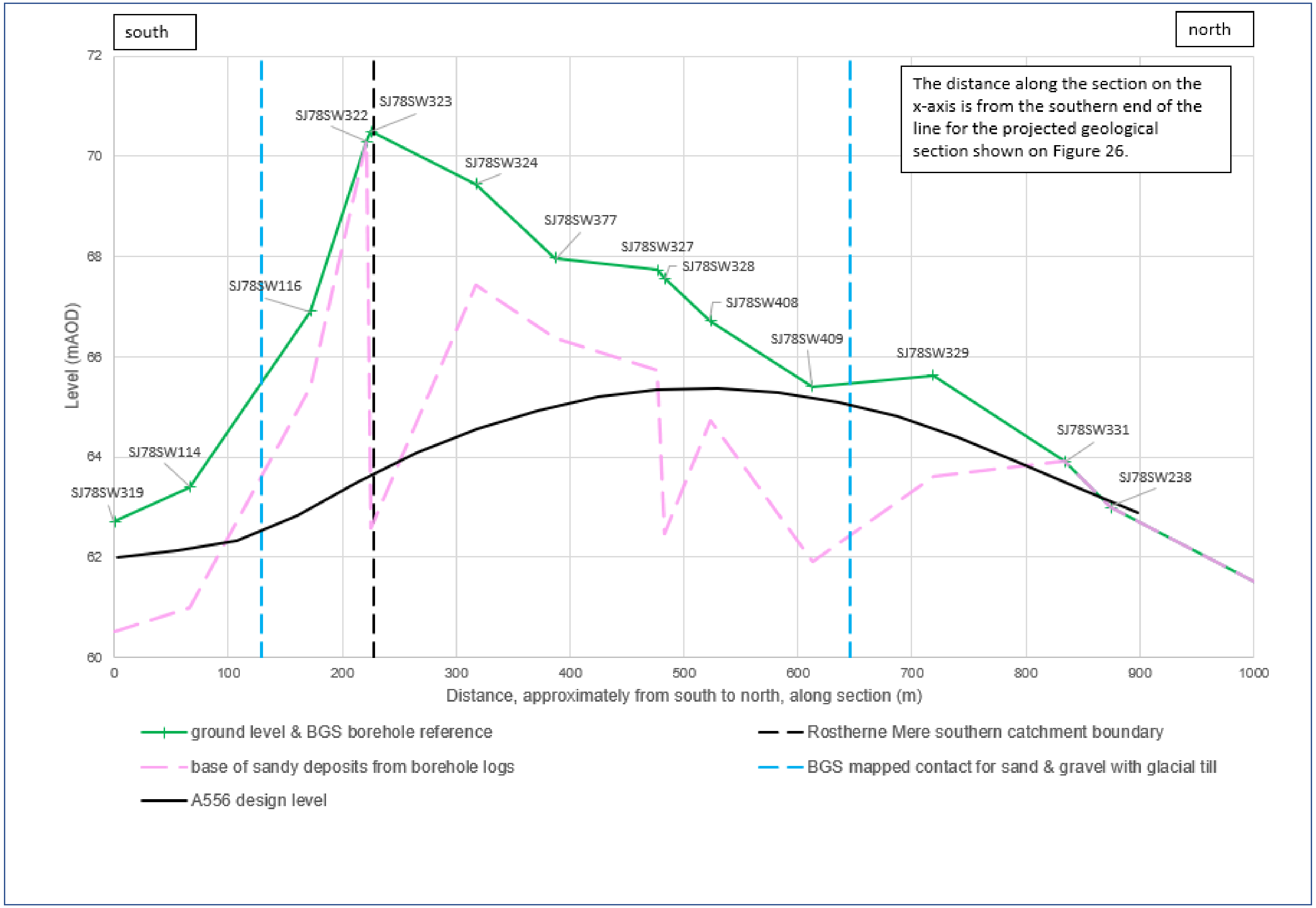


Figure B25: Geological section along the A556



Combined impacts

5.2.26 The possible reductions in mere water level from both sets of Proposed Scheme cuttings are shown in Figure B23 to give the overall maximum potential reduction in mere water level for a total reduction in baseflow of 2.3% for 2018. The rainfall/runoff component of inflow was reduced by 0.4% for the combined simulation. As expected, the results indicate that water levels decline between 4mm – 5mm from April onwards through the late spring and summer months. The decline in water level is again greater in the winter months, increasing up to about 6mm when inflows and water levels are higher. The modelled mere water level hydrographs included on Figure B23, with and without the cuttings in place, demonstrate the marginal impact of the changes in water level due to the cuttings as compared to the total variation in water levels for 2018. As also indicated on Figure B23, there is a total of only five days (in July/August 2018) when the modelled mere water level with The with the cuttings in place falls below the minimum modelled water level in 2018 without the cuttings.

5.2.27 The water balance model was also used to assess the impact of the cuttings on water levels in Rostherne Mere in other years in which particularly dry conditions existed. Figure B26 shows the impacts of the cuttings simulated for conditions in 1996. The combined effect of the two sets of cuttings is to produce a decline in water levels of about 3.5mm – 5mm throughout the period of simulation from February to September 1996. Again, the impact of the cuttings on water levels is marginal when compared to the total variation modelled for 1996. There is a short period of six days (in August 1996) when the modelled mere water level with the cuttings in place falls below the minimum modelled water level for 1996 without the cuttings.

5.2.28 The water balance was also simulated for the 1976 drought year to assess the impact of the cuttings. As already discussed, the simulated outflow from Rostherne Mere is lower in the summer of 1976 than in 1996. The impact of the combined sets of cuttings are, however, similar, with water levels declining by about 3.5mm – 4.5 mm, as shown on Figure B27. Impacts on water levels are again marginal when compared to the total variation in water levels for 1976. There is a total of ten days (in August/ September 1976) when the modelled mere water level with the cuttings in place falls below the minimum modelled water level for 1976 without the cuttings.

5.2.29 In both 1976 and 1996, the impact of just the Millington and Rostherne cuttings is to produce a decline in mere water levels of up to 0.6mm, similar to the late spring and summer in 2018.

5.2.30 As already indicated, it was not possible to simulate a direct rainfall component on Rostherne Mere for 2018 owing to the lack of currently available rainfall data. However, daily catchment rainfall data was available from the NRFA website for years up to 2015 at the time of assessment, and the potential impact of direct rainfall was assessed for 1976 and 1996.

5.2.31 Daily catchment rainfall is available for the Dunham Massey gauging station located in the lower Bollin catchment, and for the Wilmslow gauging station on the River Bollin and the Stanneylands gauging station on the River Dean further up the catchment. The catchment rainfall data for the Dunham Massey gauging station includes rainfall for the catchments of the gauging stations further up the catchment. As Rostherne Mere is located in the lower part of the Bollin catchment, a more appropriate daily rainfall record for the Rostherne Mere catchment was created for 1976 and 1996 by subtracting the total daily rainfall volumes over the gauging station catchment areas upstream of Wilmslow and Stanneylands from the total rainfall volume over the entire catchment area upstream of Dunham Massey. The resulting total rainfall volume for each day was divided by the area of the catchment downstream of Wilmslow and Stanneylands to give a daily rainfall record for the lower part of the Bollin catchment. The record was then applied over the area of Rostherne Mere (approximately $0.5km^2$) to give an additional, direct rainfall, inflow component in the water balance model.

5.2.32 The water balance model was rerun with the direct rainfall component added for both scenarios, with and without the sets of cuttings. Figure B26 and Figure B27 include the decline in water levels as a result of the cuttings, taking into account direct rainfall. In both cases, the decline in water levels with the cuttings is reduced when direct rainfall is taken into account. This is because the cuttings have no impact on the direct rainfall component of the water balance. However, for both 1976 and 1996 the reduction is minor, generally up to about 0.5mm, with a maximum of about 0.8mm in September 1996. The mere water, also included in the figures for the simulation with the direct rainfall component, rises by up to about 100mm as a result of direct rainfall in late September 1976.

5.2.33 The assessment of the impact of direct rainfall does not necessarily mean that the actual decline in mere water level would be less than indicated without direct rainfall. As direct rainfall is missing as a component in calibration for 2018, the effects of direct rainfall are assumed to be accounted for in the calibration. Therefore, by implication, the effects may also be taken into account in the model simulation without the direct rainfall component for 1976 and 1996. What the assessment does indicate, however, is that direct rainfall is a component of the water balance which has a minor impact on the effect of the cuttings in periods of dry weather and low water levels.

Figure B26: Impacts of cuttings on water levels – Rostherne Mere (1996)

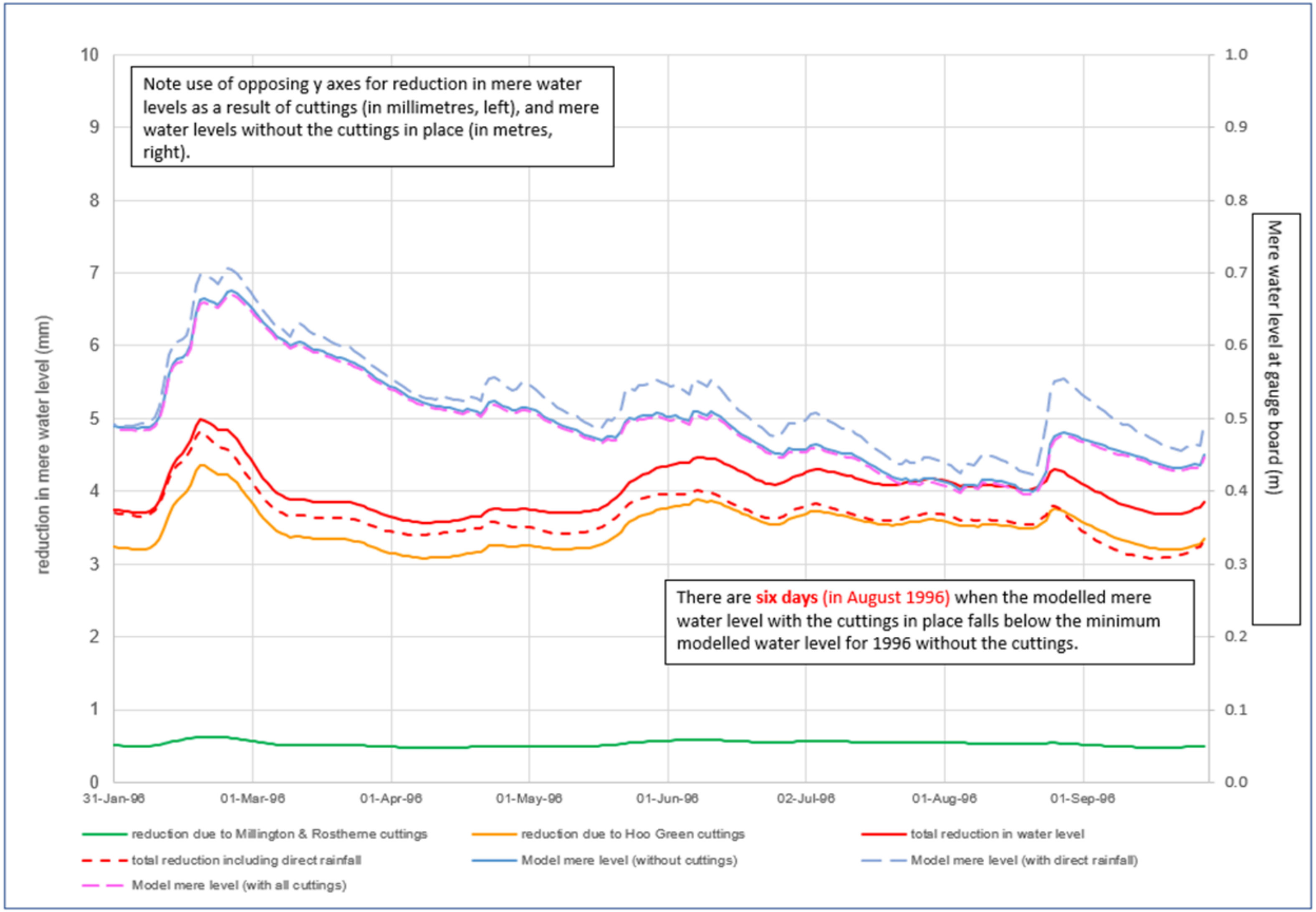
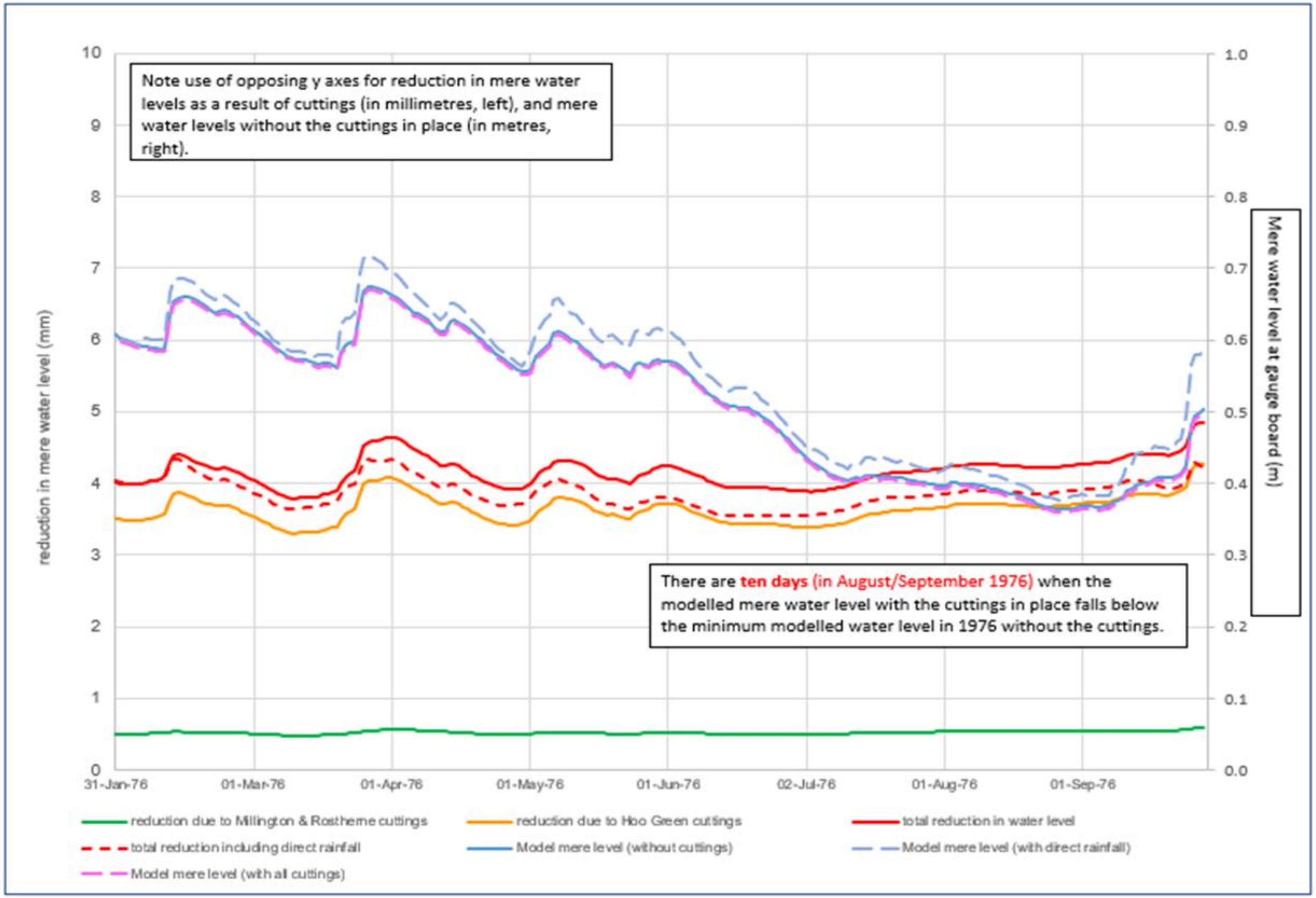


Figure B27: Impacts of cuttings on water levels – Rostherne Mere (1976)



5.3 Results of assessment

5.3.1 The results of the water balance assessment in dry to extremely dry years, represented by 1976, 1996 and 2018, are as follows:

- water levels in Rostherne Mere decline by a maximum of about 0.6mm from April onwards through the late spring and summer months as a result of the presence of the Millington and Rostherne cuttings, increasing to about 0.8mm in the winter period in 2018 when inflows and water levels are higher. However, water levels may be unaffected by the presence of the cuttings in the driest summer weather as seepages in the fields above Gale Bog and near surface discharge in Mere Covert dry up;
- water levels in Rostherne Mere could decline by about 3mm – 4mm from April onwards through the late spring and summer months as a result of the presence of the Hoo Green cuttings, increasing slightly in the winter period when inflows and water levels are higher; and
- the combined effect of the two sets of cuttings could be to produce a decline in water levels in Rostherne Mere of 4mm – 5mm from April onwards through the late spring and summer months. The decline in water level would generally be slightly greater in the late autumn, winter and early spring periods when inflows and water levels are higher. Overall, the impact of the cuttings on water levels is marginal when compared to the total variations modelled. The model results also indicate there would only be short periods in any year in which the mere water level, with the cuttings in place, would fall below the minimum water level for that year without the cuttings. These short periods would vary between a total of about five and ten days in each drought or dry year similar to 1976, 1996 or 2018.

5.3.2 As indicated previously, the results of the water balance modelling may not be precise and accurate. However, they do indicate that:

- the Millington and Rostherne cuttings are likely to have an impact of less than one millimetre on water levels in Rostherne Mere, and potentially no impact in particularly dry conditions;
- the Hoo Green cuttings may have an impact of a few millimetres (up to about 3mm – 4mm) on water levels in Rostherne Mere in dry or very dry conditions. However, this impact could be reduced depending on:
  - the actual directions of drainage and groundwater flow in the surface water catchment area to the west of The Mere, Mere; and
  - the impact which the new A556 Chester Road has had on groundwater flow and the existing drainage systems in the area.
- in addition, the calculation of a reduction in inflow of 2% to Rostherne Mere is based on the area of the Rostherne Mere catchment down-gradient of The Mere, Mere sub-catchment. There was no outflow from Little Mere at the downstream end of The Mere,

Mere in late July 2018. However, at the meeting in August 2019, local councillors indicated that this had never been known to occur previously. In general, therefore, there will be surface water flow from The Mere, Mere sub-catchment contributing to the Rostherne Brook and Rostherne Mere, and possibly a sub-surface groundwater contribution to the down-gradient catchment. As a result, in all conditions apart from the summer in 2018, the reduction in inflow to Rostherne Mere of 2% is likely to be an over-estimate based on the down-gradient catchment area. It may give rise to a significant over-estimate of the resulting change in water level in Rostherne Mere in all historical conditions apart from the summer in 2018;

- overall, the total impact of the cuttings, producing a decline in water levels of 4mm – 5mm in dry or very dry conditions, is marginal when compared to the total variations in water level modelled for Rostherne Mere. The reduction in water levels would almost certainly be undetectable, taking into account the existing variations between seasons and from year to year, together with the limitations for accurate measurement in natural surroundings and site conditions. The total impact on water levels might also be less than the temporary impact of reed cutting if carried out in the discharge channel from Rostherne Mere. Reed cutting may reduce the effect of the vegetation in partially impeding outflow and maintaining a marginally higher water level in the mere;
- the reverse flow events occurring from time to time in Blackburn's Brook may also produce minor changes in the channel which have an impact on the relationship between water levels and outflow from Rostherne Mere;
- as discussed in the assessment of potential hydro-morphological impacts (see Section 8.2), a 5mm reduction in water level was assessed as a reasonable worst-case using the 2004 bathymetry survey. The analysis predicts that, as a broad indication, the loss of mere surface area would be approximately 0.05ha, or 0.1% of the total surface area of the mere, at the time of the survey; and
- the model results also indicate there would only be short periods in any year in which the mere water level, with the cuttings in place, would fall below the minimum water level for that year without the cuttings. These short periods would vary between a total of about five and ten days in each drought or dry year similar to 1976, 1996 or 2018.

5.3.3 The evidence from the field visits and information from a local stakeholder indicates that the flows in Mere Covert would not be affected by the Proposed Scheme. As indicated in Section 4, the two seepages referred to in May 2018 were very small and unlikely to be affected by the zone of influence of the Rostherne cutting.

5.3.4 The main flow in the centre of Mere Covert is understood to originate as surface or near surface drainage in the fields above Mere Covert. Contouring at 1m intervals indicates that the area around the Rostherne cutting is one to two metres lower than the elevations at the watershed of the Rostherne Mere catchment above Mere Covert. As a result, surface water in the area around the cutting would be expected to drain towards the north rather than to Rostherne Mere. Therefore, the presence of the cutting would not affect the flow in Mere

Covert, although the directions of drainage within the area may also be controlled by the depth of any field drains and drainage connections.

6 Groundwater and seepages north of Rostherne Mere

6.1 Background

6.1.1 The superficial geology in the vicinity of the Proposed Scheme is shown in Figure B2. A review of publicly available information from the geological logs of some existing boreholes[1] in the vicinity of the cuttings indicate a sand and gravel layer at the base of the glacial till. The boreholes were constructed in connection with highways schemes in the area. The sand and gravel layer, with a thickness from 7m – more than 10m, is located below approximately 10m of silty sandy clay deposits. Recorded water levels within the upper glacial till range from 3mbgl – 9mbgl (24mAOD–36mAOD) which is higher than the levels of Rostherne Mere (20mAOD – 21mAOD). Recorded water levels in the basal sands and gravels ranged from 19mAOD – 24mAOD.The initial conceptual understanding of the hydrogeology on the northern side of Rostherne Mere in the vicinity of the Millington and Rostherne cuttings is that if the sand and gravel layer extends as far as Rostherne Mere, then groundwater within the layer may potentially provide a small groundwater contribution to the mere.

6.1.2 A hydrogeological study was undertaken to supplement the water balance assessment of the impact of the cuttings on mere water levels. This involved:

- a detailed assessment of the geology for boreholes with data available on the BGS website which are located around the cuttings and between the cuttings and Rostherne Mere. The assessment included details from many of the boreholes in the area constructed to a depth of 10m or more; and
- use of groundwater level monitoring data for 1991, collected for the A556 (M56 – M6) Improvement Ground Investigation[16].

6.2 Geology of the superficial deposits

6.2.1 The locations of boreholes included in the assessment are shown on the plan in Figure B28, together with individual borehole numbers assigned by BGS. On the BGS website, the numbers shown on Figure B28 are prefixed by SJ78SW, SJ78SE or SJ78NW, depending on whether they are located to east or west of easting 375000, or north or south of Northing 385000. The plan also includes:

- the centreline of the Proposed Scheme;
- an approximate outline of the northern shoreline of Rostherne Mere;

[16] Allott & Lomax for Department of Transport (1992), *A556 (M56 – M6) Improvement – Volume 1 Part 3 of 4, Factual Report on Ground Investigation, D1133*.

- the extent of the Ramsar site for Rostherne Mere which coincides with the outer boundary of Gale Bog on the north side of Rostherne Mere;
- the extent of the Rostherne Mere SSSI;
- the Rostherne Mere catchment boundary;
- the zone of influence for the Millington and Rostherne cuttings; and
- the approximate location of the M56.

6.2.2 For each borehole log, the superficial materials are very variable. However, in a number of boreholes it is possible to identify a predominantly clayey layer above a predominantly sandy layer, although occasional thin bands of sandier material are sometimes present in the upper clay layer. A mix of sandy and clayey layers can also occur below the base of the upper, predominantly clayey layer. For example, the following is a summary of the geological log for borehole 154 from the surface at 31.4mAOD to the top of the Mercia Mudstone at 16.1mAOD:

- clay with a little gravel in places and occasional fine sandy bands (0.2m thick) to 26.0mAOD;
- sandy clay to 25.8mAOD;
- clayey sand, with bands of sandy clay to 24.1mAOD;
- silty fine sand to 21.1mAOD;
- silty fine, medium and coarse sand to 19.1mAOD; and
- silty fine, medium and coarse sand with gravel to 16.1mAOD.

6.2.3 In Figure B29, the level of the base of the upper, predominantly clayey layer is shown for the boreholes. No level is given for boreholes where there is no upper clayey layer. The levels of the base of the Proposed Scheme track filter drainage, and approximate contours at 5m intervals between the Proposed Scheme and Rostherne Mere and for the boundary of Gale Bog, are also included on the figure. The figure has also been extended to include the area of the Rostherne cutting to the east of Mere Covert. It shows the potential lowest elevations for sealed carrier drains, which are located below the filter drains in the cutting. The carrier drains are discussed in Section 6.5.

6.2.4 The levels for the base of the predominantly clayey layer demonstrate considerable variability and complexity in the area between Gale Bog and the Proposed Scheme to the north and north west. As shown above, the log for borehole 154 indicates that the base of the clay layer is at 25.8mAOD, approximately 0.9m above the base of the filter drainage (at 24.9mAOD) in the area. For borehole 104, sandy clay was recorded down to 27.15mAOD. For the group of five boreholes, 196 to 200, just to the south of the route, the base of the clay layer varies between 18.3mAOD and 26.9mAOD over a distance of about 100m. Geological logs for four of the five boreholes indicate that predominantly clayey deposits are present down to a level of 22.1mAOD or lower, a minimum of almost 3m below the proposed base of the filter drainage.

Figure B28: Location of boreholes north of Rostherne Mere

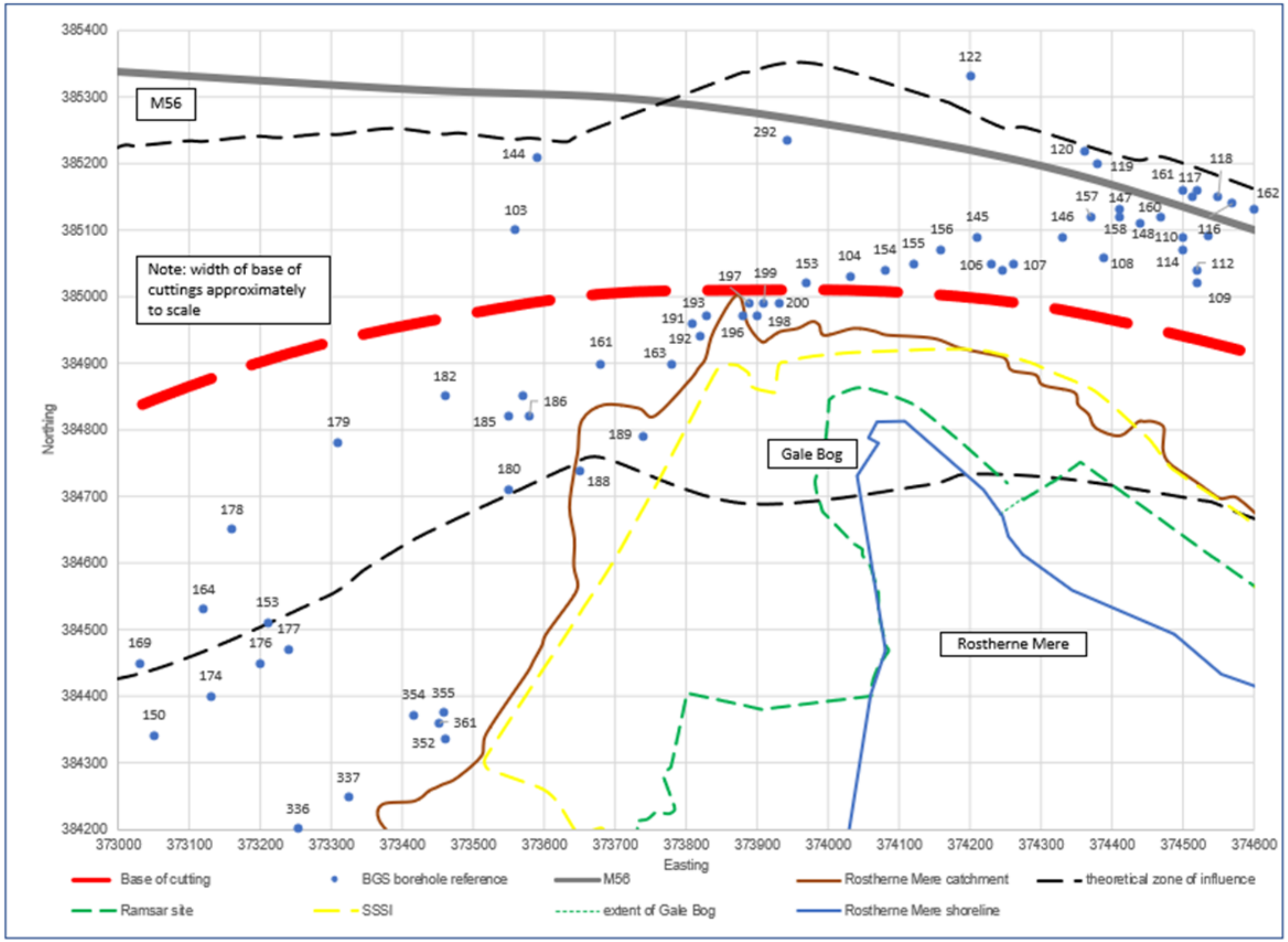
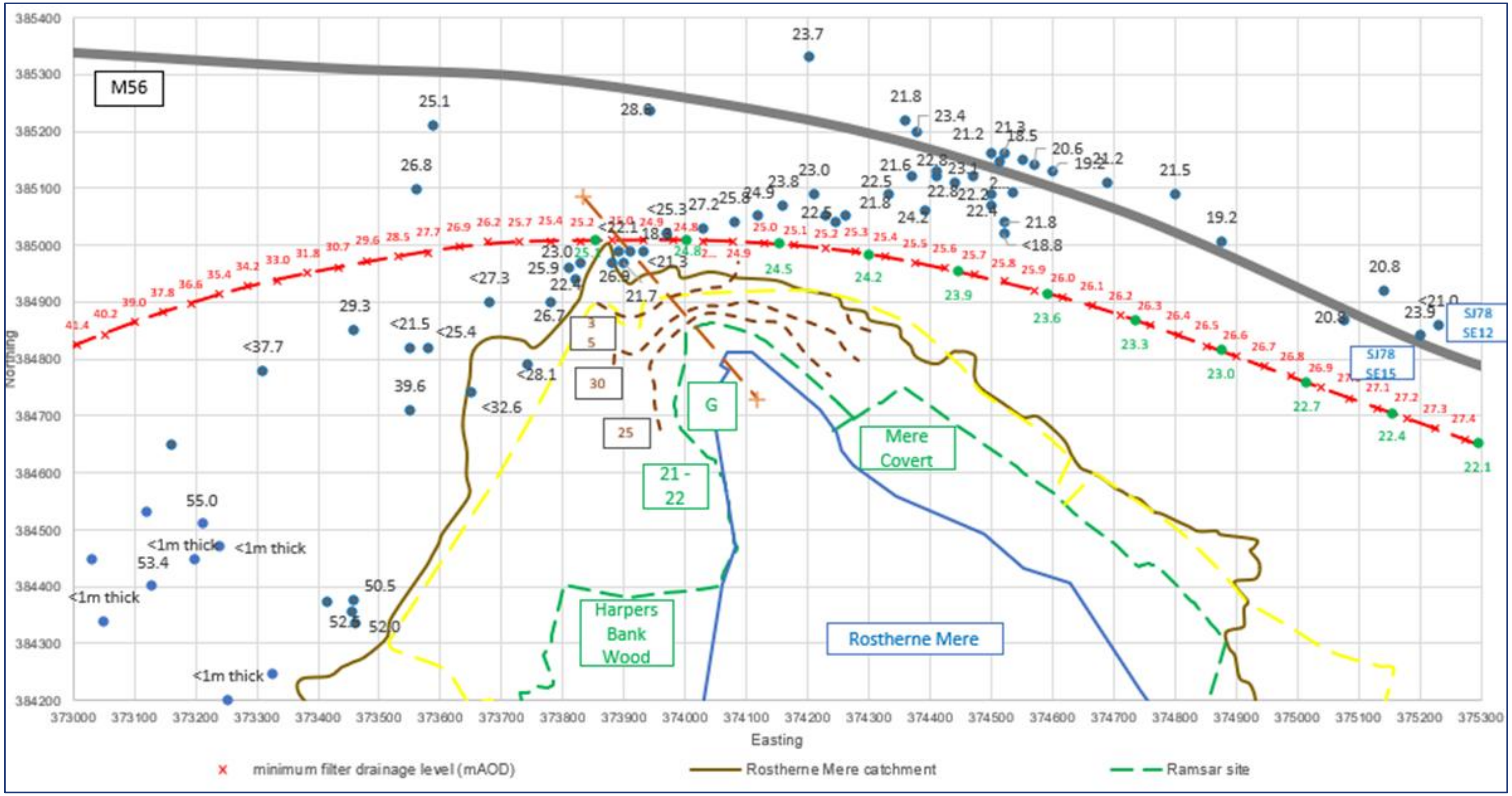


Figure B29: Base of upper clay layer in superficial deposits



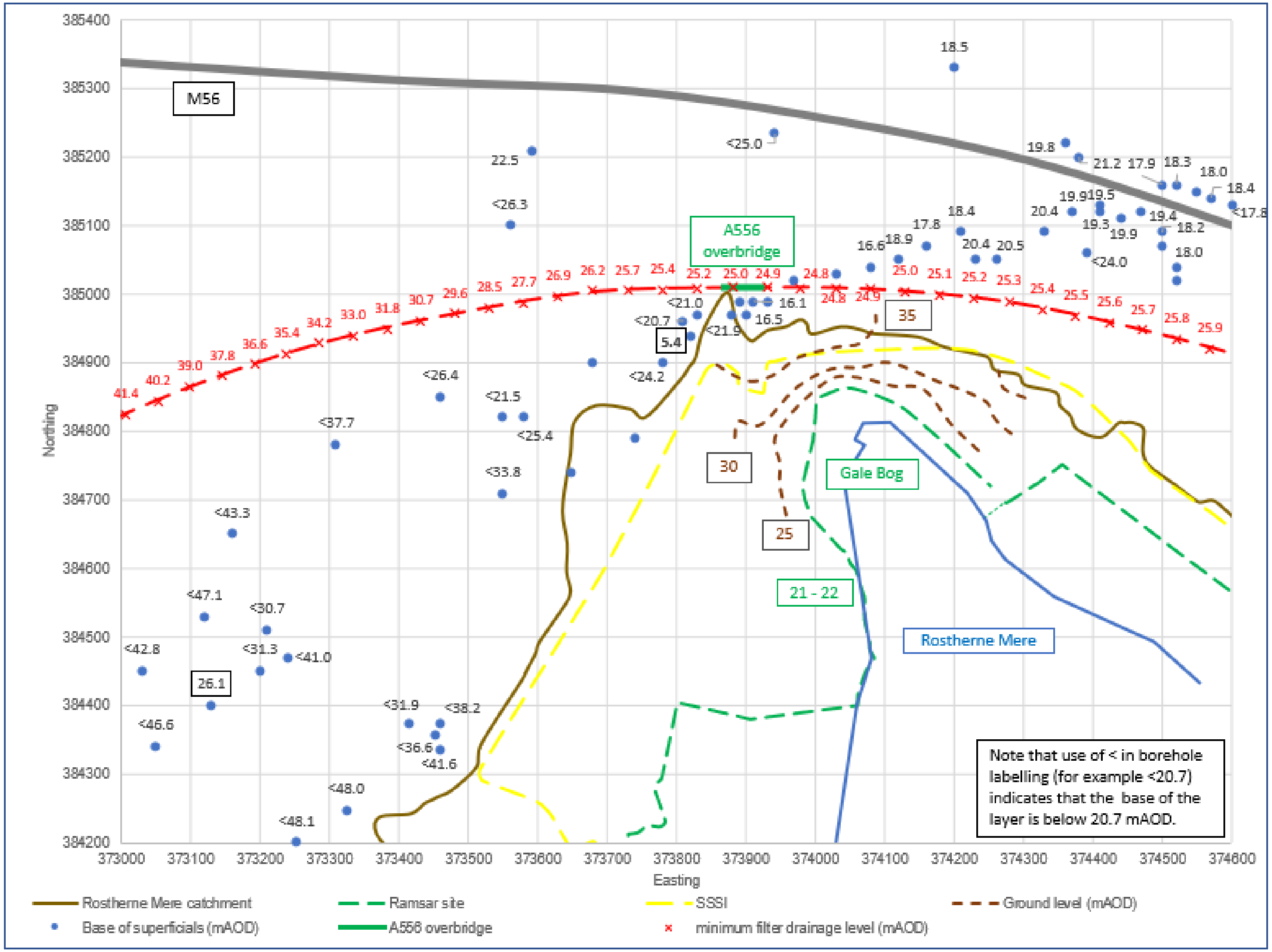
Note that use of < in borehole labelling (for example ,25.3) indicates that the base of the layer is below 25.3mAOD. <1m thick indicates the upper clay layer has less than 1m total thickness.

6.2.5 In addition, although the base of the main clay layer in borehole 154 is shown as 25.8mAOD in Figure B29, the underlying sand is clayey with bands of sandy clay to 24.1mAOD, as indicated in the summary log. The presence of clay in the sand, and bands of sandy clay, will reduce the permeability of the formation substantially at levels below the base of the filter drains. In borehole 104, two bands of silty sand with thicknesses of 0.355m and 0.535m, located below 27.15mAOD, are separated by a 1.4m thickness of clay with a little gravel. The borehole was completed at 24.7mAOD in sandy clay.

6.2.6 Figure B30 shows the level of the base of superficial deposits on the underlying Mercia Mudstone. For many of the boreholes close to the Proposed Scheme, and between the Proposed Scheme and Gale Bog, the base of superficial deposits, generally in sandy deposits, is a few metres below the level of the bog at about 21mAOD – 22mAOD. There is, therefore, the potential for a hydraulic connection between Rostherne Mere and the lower sandy deposits in the superficial deposits. The connection would be through the alluvium indicated on BGS mapping in Figure B6, or other mire and lake bed sediments. However, the occurrence of silts and clays, mixed within the sands, would be expected to reduce permeabilities considerably in many sections of the sands. As a result, the lower sandy deposits are unlikely to be a particularly significant aquifer. In addition, the sandy deposits could be poorly connected hydraulically with the mere or Gale Bog through the alluvium, mire and lake bed sediments. Assuming the sediments include a substantial portion of silty or clayey material from deposition in still water conditions, then the permeability would be low, limiting any inflow or upward leakage from the sands in the glacial till.

6.2.7 For one borehole (192), sands (with a little gravel) extend down to 5.4mAOD, a total depth of more than 30m below the surface. A more deeply eroded, faulted or collapse feature may be present in the Mercia Mudstone bedrock at this location.

Figure B30: Base of superficial deposits



6.3 Groundwater in the superficial deposits

6.3.1 The groundwater level monitoring for the A556 (M56 – M6) improvement investigation was undertaken from July to the beginning of November 199120. Analysis of the hydrograph for the River Bollin at Wilmslow in Figure B10 indicates that the minimum daily flow which occurred in 1991 was very slightly below average when compared to the minimum daily flows in other years. The minimum daily flow was lower than for 1991 in 20 of the 44 years of record at the gauging station.

6.3.2 The lowest flows in 1991 occurred in the period late August to late October. Therefore, over much of the period in 1991 when groundwater levels were monitored, groundwater levels are likely to have been at about (or possibly just below) average levels for a summer/autumn period. Flows in the River Bollin catchment at Wilmslow increased significantly in the final month of monitoring in November 1991. Therefore, groundwater levels might also have risen at the end of the monitoring period.

6.3.3 The range of depths to groundwater for each of the monitoring boreholes in the period July to November 1991 is shown in Figure B31. The maximum groundwater levels, together with the range in levels, are given in Figure B32. Between three and six water level readings are available for each of the monitoring boreholes. Monitoring for each borehole was generally restricted to a period covering two to three months. No boreholes were monitored across the entire period from July to November 1991.

6.3.4 Single piezometers were installed in one metre sections of each borehole, backfilled with granular material. The monitored sections were sealed above and below. The formation being monitored varied, with several of the boreholes monitoring in clays overlying the lower sandy deposits. Hence the levels from these boreholes are unlikely to be representative of groundwater conditions in the sand. Several of the piezometers were also dry during monitoring, indicating that either:

- there was no groundwater in the deposits encountered at that depth; or
- the piezometer was located above the actual groundwater level in the superficial deposits.

6.3.5 To the north of Rostherne Mere, four monitoring boreholes, 104, 112, 145 and 199, provide some indication of groundwater levels in the lower sandy deposits. The groundwater levels for these boreholes are shown in blue in Figure B32. For boreholes 104 and 199, located close to and on either side of the route, the groundwater levels were at a maximum of 25.1mAOD (in 104), and below 25.1mAOD (in 199). However, the piezometer was located against a thin sand layer with clay below in borehole 104, and may not be a reliable indicator of groundwater levels in the sandy deposits across the area. The piezometer was located in a dry formation at the base of the borehole in 199. Nonetheless, the base of track filter drainage between the two boreholes is at 24.8mAOD, indicating that groundwater may be intercepted in the drainage in this area.

Figure B31: Depth to groundwater below surface (July to November 1991)

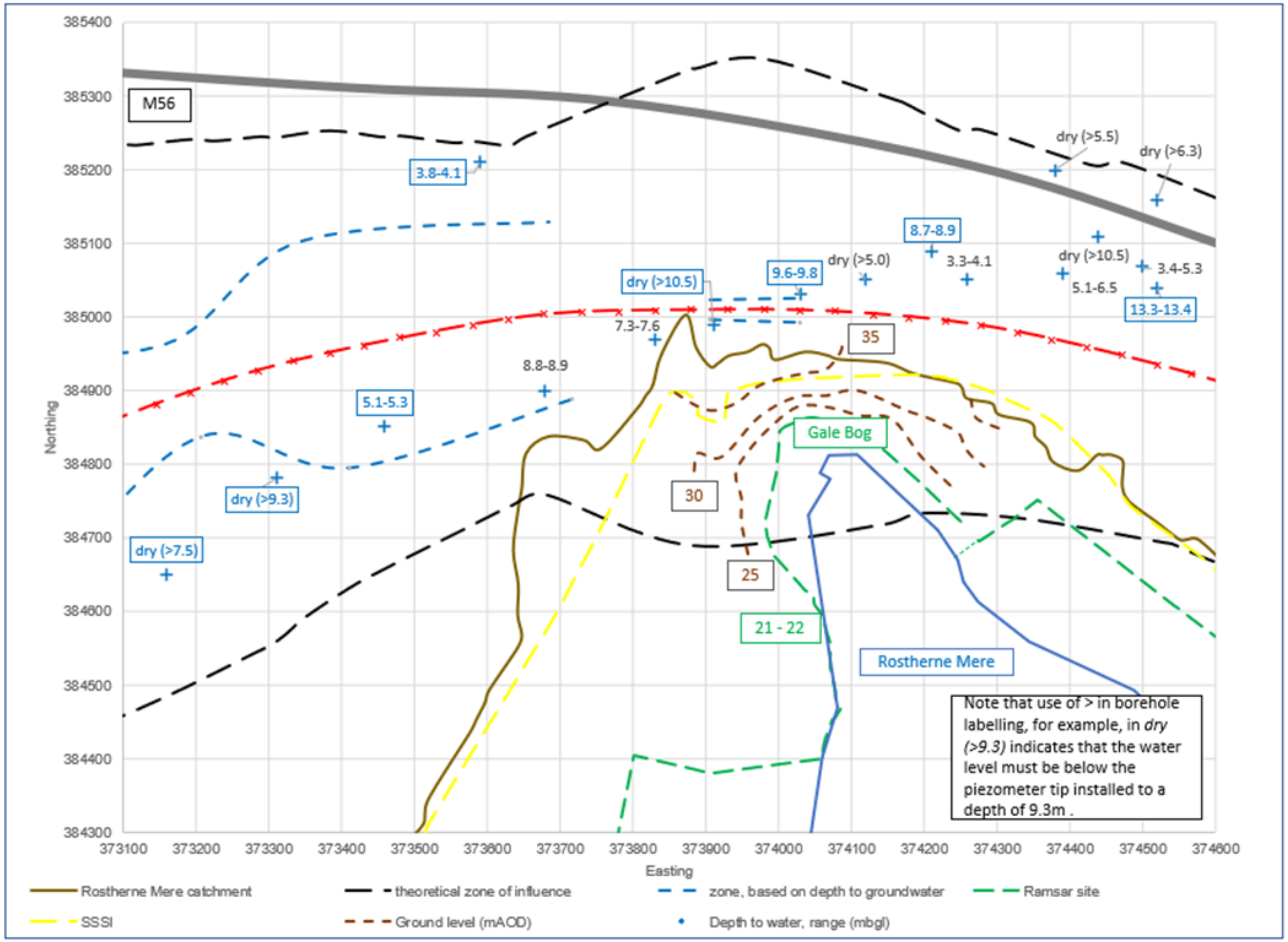
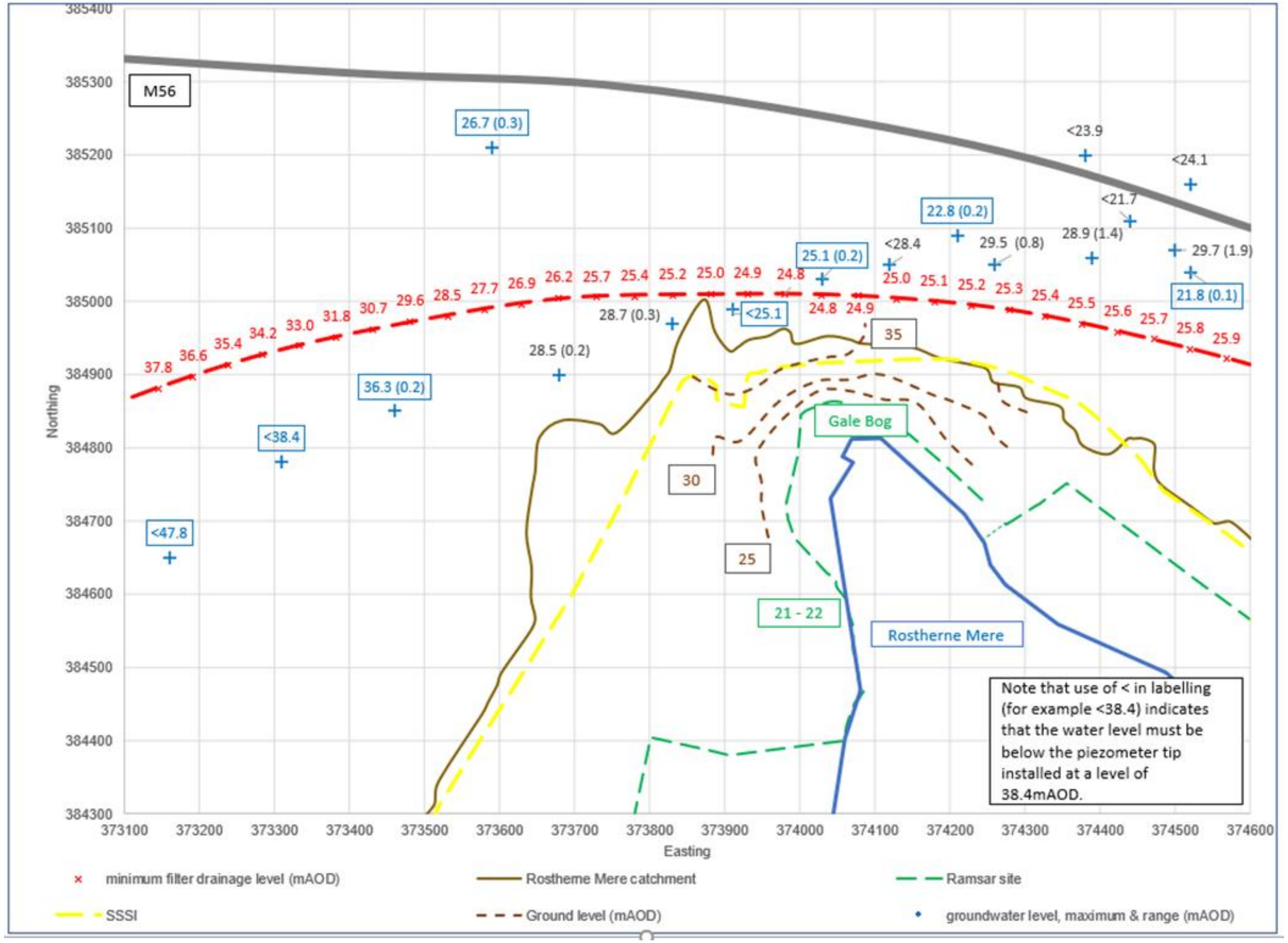


Figure B32: Groundwater levels (July to November 1991)



6.3.6 The piezometer in borehole 145 was located in a more substantial sand layer, with a thickness of 1.6m, at 8.5m below ground level (23mAOD). Interbedded, predominantly clay, gravel and sand layers were encountered below the sand layer, overlying Mercia Mudstone at 18.4mAOD. The maximum water level, 22.8mAOD, is below the base of the filter drainage at the closest point for the Proposed Scheme (25.1mAOD), located about 100m south of the borehole.

6.3.7 The piezometer in borehole 112 was located in a silty sand layer at 13.3m – 15.2m depth, below sediments predominantly comprising clay. A 1m thick layer of sandy clay was found below the silty sand, with the top of Mercia Mudstone at 16.2m depth. The maximum water level, 21.8mAOD, is also below the base of drainage of the Proposed Scheme at the nearest point (25.7mAOD), again about 100m from the borehole.

6.3.8 The monitoring data indicates that the Proposed Scheme filter drainage could intercept some groundwater in average summer/early autumn conditions. This interception might increase in winter months when groundwater levels are higher. However, the evidence from the site visits is that groundwater seepages in the slopes above Gale Bog, down to an elevation of 21mAOD to 22mAOD, ceased in the summer in 2018. Based on a comparison of the minimum flows in the River Bollin at Wilmslow for 1991 and 2018 (see Figure B10), in the drier conditions in 2018 it seems very likely that the groundwater level in the lower sandy deposits would fall below the level of the base of the drainage in the vicinity of the cuttings. Hence, in drier conditions such as in 2018, the drains in the cuttings are likely to be dry. The drains should not, therefore, affect any minor groundwater discharge at a lower level (below 21mAOD – 22mAOD) into Gale Bog or Rostherne Mere, in the event that any such discharge does actually occur.

6.3.9 In average conditions as in 1991, or in wetter periods, there is unlikely to be a discernible impact on any minor groundwater discharge into Gale Bog or Rostherne Mere, if any such discharge does actually occur. At present, higher groundwater levels in any sandy horizons in the glacial till, above the proposed base level for the filter drainage, may give rise to increased discharges in seepages located in the slopes above Gale Bog. The presence of filter drains in the cuttings could reduce the current discharge from these seepages, or might cause some of the seepages to dry up.

6.3.10 Seepages in the slopes above Gale Bog, at elevations below the base of the filter drainage at 24.8mAOD, might not dry up in approximately average summer/early autumn conditions, as in 1991, as a result of the presence of the cuttings. The impact on the seepages is dependent on the hydraulic gradient between the area of the cuttings and the slopes. If the gradient is shallower, such that the groundwater level in the slopes remains above 21mAOD when the level drops below the base of the drainage in the cuttings, then all the seepages are unlikely to dry up as a result of the drainage. If, however, the groundwater level in the slopes declines to about 21mAOD when the level around the cuttings remains above the base of the drainage, then all the seepages in the slopes could dry up as a result of the drainage.

6.3.11 A section through the area around the Proposed Scheme cuttings, the slopes above Gale Bog, Gale Bog and the northern part of Rostherne Mere is presented in Figure B33. The location of the section is shown on Figure B29. The section in Figure B33 includes:

- an approximate cross section through the Proposed Scheme, including the filter drainage in the base of the cutting;
- four lines of piling for the proposed A556 Chester Road overbridge shown in plan on Figure B30. The overbridge is located on the section. It should be noted, however, that the piling extends a distance of only 40m along the route and will therefore have an impact on groundwater conditions over a relatively small part of the cuttings. The impact of the piling is discussed separately in Section 6.6;
- topography, demonstrating the steepness of the slope above Gale Bog in relation to the plateau area in which the Proposed Scheme is located. In addition, it can be seen that the cuttings in this area are located close to the watershed between the Rostherne Mere catchment and the catchment of a tributary of the River Bollin to the north-west;
- the approximate position of seepages in the slopes above Gale Bog. The range of levels has been determined using a photograph showing areas of wetland species in the slope close to the location of the section. The photograph was taken on the site visit in late July 2018 when, as indicated in Section 4.2, there was no evidence of any discharge from seepages in the area. It is included as Figure B34;
- Rostherne Mere water levels are included for two contrasting times:
  - late July 2018 when the water level on the gauge board at the boat house was at its lowest seen during visits to the site (0.41m);
  - late October 2019 when the water level, monitored using a logger installed a few weeks earlier, peaked at a reading equivalent to 1.37m on the gauge board; and
  - the precise water levels for the mere are not known as the elevation of the gauge board (in mAOD) is not known. However, the approximate levels in Figure B33 are based on gauge board readings and the observation that Gale Bog was very wet during a visit by the ecology team in late July 2019. They also tie in reasonably well with an observation by Natural England that low lying areas at the base of the slopes behind Gale Bog were inundated during a visit on 18 November 2019. The logger data indicates that the water level on the gauge board would have been about 1.0m at the time of the visit;
- the maximum groundwater level (from borehole 104) in the period July to November 1991;
- illustrative borehole logs are included for three of the boreholes for which BGS holds geological data. The locations of the boreholes are shown on Figure B28. The offset of each borehole location from the section is included with each borehole number. Although borehole 196 is shown as closer to the base of the cutting, borehole 199 is much closer to the section (offset 5m compared to 40m for borehole 196) as indicated in the borehole labels; and

- the sections in the borehole logs are divided according to the dominant component ranging in increasing permeability from clay (in blue), through silty and sandy clay (red) to clayey and silty sand (orange), and sand (yellow). A substantial layer of silty sand and gravel (orange dashed fill) is also included for borehole 196. The bedrock Mercia Mudstone is shown in black.

Figure B33: Hydrogeological section north of Rostherne Mere

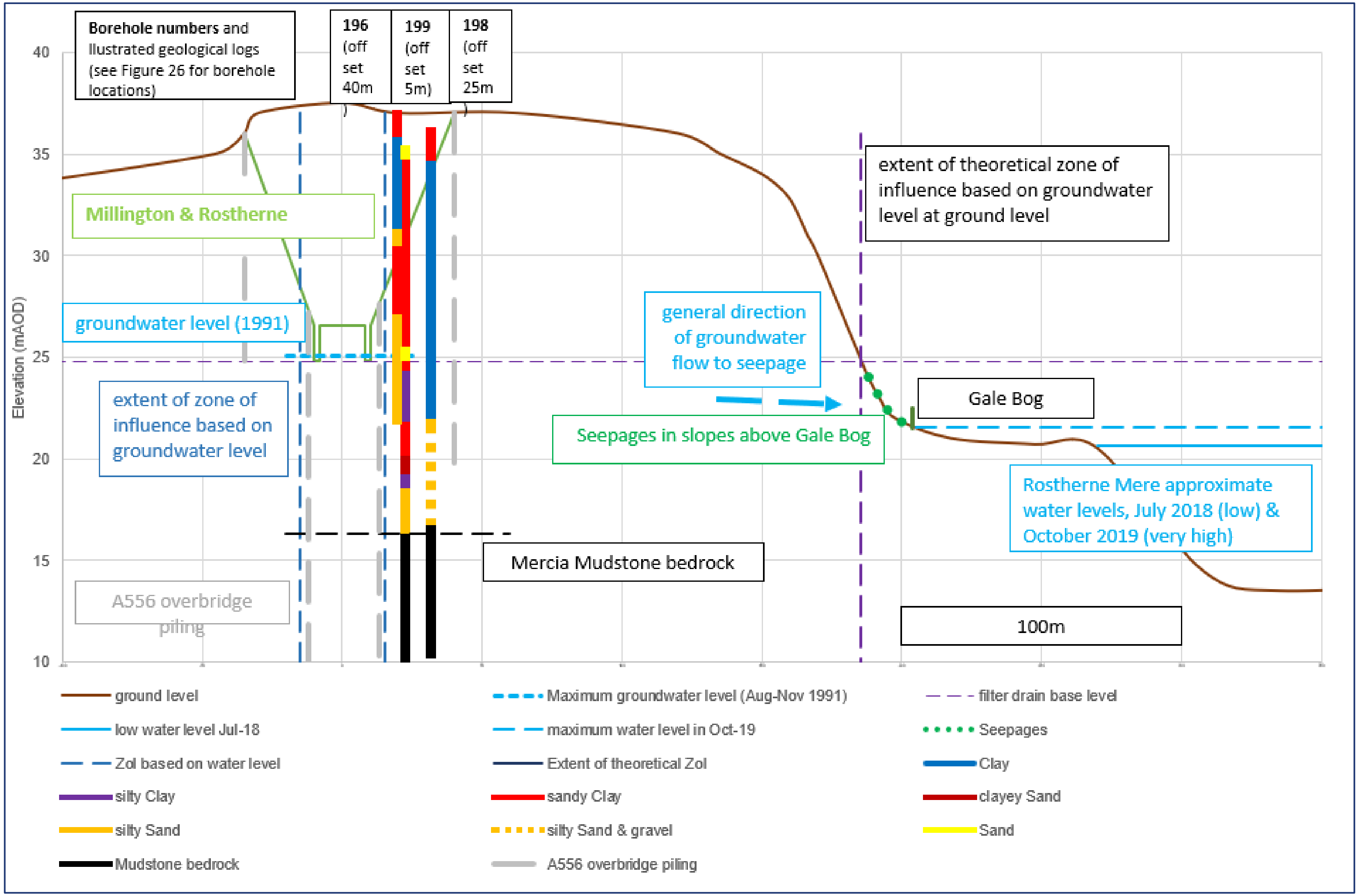


Figure B34: Slope above Gale Bog (July 2018)

6.3.12 The illustrative borehole logs demonstrate that much of the superficial deposits on or close to the section, within the extent of the cutting on the southern, Rostherne Mere side, is likely to comprise low permeability materials to a level below the base of the cuttings. If groundwater does move from the area of the cuttings in the direction of Rostherne Mere, this is likely to occur via convoluted routes in interlinking silty sands, sands and some more gravelly layers. In addition, the difference in elevation between the groundwater level close to the cuttings and the top of the seepage zone on the slopes above Gale Bog is small. The low discharges of seepages seen in the slopes above Rostherne Mere may well reflect the impediments to groundwater flow and the low groundwater gradient. Alternatively, the seepages could originate as recharge over the plateau area between the route of the Proposed Scheme and the slopes above Gale Bog.

6.3.13 In summary, the presence of the proposed cuttings may have an effect on seepages, depending on the directions of groundwater flow between the cuttings and the slopes above Gale Bog. However, as already discussed, once the groundwater level in current conditions falls below the level of the base of the filter drains, the cuttings would cease to have any potential impact on the seepages.

6.3.14 Water levels in the soil underlying Gale Bog are likely to be linked closely to water levels in Rostherne Mere when the mere water level is at or below the ground level in the bog. When

Gale Bog is inundated/ flooded, the surface water level would be the same as for Rostherne Mere.

6.4 Reassessing the zone of influence of the cuttings

6.4.1 As already discussed, the zone of influence of the Millington and Rostherne cuttings, shown on Figure B1 and Figure B2, is based on an assumption that groundwater levels are at ground level. However, the monitoring data collected in 1991 indicates that this is not the case in the area of the cuttings. As shown in Figure B31, the minimum depths to groundwater in 1991 varied considerably and, in many boreholes, was at least 5m below ground level.

6.4.2 Using the data available on Figure B31, it is possible to determine very approximately the likely impact of actual groundwater levels in the average summer/autumn conditions in 1991 on the zone of influence. Data for boreholes with piezometers monitoring sandier horizons below the upper clay layer were used in this assessment.

6.4.3 For boreholes 104 and 199, close to the route of the Proposed Scheme just to the north of Rostherne Mere, the minimum depth to groundwater is 9.6m (in 104). The radius of influence for the section of cutting closest to borehole 104 was reassessed, applying Sichardt's formula (as set out in the SMR) and assuming a maximum water level of 25.1mAOD as recorded for the borehole. Borehole 199 was dry when monitored on three occasions. The radius of influence for the section of cutting closest to borehole 199 was reassessed, assuming a maximum water level at the piezometer tip (also 25.1mAOD).

6.4.4 Boreholes 145 and 112 are about 100m from the centreline of the Proposed Scheme. The radius of influence was calculated at the closest points on the route assuming that the groundwater level (in mAOD) was the same as at the borehole. However, as the maximum groundwater levels (22.8mAOD and 21.8mAOD respectively) were below the base of the track filter drainage at the closest point (25.1mAOD and 25.7mAOD), there would be no calculated radius of influence to the north east of Rostherne Mere.

6.4.5 The depths to water and groundwater levels are shown in blue in Figure B31 and Figure B32 for these boreholes. The resulting extent of the zone of influence is marked on Figure B31 close to boreholes 104 and 199, for comparison with the theoretical extent of the zone of influence. Using the actual groundwater levels from 1991, the calculated zone of influence may extend laterally only as far as 10m, or possibly less, to either side of the centreline of the Proposed Scheme. Allowing for the assumptions and approximations in calculation, the actual zone of influence is likely to be very substantially reduced in comparison with the theoretical extent of the zone of influence. Further east, there may be no zone of influence for the cutting drainage, assuming that the water levels for boreholes 145 and 112 are applicable to the closest points in the cutting. There is, however, no reliable monitoring data for the sands underlying the upper clay layer in the immediate vicinity of the route in this area, in order to confirm the water levels along the route.

6.4.6 A similar approach was used to assess the zone of influence based on actual groundwater levels for the Millington cutting to the west of Rostherne Mere. In this area there are no boreholes in close proximity to the route. However, four boreholes with piezometers located in sand, silty/clayey sand and sandy clay (144, 178, 179 and 182, depths to water also shown in blue in Figure B31 and Figure B32 are located within about 200m of the centreline of the Proposed Scheme. From a plateau area to the east of the Agden Brook crossing, the section of the route descends a slope to the north east, as can be seen from the contouring in Figure B6. As the slope is reasonably uniform across the area, it is assumed the depth to water encountered in each borehole would also be encountered along the cutting at the location where the current ground level is approximately the same as at the borehole. This very approximate assessment again produces a substantial reduction in the extent of the zone of influence.

6.4.7 In conclusion, the data available from boreholes which were monitored in 1991 allows a very approximate reassessment of the potential zone of influence of some areas of the cuttings based on actual groundwater levels. The reassessment is not considered to provide an accurate definition of the zone of influence. In addition, the extent of the zone of influence would increase in higher groundwater level conditions. However, the analysis does indicate that the actual zone of influence of the cuttings is likely to be substantially smaller than the theoretical zone of influence produced with the original calculations. In addition, the zone of influence is very limited in area along the section of the route closest to Rostherne Mere. As a result:

- the impact on any groundwater throughflow in sandier deposits, close to the base of the filter drains to the north of Rostherne Mere, is also likely to be very limited; and
- fewer seepages should be affected, with a reduction to discharges only from seepages in the slopes around the northern part of Gale Bog.

6.5 Carrier drains below Rostherne cutting

6.5.1 Two deeper sealed carrier drainage pipes and connecting manholes have been included in the drainage design below the Rostherne cutting and filter drainage in the CP3 Proposed Scheme design, to convey the drainage water away to a discharge point on Blackburn's Brook. The diameter of the pipes in the design increases from 1,125mm to the north of Rostherne Mere, to 1,200mm near Blackburn's Brook. Assuming that installation of the carrier drainage pipes takes place in a supported trench, excavated below the base of the cutting, construction of the trench and installation of the pipes is likely to require some temporary dewatering to the invert for the carrier drains. The dewatering would use pumps located in sumps in the trench. Excavation of the trench, installation of the pipes and backfilling would be undertaken in sections. Although only an estimate at this stage, completion of these works should proceed at a rate of about 100m per week. Note, for comparison, that Figure B29 is divided into 100m grid squares.

6.5.2 Potential invert levels for sections of the carrier drain below the Rostherne cutting are included in Figure B29, together with the invert levels for the filter drainage in the cuttings. Carrier drains are located on either side of the cutting. The invert levels are for the lower of the two carrier drains.

6.5.3 The more extensive of the two carrier drains could intercept the cutting filter drainage to the north west of Rostherne Mere, at an elevation of about 25.1mAOD. From that point, the alignment of the carrier drain falls steadily to the east along the line of the cutting. The most easterly point indicated for the drain on Figure B29 is at 22.1mAOD, about 5.3m below the base of the filter drainage in the cutting. This is above the level of Rostherne Mere (at approximately 21mAOD). The discharge point for the carrier drain to Blackburn's Brook, located about 250m south east of the drain elevation of 22.1mAOD on Figure B29, is at a level of 21.0mAOD.

6.5.4 Taking into account the expected rate of progress of these works, if dewatering is required during construction, then the temporary impact on groundwater would not be expected to significantly exceed the permanent impact of the cutting filter drainage. The assessment of the permanent impacts of the cutting drainage already takes into account the possible cessation of minor groundwater discharges in the slopes behind Gale Bog. Depending on the groundwater level conditions prevailing at the time of construction, dewatering for installation of the carrier drains might also cause the discharges to dry up temporarily.

6.5.5 To the east of Gale Bog, the carrier drains are further from and outside the catchment for Rostherne Mere. The drains are also located behind Mere Covert where the very small groundwater seepages, referred to in connection with the site visit in May 2018, are likely to be localised features. The seepages dried up in the summer in 2018. Figure B29 includes the elevations of the base of the upper clay layer in existing boreholes in the area. No boreholes are located along the route of the Proposed Scheme behind Mere Covert, although several are within about 200m of the route.

6.5.6 With one exception, the boreholes to the east of Mere Covert all indicate that the upper clay layer extends to a level below the invert level on the carrier drain in the vicinity of the borehole. The exception is for borehole SJ78SE15, labelled on Figure B29, in which the base of the clay layer was at about 23.9mAOD; the invert level for the carrier drain in the same area is 22.4mAOD. However, between 23.9mAOD and 19.7mAOD the formation in the borehole is described as clayey sand (with some gravel). The log for borehole SJ78SE12, about 40m from SJ78SE15, describes sandy clay (with a little gravel) to the end of the hole at 21.0mAOD. As previously indicated, therefore, the glacial till can be variable in composition over short distances. Any clay present in sand horizons would be expected to reduce formation permeability and any groundwater throughflow very substantially.

6.5.7 Overall, owing to the presence of clayey materials generally down to the invert level, there may be little requirement for dewatering in the trench to the east of Gale Bog and Mere

Covert. Any impact on groundwater levels due to dewatering associated with the carrier pipe would not be expected to affect the Rostherne Mere Ramsar or SSSI.

6.5.8 The carrier drainage pipes will be installed with a suitable sandy backfill bedding material. The rest of the trench will be backfilled generally with solidly compacted, granular materials. If there is a risk that any groundwater in the vicinity of Rostherne Mere could drain away through the bedding material for the carrier drain, concrete dams or geomembrane could be installed across the lower section of the trench just downgradient of points of significant groundwater inflow. In addition, the trench backfill material could be varied between more and less permeable materials to prevent groundwater draining away in the backfill along the trench. Precise construction details will form part of the detailed design.

6.5.9 The trench backfill material might also affect the continuity of groundwater flow within any sandy layers in the glacial till. The groundwater would, however, be expected to re-establish a flow path through the trench backfill or the bedding material around the carrier drainage pipes. Overall, therefore, the presence of the backfilled trench should have a marginal impact at most on any groundwater flow, particularly close to the northern end of the SSSI where the carrier drains are at their shallowest.

6.6 Piling beneath the A556 Chester Road

6.6.1 As discussed in Section 3, piling for the cutting beneath the A556 Chester Road will go through the superficial deposits and into the underlying Mercia MMG. The piling will effectively form an impermeable barrier in superficial deposits along the section of track beneath the A556 Chester Road overbridge.

6.6.2 The location of the overbridge is shown on Figure B30. Piling for the overbridge, proposed over a distance of about 40m along the cutting, is illustrated on the section in Figure B33. The overbridge is located close to the catchment watershed and just outside the Rostherne Mere catchment where groundwater movement may be occurring to north and south away from the watershed. If, however, groundwater is moving towards Rostherne Mere from this area, the effect of the localised impermeable barrier caused by the piling could be to raise the groundwater level in sandier deposits on the north side of the overbridge and, as a result, potentially produce a minor increase in discharge to the filter drainage. However, as a result of the increase in groundwater level, much of the groundwater would be expected to move around the barrier by extended routes in sandier deposits.

6.6.3 Taking into account the short length of the overbridge and the piling, and regardless of the direction of groundwater flow, the impact on discharges in the Rostherne Mere SSSI due to the piling is expected to be negligible. However, a full assessment of the hydrogeology and directions of groundwater flow will be undertaken at a later stage when site investigation boreholes are installed.

6.6.4 As also indicated in Section 3, only partial retaining walls are likely to be constructed for the retained cut to the south of the existing slip road. The base (toe) of the piles beneath the retaining walls are not expected to extend much deeper than the actual depth of the cut for this section of the route. As a result, any additional impact on groundwater flow in the area should also be negligible.

7 Water resources assessment for The Mere, Mere

7.1 HRA screening report (2012)

7.1.1 The HRA screening report for the Midland Meres and Mosses Phase 1 Ramsar site[17], produced in 2012, includes the following assessments in relation to groundwater contributions to The Mere, Mere:

- five route options were considered for the Proposed Scheme. A table of relevant route options indicates that all these routes are 1.2km from The Mere, Mere at the nearest point. However, some of the options are at a greater distance and are in the vicinity of the Proposed Scheme. For comparison, at the nearest point, the Proposed Scheme is a distance of about 1.7km from The Mere, Mere;
- the route options do not intercept the surface water catchment of The Mere, Mere. However, the screening report indicates that groundwater in the glaciofluvial deposits located to the north west of The Mere, Mere, between The Mere, Mere and the route options, may contribute to The Mere, Mere. The route might cut through or impede the groundwater flows. The report states that the contribution to The Mere, Mere is unlikely to be significant but, in the absence of detailed groundwater flow information, it cannot be discounted. Potential impacts are avoidable through mitigation measures; and
- the screening report indicates that the mitigation measures would comprise groundwater underpass structures filled with granular material. The cutting would be contained in an impermeable box structure to prevent groundwater drainage to the cutting.

7.2 Groundwater conditions west of The Mere, Mere

7.2.1 Figure B24 shows the location of the Hoo Green cuttings, and zone of influence of the cuttings, to the west of The Mere, Mere, together with the superficial geology and detailed topography. The cuttings are located a substantial distance from the surface water sub-catchment of The Mere, Mere. The Proposed Scheme intercepts only the extreme western extent of the Rostherne Mere surface water catchment in an area shown by BGS to be underlain by a narrow band of glaciofluvial deposits.

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[17] High Speed Two Ltd (2012), *Habitats Regulations Assessment (HRA) screening report for the Midland Meres and Mosses Phase 1 Ramsar site*. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/627056/E52_EC-017-001_WEB.pdf.

7.2.2 To the west of the Rostherne Mere catchment, in the area of the cuttings, a ridge between catchments draining to north (Millington Clough) and south (Tabley Brook) is underlain by a continuation of the glaciofluvial deposits. There is no particular reason to consider that groundwater in this area outside the Rostherne Mere catchment would drain to the Rostherne Mere catchment. Groundwater would be expected to drain down-gradient to north and south, to the Millington Clough and Tabley Brook respectively.

7.2.3 As already discussed in Section 5, any groundwater in the Rostherne Mere surface water catchment which would be intercepted by the Hoo Green cuttings is assumed to contribute to the Rostherne Mere catchment. Some groundwater in this area may, however, contribute to the adjacent catchments rather than following a more extended groundwater flow path and direction within the Rostherne catchment. In addition, the A556 Chester Road drainage may also be intercepting some groundwater moving from this area of the catchment towards Rostherne Mere.

7.3 Groundwater flow and discharge

7.3.1 As discussed in Section 3.4, a local parish councillor has been told that land drainage from the area in the Rostherne Mere catchment around the Mere Court Hotel is conveyed by pipeline towards Bucklow Hill. However, the area of this drainage, and the potential for recharge to groundwater to be intercepted by the drainage system, are not known.

7.3.2 In the current conditions, at least some of the groundwater within the zone of influence for the cuttings in the west of the Rostherne Mere catchment may drain down the topographical gradient to the north east. Groundwater could flow towards the boundary with the glacial till to the north of the glaciofluvial deposits, although the flow might also be affected by the A556 Chester Road drainage. Discharge from the zone of influence could occur naturally at the spring in Bucklow Hill. However, groundwater flow to the spring may be restricted by lower permeability horizons in the glacial till, as compared to the glaciofluvial deposits. As a result, some groundwater in the Rostherne Mere catchment might, in theory, move towards The Mere, Mere sub-catchment.

7.3.3 If groundwater does flow towards The Mere, Mere, the discharge location might be in the area of a ditch which runs along the A5034 Mereside Road, north-west of Little Mere, as shown in Figure B24. The ditch drains from north to south along the west side of the A5034 Mereside Road and discharges into Little Mere. There are no springs shown on OS mapping along the course of the ditch, and no other springs indicated in the area. The section of the ditch along the A5034 Mereside Road was observed on two occasions in Spring 2019 (in March and May), when groundwater levels should have been reasonably high following winter recharge. The ditch was found to be dry on both occasions with no evidence of the presence of any groundwater discharge.

Alternatively, it is possible that some groundwater from the Rostherne Mere catchment area to the west might discharge on the western side of Little Mere. However, no springs are shown on OS mapping in the slopes to the west of Little Mere are shown on OS mapping in the slopes to the west of Little Mere.

7.3.4 It seems unlikely therefore that any groundwater from the zone of influence contributes to Little Mere, although it is not be possible to confirm this at present. Groundwater may emerge in springs or might discharge through the base of Little Mere in wetter conditions. A full assessment of the hydrogeology and directions of groundwater flow will be undertaken at a later stage when site investigation data is available.

7.3.5 An assessment has been carried out to determine a theoretical limit of impact on the water level in Little Mere. This theoretical value would be substantially higher than any possible impact on the water level which might actually occur as a result of the presence of the Hoo Green cuttings, taking into account the assumptions made. The assessment utilises:

- the occasional records of flows into Rostherne Mere in the summer 2018 and the modelled inflows based on calibration using these records;
- the observation of no discharge from Little Mere in July 2018; and
- the information provided by local parish councillors at the meeting on 2 August 2019 that in the summer in 2018 the outflow weir from Little Mere was dry for approximately 3 – 4 months.

7.3.6 The methodology applied in this calculation comprised the following:

- the modelled hydrograph for inflows to Rostherne Mere in 2018, based on the correlation with approximate field measurements in Figure B11 and Figure B13, was used to determine the most likely 3 – 4 month period of low flows in which the discharge from Little Mere could have stopped. The period of lowest modelled flows was from the beginning of June – early September, after which flows increased substantially although erratically. A period of 100 days (from 1 June – 8 September) was assumed in which there was no outflow from Little Mere;
- the hydrograph for inflows to Rostherne Mere was used to estimate the baseflow in this period i.e. the component of flow likely to be derived from groundwater discharge in the Rostherne Mere catchment. The following estimates of average baseflow were used:
  - 50l/s for June; and
  - 40l/s for July to early September.
- the average groundwater contribution to the discharge to Rostherne Mere was calculated in the period June to early September 2018 as 8.3l/s/km^2 of contributing catchment, equivalent to 716m^3/d/km^2. The area of the catchment for Rostherne Mere, used for this calculation, assumes no groundwater contribution:
  - from the catchment upstream of Little Mere; and
  - from the catchment area to the west of Little Mere which includes the zone of influence of the Hoo Green cuttings.

- all groundwater flow from the catchment area to the west of Little Mere, which includes the zone of influence of the Hoo Green cuttings, is assumed to contribute to Little Mere rather than to Rostherne Mere;
- it is assumed that the average groundwater contribution to Little Mere from the zone of influence of the Hoo Green cuttings is the same as calculated for the catchment contributing to Rosthern Mere (716m^3/d/km^2 of contributing catchment). The zone of influence of the Hoo Green cuttings has an area of about 0.13km^2 in the Rostherne Mere surface water catchment to the west of Little Mere. Therefore, the contribution from the zone of influence to Little Mere would be 93m^3/d;
- the area of Little Mere is about 0.035km^2. In conditions in which there is no outflow from Little Mere, reducing the groundwater inflow to Little Mere by 93m^3/d would give rise to a reduction in water level of about 2.7mm/d;
- for a period of 100 days in which there was no outflow from Little Mere, the reduction in groundwater inflow would give rise to a total, cumulative reduction in water level of approximately 270mm; and
- there would also be an impact on water levels in periods of outflow from Little Mere. However, this would be minor, probably of the order of magnitude of a few millimetres or less, similar to the impact calculated for Rostherne Mere. As with Rostherne Mere, the impact at times of outflow from Little Mere would be relatively constant and there would be no cumulative impact over a period of time.

7.3.7 Details of this calculation are provided to give an indication of the theoretical limit for the impact on the water level in Little Mere. However, there are several reasons why this impact would not occur. The actual impact is likely to be zero or, at worst, one or two orders of magnitude lower than this theoretical limit. The reasons are as follows:

- groundwater from the zone of influence of the Hoo Green cuttings may not contribute to Little Mere. The zone of influence is not in the surface water catchment for Little Mere. Groundwater flow in the area may follow the topographic gradient, discharging eventually to Rostherne Mere. Alternatively, as discussed in Section 5.2, the groundwater may discharge to the surface water catchments located to north and south of the zone of influence, or may in part discharge through land drainage towards Bucklow Hill. Hence there may be no impact on water levels in Little Mere;
- if any groundwater from the zone of influence does discharge to Little Mere, removing the groundwater contribution would lead to some compensation by groundwater inflow from adjacent groundwater catchments, which would then discharge to Little Mere; and
- if the water level in Little Mere was reduced, it is very likely that additional water would be drawn into Little Mere from the main water body of The Mere, Mere by leakage through the ground between the meres. Hence, any change in water level would be distributed to some extent across the whole of The Mere, Mere waterbody.

7.3.8 The information from local councillors, provided at the meeting in August 2019, that Little Mere was almost filled with sediment and has been dredged in recent years, is also of interest for the assessment. The dredging will have removed substantial amounts of fine sediment which may previously have restricted the leakage of surface water through the mere bed in dry periods. The dredging could explain why there was no discharge over a few months in 2018, compared to the anecdotal evidence that, in previous extremely dry years such as 1976, discharge continued throughout the summer.

7.3.9 Assuming the dredging did give rise to significant leakage losses from Little Mere, the bed of the mere may be located above the water table in underlying superficial deposits in dry periods. The leakage would pass through an unsaturated zone in the top of the superficial deposits before reaching the water table. If this is the case, it is unlikely there could be any groundwater inflow to Little Mere in these periods. Hence, any change in groundwater flow in the groundwater catchment, following the construction of the Proposed Scheme, could have no direct impact on mere water levels in dry conditions.

7.3.10 A possible alternative explanation for the interruption to surface water discharge from Little Mere in 2018 is that the recent installation of drainage in the cutting on the new A556 Chester Road has diverted groundwater away from the catchment. However, this seems less likely to have produced the potentially dramatic reduction in outflow seen in 2018 than the dredging of Little Mere.

7.3.11 A detailed assessment of groundwater conditions will be undertaken as part of geotechnical site investigations, prior to construction of the Proposed Scheme, to provide:

- an understanding of the detailed hydrogeology between the Hoo Green cuttings and Rostherne Mere and The Mere, Mere;
- the likely directions of groundwater flow; and
- groundwater levels close to The Mere, Mere.

7.3.12 One of the main objectives of the investigations will be to determine whether the water levels in The Mere, Mere (including Little Mere) could actually be affected by the Hoo Green cuttings.

8 Assessment of impacts on ecology

8.1 Introduction

8.1.1 This section considers the potential impacts of changes in water level in Rostherne Mere, resulting from the Millington and Rostherne cuttings to the north of Rostherne Mere and the Hoo Green cuttings to the west of The Mere, Mere, on the ecological status of Rostherne Mere. Potential hydro-morphological impacts affecting the shoreline of the mere are discussed. Assessments are provided for the potential ecological impacts on the main water body, the mere margins, Gale Bog and spring-fed flushes in the fields above Gale Bog.

8.1.2 It is uncertain whether the Hoo Green cuttings could affect ecological communities in The Mere, Mere SSSI, given the uncertainty regarding groundwater movement and the potential changes in water level in Little Mere, as discussed in Section 7. As a result, no assessment of the possible impacts on ecology of potential changes in water level are included in this Technical note. A detailed assessment of the ecological data for The Mere, Mere is provided in the Document to inform a Habitats Regulations Assessment for Rostherne Mere Ramsar site and Midland Meres and Mosses Phase 1 Ramsar site.

8.2 Potential hydromorphological impacts – Rostherne Mere

8.2.1 The ecological impact of a change in water levels would be greatest in the margins of the mere where either:

- the distribution of submerged and exposed areas could change; and/or
- the proportionate change in depth would be greatest.

8.2.2 It is possible to approximate the lateral change of water line on the marginal shelf, for a given change in water level, using data from Environment Agency lake macrophyte surveys. The lake macrophyte survey methodology involves an approach where four to eight ‘sections’ are surveyed. Each section should include a 100m ‘perimeter transect’ close to the shoreline, a ‘boat transect’ running perpendicular to the shoreline from the centre of the perimeter transect, and five equally-spaced ‘wader transects’ running perpendicular from the shoreline to 0.75m depth. For each of these sections, the distance from the water’s edge to the point at which water depth is 0.75m was estimated and recorded in July 2018. The distances were not recorded in the previous years of survey (2007, 2012 and 2015).

8.2.3 The lateral change in shoreline in response to a reduction in water level was assessed by assuming a uniform slope in bed level across the marginal shelf between the shoreline and the depth of 0.75m determined in the 2018 survey. The method cannot take into account any natural undulations in the lake bed. In addition, it assumes that the transects surveyed by the Environment Agency are representative of the marginal shelf in the area. However, taking into account these limitations, the assessment should still provide a reasonable indication of potential changes to the shoreline.

8.2.4 The lateral changes in shoreline were calculated for the following options:

- a maximum reduction in water level of 1mm resulting from the Millington and Rostherne cuttings to the north of Rostherne Mere;
- a maximum reduction in water level of 4mm resulting from the Hoo Green cuttings to the west of The Mere, Mere; and
- a combined, maximum reduction in water level of 5mm resulting from the cuttings to the north of Rostherne Mere and to the west of The Mere, Mere.

8.2.5 The results of the assessment for the four areas of macrophyte surveys shown in Figure B3 are presented in Table B9. The approximate lateral movement of the shoreline in response to a maximum water level change of 5mm, resulting from both sets of cuttings, was calculated to be between 80mm and 267mm. The survey which provided the data for this analysis was carried out on 4 July 2018. As can be seen from Figure B15, the water level in Rostherne Mere would have been quite low at the time. It is estimated to have been at about 0.44m on the gauge board at the boathouse. This water level can be compared with a minimum modelled (and observed) level of 0.41m in 2018, and a minimum water level of 0.36m for all years modelled, in 1976.

8.2.6 A second method of predicting the impact of lowering water levels used the 2004 bathymetry survey. The method was used to estimate the total loss in lake area for the modelled reduction in water levels. However, a concern with this analysis is that, although in the survey depths were determined at nearly 700 points, shown in Figure B4, the detailed topography of the lake margins was modelled by extrapolation from these points rather than being observed directly.

8.2.7 A 5mm reduction in water level was modelled as a reasonable worst-case scenario in response to the cuttings using the 2004 bathymetry survey. The analysis predicts that the loss of lake area would be approximately 0.05ha at the time of the survey. This is approximately 0.1% of the total lake area, and about 2.6% of the shelf area above the one metre depth of water. The habitat type affected would represent about 1.5% of the 3.3ha of fringing reedswamp currently estimated for the SSSI, as indicated in the FCT. An additional limitation of the analysis is, however, that there is an inherent level of error associated with modelling a minor change at this scale. The result should only be taken as a broad indication of the potential change to the marginal zone.

8.3 Potential ecological impacts – Rostherne Mere

Macrophyte communities associated with the main water body

8.3.1 As indicated in Section 3.5, the NVC report[4] describes the main body of water at Rostherne Mere as 'extremely species-poor'. Macrophyte surveys by the Environment Agency indicated a consistently species-poor aquatic macrophyte flora. Macrophyte growth is limited to the marginal areas of the lake.

8.3.2 The Joint Nature Conservancy Council (JNCC) description for a 'natural eutrophic lake (*Magnopotamion* or *Hydrocharition*-type vegetation) (habitat type 3150)[18], suggests that characteristic macrophyte species should include pondweeds (*Potamogeton spp*.), spiked water-milfoil (*Myriophyllum spicatum*), yellow water lily (*Nuphar lutea*), and occasional stoneworts (*charophytes*). The FCT lists a similar range of expected species with specific diversity targets to meet Favourable Condition.

8.3.3 Neither spiked water-milfoil nor yellow water-lily are, however, known to occur in Rostherne Mere. No broad-leaved pondweeds (*Magnopotamion*-type vegetation) are currently known to occur in the mere, including all the site-specific target pondweed species listed in the FCT, although the narrow-leaved species Berchtold's pondweed (*Potamogeton berchtoldii*) and lesser pondweed (*Potamogeton pusillus*) have been recorded in low abundance. No free-floating (*Hydrocharition*-type) vegetation is known to be present.

8.3.4 The only stonewort currently known in Rostherne Mere is fragile stonewort (*Chara globularis*), which is present in low abundance. *Chara globularis* is relatively common and widespread with no specific conservation designation. It is a species that can tolerate a relatively high degree of nutrient enrichment, though may be threatened by competition from *Elodea canadensis* and other algae. It is usually found in deeper waters, typically 0.2 to 2m depth but potentially greater. As a result, *C globularis* is highly unlikely to be affected by a change in water level of a few millimetres.

8.3.5 Other characteristic taxa mentioned in the FCT include water-starworts (*Callitriche spp*.). Autumn water-starwort (*Callitriche hermaphroditica*) was recorded in 2007 and 2015. It is relatively uncommon, though widespread in Scotland and the north of England, with no specific conservation designation. The Nationally Scarce short-leaved water-starwort (*Callitriche truncate*) was recorded in 2018. However, given the established distribution of *C. truncata* and its morphological similarity to *C. hermaphroditica*, it is considered highly probable the 2018 *C. truncata* record was a mis-identification.

[18] Joint Nature Conservancy Council (JNCC) (2021), *Natural eutrophic lakes with Magnopotamion or Hydrocharition-type vegetation*. Available online at: https://sac.jncc.gov.uk/habitat/H3150/.

8.3.6 It is highly unlikely that *C. hermaphroditica* would be adversely affected by the minor loss of water depths suggested by hydrological modelling, given that water-starworts are typically found in a range of depths and are often terrestrialised.

8.3.7 Overall, the data from previous surveys suggests these Favourable Condition requirements have not been met at Rostherne Mere. The data is consistent with the view that macrophyte diversity is limited by the effects of excessive nutrient loading and competition from invasive species and algae. However, there is no reason to consider that the present community would be affected significantly by the changes in water level indicated by the water balance modelling. No significant changes to ecological processes would be expected within the open water body of the mere, given that productivity is dominated by pelagic algae.

Rostherne Mere margins

8.3.8 As noted above in Section 4.5, the results of the 2019 NVC survey[2] are broadly similar to the vegetation survey carried out in 2010[4].

8.3.9 The marginal reedswamp communities, and especially S26 *Phragmites australis-Urtica dioica* fen, suggest that the marginal vegetation is associated with eutrophic conditions and varying soil moisture levels which allow species such as common nettle to persist in stands of common reed. S4a *Phragmites australis* swamp can survive in a wide range of water regimes (from 2m above to 1m below the substrate) but performs best where water levels range from +0.5m – -0.2m and with regular cyclical changes in the water regime. It is associated with a range of trophic conditions but is most productive in eutrophic habitats. S13 *Typha angustifolia* swamp at Rostherne Mere occupies a typical position, forming a narrow band between common reed-dominated vegetation and open water. Nationally, it occurs in a considerable range of water depths up to 0.6m and is intolerant of exposure. S13 has affinities with rich fen vegetation of mesotrophic conditions.

8.3.10 The NVC report is in broad agreement with Environment Agency data. The report indicates that the margins are dominated by Phragmites australis, with reed canary-grass (*Phalaris arundinacea*), branched bur-reed (*Sparganium erectum*), common reedmace (*Typha latifolia*), and yellow flag (*Iris pseudacorus*) also recorded.

8.3.11 The marginal species composition is consistent with that described in both the NERC S.41 and JNCC descriptions for natural eutrophic lakes. The presence of these characteristic species can be attributed to their occurrence in shallow waters where macrophytes are less affected by competition from algae.

8.3.12 These characteristic species may all be found growing in shallow water or above the water line on the damp margins of waterbodies. It is therefore considered highly unlikely that they would be adversely affected by a decline in water level of up to 5mm, particularly given the regular natural variation of about 600mm. The spatial distribution of marginal macrophytes may alter slightly in response to the potential hydrological changes. While the predicted 1.5%

decrease in the extent of submerged marginal shelf could result in a decrease in their extent, the ecological tolerance of the species present suggests this may not occur.

Gale Bog

8.3.13 As indicated in Section 6.3, water levels in Gale Bog are likely to be linked closely to water levels in Rostherne Mere. Any changes in the vegetation in response to the Proposed Scheme would be expected to occur as a result of a maximum decline in water level of 5mm in the soil in dry conditions when the mere water level is at or below the ground level in the bog. A slightly greater reduction in surface water level might be expected when the bog is inundated/ flooded.

8.3.14 The swamp and mire communities that best describe the open vegetation both have wide ecological tolerances. S7 *Carex acutiformis* swamp will develop in standing water, as well as areas with high water tables and/or which are periodically inundated (such as hollows in flood meadows). M27 *Filipendula ulmaria-Angelica sylvestris* mire is widespread and varies in response to moisture levels, but is generally dominated by tall robust species that thrive in moist, reasonably rich soils. For these reasons, it is not considered that changes in water levels of the expected magnitude would cause changes in the species composition of this area.

8.3.15 Purple small-reed is noted in the SSSI citation as being a regionally uncommon species. According to the Online Atlas of the British and Irish Flora[19], the retreat of purple small-reed from its peripheral localities was apparent in the 1962 Atlas, and has continued in some areas. Even within its core range, succession and falling water tables may be reducing the extent of wetland habitats available for this species. However, small changes in water levels are unlikely to have an adverse effect on the status of this species at Rostherne Mere because:

- it is a robust rhizomatous perennial with an affinity with habitats subject to winter flooding; and
- the flood regime of the mere will not be significantly changed by the Proposed Scheme.

Fields above Gale Bog

8.3.16 Access has not been possible to the fields above Gale Bog, between Harpers Bank Wood and Mere Covert, in order to undertake surveys as part of the current studies and assessment. However, during a site visit in November 2019, following very wet weather, Natural England made observations of wetland plant species present in several areas at the base of the slopes behind Gale Bog. The vegetation was considered by Natural England to merge with the reedbed and wet woodland in Gale Bog and extended partly up-slope in some areas.

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[19] Botanical Society of Britain & Ireland (& others) (2021), *Online Atlas of the British and Irish Flora*. Available online at: https://www.brc.ac.uk/plantatlas/plant/calamagrostis-canescens.

Wetland species comprised mainly *Juncus effuses, Urtica dioica, Epilobium palustre, Epilobium hirsutum, Ranunculus repens and Cardamine flexuosa. Heracleum sphondylium* and abundant smaller leaved *Carex spp* were also identified separately in two of the areas.

8.3.17 The 2010 NVC survey[4] included about 50 quadrats in the fields which rise up steeply from Gale Bog and Rostherne Mere. NVC grassland communities dominated in the fields.

8.3.18 The NVC survey report refers to the presence of other wetland habitats around the NNR which includes spring-fed flushes, although the habitat locations are not listed. In the absence of greater detail in the report, it is assumed that the seepage features seen in the fields above Gale Bog on the site visit in May 2018 were included in this description of spring-fed flushes. The report indicates that these habitats 'tend to be species poor with some rushes and sedges, but only floating sweet-grass being constant of the aquatic species'.

8.3.19 The target notes for grasslands (Appendix A) in the report for the 2010 NVC survey refers to several small flushes fed by springs in the lower slope above Gale Bog. Although holding significantly different species, the notes indicate that these areas were still dominated by grasses (recorded as MG10a and OV28a). The species present in a small rushy, boggy area in the lower field area between Harpers Bank Wood and Gale Bog were described as being more characteristic of wetland habitats, with soft rush abundant. Lesser spearwort (*Ranunculus flammula*), water pepper (*Persicaria hydropiper*), jointed rush and marsh-bedstraw were also present. A puddled pond used as a cattle drink was located in one of the fields but was dry at the time of the 2010 survey. Aquatic species were limited to soft rush and floating sweet-grass.

8.3.20 Taking into account the considerable number of quadrats in the area in the 2010 NVC survey, it is assumed that a thorough reconnaissance of all habitats was undertaken in 2010 in the fields above Gale Bog. There is no indication in the report that any notable species were found associated with the spring-fed flushes in the area. As such, it seems reasonable to assume that the general description of a species-poor habitat was applicable to these particular spring-fed flushes. However, the spring-fed flushes above Gale Bog are of value as a feature of the SSSI, rather than for the rarity or diversity of the habitat. The SSSI citation[8] states that:

> 'The farmland includes both arable and pasture - some of which is relatively damp with species such as lady's-smock (*Cardamine pratensis*), ragged-robin (*Lychnis flos-cuculi*) and tufted hair-grass (*Deschampsia cespitosa*)'.

8.3.21 As indicated in Section 6.3, the impact on the seepages which feed and support the spring-fed flushes is dependent on the hydraulic gradient between the area of the cuttings and the slopes. However, the total discharge from the seepages may be reduced, and some seepages could dry up with greater frequency, as a result of the presence of the Millington and Rostherne cuttings.

8.3.22 It is considered that the wet areas in the fields above Gale Bog contribute to the interest of the SSSI described above, although wet grassland is not included as a designated feature of interest on which the favourable condition of the site is assessed. It is therefore unclear whether the potential for drying of these areas of wet habitat could represent an adverse impact on the integrity of the site. This is because the status of these areas of wet habitat as a reason for designation, and their current extent and character in this part of the SSSI, are uncertain.

Macroinvertebrate communities

8.3.23 Environment Agency macroinvertebrate data was gathered in the spring, summer, and autumn 2004, and spring 2009 (see Appendix A). At the community level, the data indicates a diverse invertebrate community, represented by all expected major groups such as flatworms, leeches, molluscs, crustaceans, damselflies, aquatic bugs, aquatic beetles, mayflies, caddis flies and true flies. Taxa have typically been identified only to family level and, therefore, it is not possible to assess the conservation value of the macroinvertebrate species collected. Taking into account the extent of Rostherne Mere and the relatively small potential hydrological impacts of the Proposed Scheme, a significant impact would not be expected on the macroinvertebrate community.

8.3.24 This also applies to the WFD chironomid classification, for which a decline would not be expected without a significant decline in water quality.

Birds

8.3.25 Given the limited predicted extent of any changes in the 'fringing reedbed', the Proposed Scheme should not have an adverse impact on bird populations.

9 Rostherne Mere mitigation proposals

9.1.1 Although the potential impacts on water levels in Rostherne Mere are small and almost certainly undetectable, mitigation is included in the Proposed Scheme associated with the potential impact of both sets of cuttings.

9.1.2 For the Millington and Rostherne cuttings, filter drainage water from an area of the cuttings extending a considerable distance outside the Rostherne Mere catchment could be discharged to Rostherne Mere via a recharge trench. The approximate section of the cuttings contributing to the mitigation drainage scheme is indicated on Figure B6, together with the possible location of the recharge trench north east of Rostherne Mere. The timing of the discharge from the cuttings to the recharge trench may be different to the timing of natural groundwater seepages in the area above Gale Bog and in Mere Covert. However, the additional discharge from the extended area of the cuttings would mean that the total discharge is likely to exceed the natural groundwater discharge in the area.

9.1.3 A potential drawback to a recharge scheme in this area is that the scheme is located on glacial till which could be of low permeability, permitting little infiltration. The occurrence of low permeability is supported by the information provided by a local parish councillor at the meeting with local councillors on 2 August 2019. He indicated there is solid clay below the soil layer in the fields above Mere Covert and rainfall runs off quickly above this clay layer. As a result, it may not be possible for any significant amount of drainage water to infiltrate through the recharge trenches. At most, infiltration, perhaps of the order of one or two litres per minute, might occur. Depending on the drainage contribution, the scheme drainage water might discharge from low points in the ground level along the recharge trenches down the slope behind Gale Bog.

9.1.4 A possible alternative might be to construct recharge wells in the base of the trench, through the upper clay layer and into the lower sandier deposits underlying the area. Infiltration could then take place to the sandier deposits through these wells. Use of recharge wells might be feasible, although there would be substantial additional complications for operation and maintenance.

9.1.5 A recharge scheme might also restore or increase the discharges from some seepages in the slopes north east of Gale Bog which could be affected by the Proposed Scheme. However, the geology of the superficial deposits supplying the seepages is complex, as discussed in Section 6. Even if recharge wells extended around the whole perimeter of the SSSI on the slopes above Gale Bog, there could be no guarantee that the current seepage conditions would be replicated closely in any of the slopes.

9.1.6 Direct discharge of drainage water from the recharge trenches to Rostherne Mere could produce marginally higher water levels in some conditions, but not necessarily in very dry periods when little if any drainage discharge would be available. In addition, concerns were expressed by local parish councillors at the meeting on 2 August 2019 about the quality of drainage discharge from the Proposed Scheme. Although the quality is assumed to be reasonable and without any significant contamination, it may be prudent to avoid direct discharge to a Ramsar site.

9.1.7 For the area to the north west of The Mere, Mere, drainage from sections of the Hoo Green cuttings, extending across and outside the Rostherne Mere catchment, could be pumped to recharge trenches in the superficial deposits to the east of the zone of influence of the cuttings. The approximate sections of the cuttings contributing to the mitigation drainage scheme, and also the provisional location of the recharge trenches to which the drainage water will be discharged, are indicated on Figure B24. The sections of cuttings from which drainage water can be utilised for recharge were determined taking into account the varying levels of the cuttings on the route of the Proposed Scheme, both the HS2 WCML connection and the HS2 Manchester spur. The geological mapping in Figure B24 indicates that glaciofluvial deposits comprising permeable sands and gravels are likely to be present at the location of the recharge trenches.

9.1.8 The recharge trenches should produce a contribution which exceeds the natural recharge in the area of the zone of influence. There may be differences in precise timing between recharge through the trenches and the natural groundwater throughflow in the zone of influence. However, taking into account the distance of the recharge scheme from Rostherne Mere or The Mere, Mere, if some groundwater does flow towards The Mere, Mere, a slight variation in the timing of recharge should make no significant difference to the timing of groundwater discharge in the catchment.

9.1.9 The recharge scheme outlined for the area to the west of The Mere, Mere does not, however, take into account:

- any impact that drainage for the A556 Chester Road is having on groundwater flows in the area; or
- the existing farm drainage system in the area around the Mere Court Hotel, referred to by a local parish councillor, or the impact the A556 Chester Road may have had on the routing of this drainage towards Bucklow Hill.

9.1.10 The implementation of the recharge schemes would be preceded by detailed site and ground investigations to refine the design or, indeed, to establish whether the schemes are actually required or not. Once implemented, the recharge schemes would be subject to careful management, operation and maintenance to ensure correct functioning during the lifetime of the Proposed Scheme. Monitoring of groundwater levels would also be needed prior to and during the early years of operation, to confirm the effectiveness of the recharge schemes.

10 Further monitoring and data collection

10.1 Ecology and protected features

10.1.1 With the inclusion of mitigation proposed to maintain water levels it is considered highly unlikely that a significant impact on the water body and margins within the Rostherne Mere and The Mere, Mere SSSI would be caused by either the individual or combined effects of the Millington and Rostherne cuttings, and the Hoo Green cuttings. Consequently, no significant impact would be expected for key biological receptors including aquatic macrophytes, macroinvertebrates, and birds.

10.1.2 It is not expected that WFD ecological quality elements of Rostherne Mere and The Mere, Mere would be impacted by the Proposed Scheme. Therefore, a deterioration under WFD legislation should not occur.

10.1.3 No further monitoring of Rostherne Mere and margins, including Gale Bog, are therefore proposed as part of the current studies. If, however, access becomes available to the slopes behind Gale Bog, then a reconnaissance visit could be undertaken. The visit would be used to gain a better understanding of the potential ecological interest associated with the spring-fed flushes and would add to information obtained in the visit to the site by Natural England in November 2019.

10.1.4 As access is now available to much of the western shoreline of The Mere and Little Mere, a vegetation survey was carried out by the ecology team in August 2020 to provide additional details to supplement the ecology data supplied by the Environment Agency. A detailed assessment of the ecological data for The Mere, Mere is provided in the Document to inform a Habitats Regulations Assessment for Rostherne Mere Ramsar site and Midland Meres and Mosses Phase 1 Ramsar site.

10.2 Water resources

Rostherne Mere

10.2.1 The information collected from the four site visits in May to September 2018 provided a reasonable basis for water balance modelling and for establishing the approximate impacts on water levels in Rostherne Mere resulting from the Proposed Scheme. While additional flow monitoring data in low flow conditions may provide an additional check on the assessment, the availability of the Environment Agency's data has been more useful for developing reasonable confidence in the water balance model, particularly in very dry conditions as in 1996.

10.2.2 Monitoring of water levels in Rostherne Mere has commenced. With Natural England's permission, a water level logger was installed by MWJV on behalf of HS2 Ltd in October 2019 at the jetty by the boathouse where the gauge board is located. A separate barometric logger was also installed to monitor barometric pressure for adjustments to the water level data. Data obtained for the period October to November 2019 has been used to check the results of the water balance model.

10.2.3 No additional water resources surveys are considered necessary to assess the potential impact of the cuttings on the mere component of Rostherne Mere SSSI and the Rostherne Mere Ramsar site.

10.2.4 As discussed in Section 5.3, it is possible that reed cutting, when carried out in the discharge channel from Rostherne Mere, could reduce temporarily the effect of the vegetation in partially impeding outflow and maintaining a marginally higher water level in the mere. Therefore, the impact of the extent and timing of any reed cutting along the discharge channel will be reviewed during design progression.

Upstream of Rostherne Mere and around The Mere, Mere

10.2.5 The following hydrological reconnaissance and monitoring is still proposed in the catchment upstream of Rostherne Mere:

- survey and monitor springs near Bucklow Hill, and spring fed tributaries of Rostherne Brook which are located down-gradient of the expected zone of influence on groundwater levels of the Hoo Green cuttings to the west of The Mere, Mere. As discussed in Section 5, groundwater flows and, hence, spring discharges might be affected by the cuttings. Approximate assessments of the spring discharges will be carried out during design progression in order to determine their importance in contributing to Rostherne Mere via Rostherne Brook. However, these assessments would not affect the current assessment of the impacts of the Proposed Scheme; and
- a reconnaissance survey of the western shoreline of Little Mere, where the ditch by the A5034 Mereside Road discharges to Little Mere, and surrounding area. This will be undertaken once access is available to the whole shoreline and ponds located close to the mere. There is no evidence of springs on Ordnance Survey mapping in the area. However, a walkover and investigation of the ponds in the area adjacent to Little Mere should be completed to check for any springs or seepages.

10.2.6 It would also be worthwhile undertaking the following actions as part of the next stage of investigations:

- contact the farmer who advised the local parish councillor about the drainage pipeline from the area around the Mere Court Hotel. An understanding of the existing drainage in this area would be useful. The information might contribute to the assessments of recharge and groundwater discharge from the area towards Rostherne Mere or The Mere, Mere; and

- investigate from published material, or through the Highways Agency, the changes to the drainage pipeline as a result of the construction of the A556 Chester Road, and also any occurrence of groundwater discharge into the A556 Chester Road drainage.

10.2.7 Long term monitoring of water levels in Little Mere and The Mere would be worthwhile so that conditions can be compared prior to and following the construction of the Hoo Green cuttings. In order to do this, however, permissions will be required as for Rostherne Mere. If there is existing water level data, the data could be very useful in extending the record prior to the construction of the cuttings.

10.3 Geotechnical site investigations

10.3.1 Further assessments of groundwater conditions will be undertaken as part of geotechnical site investigations prior to construction of the Proposed Scheme to provide:

- an understanding of the detailed hydrogeology between the Millington and Rostherne cuttings and Gale Bog and Rostherne Mere, and the likely effects of the Proposed Scheme on seepages in the slopes above Gale Bog;
- an understanding of the detailed hydrogeology between the Hoo Green cuttings to the west of The Mere, Mere and Rostherne Mere and The Mere, Mere, and the likely directions of groundwater flow;
- the feasibility and design of recharge schemes if these are required; and
- borehole installations for long term monitoring of the impacts of the Proposed Scheme on groundwater levels and seepages.

11 Conclusions

11.1 Flow monitoring in 2018

11.1.1 Four site visits were made to Rostherne Mere between May and September 2018. The approximate assessment of major flows and estimation of minor flows during these visits needs to be taken into account when analysing the results. However, the flow records provide a very useful indication of the relative contributions of watercourses, springs and seepages to the mere.

11.1.2 The data collected indicated that the sum of the three main inflows to Rostherne Mere, comprising Rostherne Brook and spring-fed channels in Harpers Bank Wood and below Wood Bongs, varied from about 45l/s – 39l/s during visits between July and September 2018. The three inflows equated to 98% or more of the total inflow to the mere. Rostherne Brook, the main watercourse in the catchment, provides by far the most important single inflow, comprising approximately 80% of the total inflow at the time of the visits.

11.1.3 The total discharge in areas below or close to the zone of influence of the Millington and Rostherne cuttings ranged from about 1.5l/min – 7l/min at the times of the monitoring visits. The discharge equated to 0.1% – 0.3% of the total inflows estimated for Rostherne Mere.

11.2 Gauging station records

11.2.1 Extended periods of hot, dry weather occurred during the monitoring in the spring and summer in 2018. However, records available for four gauging stations in the River Bollin catchment, which includes Rostherne Mere, indicate that 2018 was not an exceptionally dry year. The lowest reliable daily flows at the gauging station on the River Bollin in Wilmslow were recorded in 1976 and 1996. In addition, there were about ten other years in the record in which the minimum daily flow was lower than, or approximately equal to, the lowest flow in 2018.

11.2.2 Late July 2018 was a particularly useful time for a monitoring visit to Rostherne Mere as it followed an extended period of almost three months of generally dry weather. Flows at the gauging stations in the Bollin catchment were at about their lowest level for 2018 at the time of the visit. As a result of the extended dry period, flows in the Rostherne Mere catchment in late July were presumably dominated by groundwater discharges from springs in the catchment.

11.3 Impact of cuttings on water levels at Rostherne Mere

11.3.1 A water balance assessment was undertaken for dry to extremely dry years, represented by 2018, 1976 and 1996, in order to assess the impact of possible reductions in inflows to Rostherne Mere. The reductions would be caused by groundwater drainage in cuttings included in the Proposed Scheme. The results of the water balance modelling may not be precise and accurate. However, there can be reasonable confidence in the following conclusions:

- the Millington and Rostherne cuttings are likely to have an impact of less than one millimetre on water levels in Rostherne Mere;
- water levels may be unaffected by the presence of the cuttings in extended dry periods in the summer, when seepages in the fields above Gale Bog dry up in current conditions; and
- the Hoo Green cuttings to the west of The Mere, Mere may have an impact of a few millimetres (up to about 3mm – 4mm) on water levels in Rostherne Mere from April onwards, through the summer, in dry or very dry conditions. However, these impacts may be reduced depending on:
  - the actual directions of drainage and groundwater flow in the surface water catchment area to the west of The Mere, Mere;
  - the impact which the new A556 Chester Road has had on groundwater flow and the existing drainage systems in the area; and
  - whether any surface water and groundwater flow contributions to Rostherne Mere from the upstream sub-catchment of The Mere, Mere can be taken into account in the calculations.

11.3.2 Overall, the total impact calculated for the cuttings, producing a decline in water levels of 4mm – 5mm in dry or very dry conditions, is marginal when compared to the total variations in water level modelled for Rostherne Mere. The reduction in water levels would almost certainly be undetectable, taking into account the existing variations between seasons and from year to year, together with the limitations for accurate measurement in natural surroundings and site conditions. The total impact on water levels might also be less than the temporary impact of reed cutting when carried out in the discharge channel from Rostherne Mere. Reed cutting may reduce the effect of the vegetation in partially impeding outflow, helping to maintain a marginally higher water level in the mere.

11.3.3 The reverse flow events occurring from time to time in Blackburn's Brook may also produce minor changes in the channel which have an impact on the relationship between water levels and outflow from Rostherne Mere.

11.3.4 It is assumed for the water balance modelling that all groundwater seepages in the slopes behind Gale Bog would dry up completely as a result of drainage in the Millington and

Rostherne cuttings. However, seepages in some of the area located between Gale Bog and Harpers Bank Wood are unlikely to be affected by the cuttings.

11.3.5 Springs feeding watercourses in Harpers Bank Wood should not be affected by the cuttings. These springs are located well outside the zone of influence of the cuttings.

11.3.6 It seems unlikely that flows in the channel in the centre of Mere Covert originate as groundwater and, as a result, would not be affected at all by the presence of the cuttings. The evidence from various sources is that the flows comprise surface (or near surface) drainage from the fields above Mere Covert.

11.3.7 Small seepages in Mere Covert, which dried up completely in the summer in 2018, are unlikely to be affected by the zone of influence of the Rostherne cutting.

11.4 Hydrogeology north of Rostherne Mere

11.4.1 The area of the Millington and Rostherne cuttings is underlain by glacial till, although existing borehole logs, available on the BGS website, indicate that the superficial deposits are very variable. In a number of boreholes it is possible to identify a predominantly clayey layer above a predominantly sandy layer. However, occasional thin bands of sandier material are sometimes present in the upper clay layer. A mix of sandy and clayey layers can also occur below the base of the upper, predominantly clayey layer.

11.4.2 For many of the boreholes, the base of superficial deposits is a few metres below the level of Gale Bog at about 21mAOD to 22mAOD. There is, therefore, the potential for a hydraulic connection between Rostherne Mere and the lower sandy deposits in the glacial till. The connection would be through the alluvium underlying Rostherne Mere, or other mire and lake bed sediments. However, the occurrence of silts and clays, mixed within the sands, would be expected to reduce permeabilities considerably in many sections of the glacial till. As a result, the lower sandy deposits are unlikely to be a particularly significant aquifer. In addition, the deposits could be poorly connected hydraulically with the mere or Gale Bog through the alluvium, mire and lake bed sediments. Assuming the sediments include silty or clayey material from deposition in still water conditions, then the permeability would be low, limiting any leakage from the sands in the glacial till.

11.4.3 Monitoring data from 1991 indicates that filter drainage in the Millington and Rostherne cuttings could intercept some groundwater which may otherwise discharge in groundwater seepages in the slopes above Gale Bog in average summer/early autumn conditions. However, the evidence from site visits is that groundwater seepages in the slopes above Gale Bog dried up completely in the summer in 2018. In these drier conditions it seems very likely that the groundwater level in the lower sandy deposits in the glacial till would fall below the level of the base of the drainage in the cuttings. In drier conditions, the drainage should not affect any minor groundwater discharge occurring at a lower level in Gale Bog or Rostherne Mere, in the event that any such discharge does actually occur.

11.4.4 In addition, in average conditions or in wetter periods, there is unlikely to be a discernible impact on any minor groundwater discharge into Gale Bog or Rostherne Mere, if any such discharge does occur. Higher groundwater levels in any sandy horizons in the glacial till above the proposed level for the filter drainage may, at present, give rise to greater discharges in seepages located in the slopes above Gale Bog. The presence of filter drains in the cuttings could reduce the current levels of discharge from these seepages and some of the seepages might also dry up.

11.4.5 However, some seepages in the slopes above Gale Bog, at elevations below the lowest level in the filter drainage (about 24.8mAOD), might not dry up in average summer/early autumn conditions as a result of the presence of the cuttings. The impact on the seepages is dependent on the hydraulic gradient between the area of the cuttings and the slopes. If the gradient is shallower, such that the groundwater level in the slopes remains above 21mAOD when the level drops below the base of the drainage in the cuttings, then all the seepages are unlikely to dry up as a result of the drainage.

11.4.6 The groundwater level data for 1991 also allows a very approximate reassessment of the potential zone of influence on groundwater of some areas of the cuttings. The analysis indicates that the actual zone of influence of the cuttings is likely to be substantially smaller than the theoretical zone of influence produced assuming the groundwater level is at ground level.

11.4.7 The zone of influence calculated using the groundwater level data is very limited in area along the section of the route closest to Rostherne Mere. As a result:

- the impact on any groundwater throughflow in sandier deposits close to the base of the filter drains in the cuttings is also likely to be very limited; and
- fewer seepages should be affected by the cuttings, with a reduction to discharges only from seepages in the slopes around the northern part of Gale Bog.

11.5 Water resources assessment for The Mere, Mere

11.5.1 On the basis of topography, and in current conditions, groundwater in glaciofluvial deposits at the boundary of the theoretical zone of influence of the Hoo Green cuttings would be expected to drain down gradient to the north-east towards Rostherne Mere. The groundwater would flow towards a boundary with the glacial till to the north of the glaciofluvial deposits. As a result, discharge from the zone of influence might potentially occur at a spring in Bucklow Hill.

11.5.2 Groundwater flow towards the spring may, however, be restricted by lower permeability in the glacial till. As a result, some groundwater in the Rostherne Mere catchment could, in theory, move towards The Mere, Mere sub-catchment. However, there is no evidence of any spring discharge in a ditch which drains into Little Mere, at the downstream end of The Mere, Mere, and no springs are indicated in the area on OS mapping.

11.5.3 It seems unlikely therefore that any groundwater from the zone of influence contributes to Little Mere, although it has not been possible to confirm this. Groundwater may emerge in springs in wetter conditions or might discharge through the bed of Little Mere.

11.5.4 An assessment has, nonetheless, been carried out to determine a theoretical maximum limit for the impact of the Hoo Green cuttings on the water level in Little Mere. The assessment takes into account:

- the observation of no discharge from Little Mere in July 2018; and
- information provided by local councillors at a meeting in August 2019 that, in the summer in 2018, the outflow weir from Little Mere was dry for approximately three to four months.

11.5.5 The theoretical maximum limit of a reduction in water level, calculated as approximately 270mm, is, however, substantially greater than any reduction in water level which might actually occur as a result of the construction of the Hoo Green cuttings. The maximum limit was calculated for dry conditions similar to the conditions in the summer in 2018.

11.5.6 The assessment has been provided to give an indication of a theoretical maximum limit for the impact on the water level in Little Mere. However, there are several reasons why the impact would not reach this theoretical limit, and the likely impact may be zero or, at worst, one or two orders of magnitude lower than the theoretical limit. The reasons are as follows:

- groundwater from the zone of influence of the Hoo Green cuttings may not actually contribute to Little Mere;
- if groundwater from the zone of influence does discharge to Little Mere, removing the groundwater contribution would lead to some compensation by groundwater inflow from adjacent groundwater catchments; and
- if the water level in Little Mere was reduced, it is very likely that additional water would be drawn into Little Mere by leakage from the main water body (The Mere).

11.5.7 It is also possible that the bed of Little Mere is located above the water table in underlying superficial deposits in dry periods such as the summer in 2018. If this is the case, it is unlikely there could be any groundwater discharge to the surface water body in these dry periods. A change in groundwater flow anywhere in the groundwater catchment potentially contributing to Little Mere, following the construction of the Proposed Scheme, would have no direct impact on water levels in dry conditions.

11.5.8 A detailed assessment of groundwater conditions will be undertaken as part of geotechnical site investigations prior to construction of the Proposed Scheme to provide:

- an understanding of the detailed hydrogeology between the Hoo Green cuttings; and Rostherne Mere and The Mere, Mere;

- the likely directions of groundwater flow; and
- groundwater levels close to The Mere, Mere.

11.5.9 One of the main objectives of the investigations will be to determine whether the water levels in The Mere, Mere (including Little Mere) could actually be affected by the Hoo Green cuttings.

11.6 Water dependent ecology – Rostherne Mere

Potential hydromorphological impacts

11.6.1 Using data from the Environment Agency lake macrophyte surveys for July 2018, the approximate lateral movement of the water line of Rostherne Mere, in response to a maximum water level change of 5mm resulting from all cuttings, was calculated to be between 80mm and 267mm.

11.6.2 Analysis of the impact of lowering water levels using bathymetry survey data indicated that, for a reduction of 5mm, the loss of lake area would be very approximately 0.05ha. This is about 0.1% of the total lake area, and about 2.6% of the shelf area above one metre depth of water. The habitat type affected would represent about 1.5% of the 3.3ha of fringing reedswamp currently estimated for the SSSI. The potential reduction of fringing reedswamp vegetation, and any changes in composition due to the reduction in the extent of the marginal shelf, could, however, be mitigated by the measures to maintain existing water levels.

Potential ecological impacts

11.6.3 The NVC report[4] describes the main body of water at Rostherne Mere as 'extremely species-poor'. The lack of macrophyte species is attributed to a combination of lake depth and poor water quality, for which the presence of blue-green algal blooms provided additional evidence. Survey data shows a consistently species-poor aquatic macrophyte flora.

11.6.4 Overall, macrophyte data suggests that 'Favourable Condition' requirements for a standing water body have not been met at Rostherne Mere. The data is consistent with the view that macrophyte diversity is limited by the effects of excessive nutrient loading and competition from invasive species and algae. There is no reason to consider that the present community would be affected significantly by the changes in water level indicated by the water balance modelling, with the implementation of the proposed mitigation.

11.6.5 The NVC report[4] describes the margins of Rostherne Mere as supporting a 'good range of swamp, mire, and wet woodland communities'. The characteristic species may all be found growing in shallow water or above the water line on the damp margins of waterbodies. A decline in water level of up to 5mm in dry or drought conditions, particularly given the regular natural variation of about 600mm, is unlikely to cause large changes in the extent, distribution and composition of marginal macrophytes. The proposed mitigation, if required, would avoid any significant changes in the marginal vegetation at Rostherne Mere.

11.6.6 Thirty-four 'non-scoring' taxa which are wetland-dependent or tolerant of inundation are also listed by the Environment Agency. All of these, including tufted sedge (*Carex elata*) which has been classed as Near-Threatened in England, are highly unlikely to be impacted by the potential changes in water level.

11.6.7 Purple small-reed is noted in the SSSI citation[8] as being a regionally uncommon species. However, small changes in water levels are unlikely to have an adverse effect on the status of this species at Rostherne Mere as:

- it is a robust rhizomatous perennial with an affinity with habitats subject to winter flooding; and
- the flood regime of the mere will not be significantly changed by the Proposed Scheme.

11.6.8 A discernible impact would not be expected on the macroinvertebrate community, taking into account the extent of Rostherne Mere and the relatively small potential hydrological impacts of the Proposed Scheme. This also applies to the WFD chironomid classification, for which a decline would not be expected without a significant decline in water quality.

11.6.9 Given that no significant changes to the abundance of 'fringing reedbed' would be expected, the Proposed Scheme should not have an adverse impact on bird populations.

11.6.10 It is not expected that WFD ecological quality elements of Rostherne Mere would be impacted by the Proposed Scheme. Therefore, a deterioration under WFD legislation should not occur.

11.6.11 The spring-fed flushes in the fields behind Gale Bog, based on the NVC survey report[4], is assessed to be a species-poor habitat. The features are known to dry up at times in current conditions, as seen in the hydrological surveys in July to September 2018. However, the spring-fed flushes are of value as a feature of the SSSI, rather than for the rarity or diversity of the habitat. The total discharge from the seepages may be reduced, and some seepages could dry up with greater frequency, as a result of drainage to the Millington and Rostherne cuttings.

11.7 Proposals for mitigation

11.7.1 Although the potential impacts on water levels in Rostherne Mere are small and should be undetectable, mitigation, if required, is included in the design associated with the potential impact of both sets of cuttings.

11.7.2 The Proposed Scheme provides allowance for drainage water from the Millington and Rostherne cuttings, to be discharged to Rostherne Mere via a recharge trench located north east of Rostherne Mere. The timing of the discharge from the cuttings to the recharge trenches may be different to the timing of any natural groundwater discharge in the area above Gale Bog and in Mere Covert. However, the additional discharge from the extended area of the cuttings would mean that the total discharge is likely to exceed the natural groundwater discharge in the area.

11.7.3 A potential drawback to a recharge scheme in this area is that the scheme is located on glacial till which could be of low permeability, permitting little infiltration. A possible alternative might be to construct recharge wells in the base of the trench, into sandier deposits underlying the glacial till. Use of recharge wells may be feasible, although these would involve additional operational and maintenance complexities.

11.7.4 A recharge scheme might also restore or increase the discharges from some seepages in the slopes to the north east of Gale Bog which could be affected by the Proposed Scheme. However, the geology of the superficial deposits supplying the seepages is complex. Even if recharge wells extended around the whole perimeter of the SSSI on the slopes above Gale Bog, there could be no guarantee that the current seepage conditions would be replicated closely in any of the slopes.

11.7.5 Direct discharge of drainage water to Rostherne Mere could produce marginally higher water levels in some conditions, but not necessarily in very dry periods when little if any drainage discharge would be available. In addition, concerns were expressed by local councillors at the meeting in August 2019 about the quality of drainage discharge from the Proposed Scheme. Although the quality is assumed to be reasonable and without any significant contamination, it may be prudent to avoid direct discharge to a Ramsar site.

11.7.6 For the area to the north-west of The Mere, Mere, drainage from sections of the Hoo Green cuttings, extending across and outside the Rostherne Mere catchment, could be pumped to recharge trenches in the superficial deposits to the east of the zone of influence of the cuttings. Geological mapping indicates that glaciofluvial deposits comprising permeable sands and gravels are likely to be present at the location of the trenches.

11.7.7 There may be differences in precise timing between recharge through the trenches and the natural groundwater throughflow in the zone of influence. However, taking into account the distance of the recharge scheme from Rostherne Mere or The Mere, Mere (if some groundwater from the zone of influence does flow towards The Mere, Mere), a slight variation in the timing of recharge should make no significant difference to the timing of groundwater discharge in the catchment.

11.7.8 The recharge scheme for the area to the west of The Mere, Mere does not, however, take into account:

- any impact that drainage for the A556 Chester Road has on groundwater flows in the area; and
- the existing farm drainage system in the area around the Mere Court Hotel.

11.7.9 The implementation of the recharge schemes would be preceded by detailed site and ground investigations to refine the design or, indeed, to establish whether the schemes are actually required or not. If implemented, the recharge schemes would be subject to careful management, operation and maintenance. Monitoring of groundwater levels would also be needed prior to and during the early years of operation, to confirm the effectiveness of the recharge schemes.

11.8 Residual impacts on ecology

11.8.1 With the proposed mitigation, if required, the potential water level changes on the open water body and margins of Rostherne Mere, including Gale Bog, due to the cuttings would be negligible in relation to:

- hydro-morphology of Rostherne Mere;
- macrophyte communities associated with the main water body and the aquatic margins;
- macroinvertebrate communities; and
- birds.

11.8.2 There could, however, be an impact on the spring-fed flushes in the fields behind Gale Bog.

11.8.3 It is considered that these wet areas in the fields above Gale Bog contribute to the interest of the SSSI, although wet grassland is not included as a designated feature of interest on which the favourable condition of the site is assessed. It is therefore unclear whether the potential for drying of these areas of wet habitat could represent an adverse impact on the integrity of the site. This is because the status of these areas of wet habitat as a reason for designation, and their current extent and character in this part of the SSSI, are uncertain.

11.8.4 It is uncertain whether the Hoo Green cuttings to the west of The Mere, Mere could affect water levels and, hence, the ecology of The Mere, Mere including Little Mere. However, mitigation in the form of recharge trenches in the vicinity of the Hoo Green cuttings has been included in the Proposed Scheme. If needed, the mitigation may be used to compensate for any reduction in discharge to The Mere, Mere, including Little Mere, caused by the Proposed Scheme.

11.9 Further monitoring and data collection

Water resources – Rostherne Mere

11.9.1 The information collected from the site visits in May to September 2018 provided a reasonable basis for water balance modelling and for establishing the approximate impacts on water levels in Rostherne Mere resulting from the Proposed Scheme. The availability of Environment Agency flow data for Blackburn's Brook has been very useful for developing reasonable confidence in the water balance model, particularly in very dry conditions as in 1996.

11.9.2 The value of additional flow monitoring at this point is uncertain and what it would achieve. Any long-term changes to inflows resulting from the Proposed Scheme are expected to be so small as to be undetectable in flow monitoring, particularly when taking into account natural changes from year to year. Occasional monitoring in dry summer conditions as a check on the main inflows and the outflow from the mere, and for correlation with the mere water level, would probably be worthwhile.

11.9.3 We suggest that long term monitoring of water levels in Rostherne Mere is the most reliable indicator of any impact due to cuttings. Even so, mere water levels will vary substantially from year to year, as indicated by the levels seen in the summer in 2018 and 2019. Anticipated changes in level of a few millimetres would not be apparent, taking into account the natural variations and site conditions.

11.9.4 We recommend that Natural England is requested to provide details of the extent and timing of any reed cutting along the discharge channel from Rostherne Mere, when this activity takes place.

Water resources upstream of Rostherne Mere and around The Mere, Mere

11.9.5 The following reconnaissance and monitoring is proposed in the catchment upstream of Rostherne Mere:

- survey, and monitoring on one or two occasions, of any springs near Bucklow Hill and spring fed tributaries of Rostherne Brook which are located down-gradient of the expected zone of influence of the Hoo Green cuttings to the west of The Mere, Mere; and
- a reconnaissance survey of the western shoreline of Little Mere, where the ditch by the A5034 Mereside Road discharges to Little Mere, and surrounding area. This will be undertaken once access is available to the whole shoreline and ponds located close to the mere.

11.9.6 It would also be worthwhile undertaking the following actions in the next stage of the investigations:

- contact the farmer who advised the local parish councillor about the drainage pipeline from the area around the Mere Court Hotel. An understanding of the existing drainage in this area would be useful. The information might contribute to the assessments of recharge from the area to Rostherne Mere and The Mere, Mere; and
- investigate from published material, or through the Highways Agency, the changes to the drainage pipeline as a result of the construction of the A556 Chester Road, and also any occurrence of groundwater discharge into the A556 Chester Road drainage.

11.9.7 Long term monitoring of water levels in Little Mere and The Mere would also be worthwhile. In order to do this, however, permissions will be required as for Rostherne Mere. If there is existing water level data, the data could also be very useful in extending the record prior to the construction of the cuttings.

Ecology

11.9.8 No further monitoring of Rostherne Mere and margins, including Gale Bog, is proposed as part of the current studies. If, however, access becomes available to the slopes behind Gale Bog then a reconnaissance visit could be undertaken. The visit would be used to gain a better understanding of the potential ecological interest associated with the spring-fed flushes.

11.9.9 As access is now available to much of the western shoreline of The Mere and Little Mere, a vegetation survey was carried out in August 2020 to provide additional details to supplement the ecology data supplied by the Environment Agency. A detailed assessment of the ecological data for The Mere, Mere is provided in the Document to inform a Habitats Regulations Assessment for Rostherne Mere Ramsar site and Midland Meres and Mosses Phase 1 Ramsar site.

11.10 Geotechnical site investigations

11.10.1 Further assessments of groundwater conditions will be undertaken as part of geotechnical site investigations prior to construction of the Proposed Scheme to provide:

- an understanding of the detailed hydrogeology between the Millington and Rostherne cuttings and Gale Bog and Rostherne Mere, and the likely effects of the Proposed Scheme on seepages in the slopes above Gale Bog;
- an understanding of the detailed hydrogeology between the Hoo Green cuttings and Rostherne Mere and The Mere, Mere and the likely directions of groundwater flow;
- the feasibility and design of recharge schemes if these are required; and
- borehole installations for long term monitoring of the impacts of the Proposed Scheme on groundwater levels and seepages.

Appendix A: Environment Agency macrophyte and macroinvertebrate data for Rostherne Mere

Table B10: Environment Agency macrophyte data for Rostherne Mere

Macrophytes - preferred Taxon Name	LEAFPACS Scoring Taxon	Conservation	2007	2015	2018
Callitriche hermaphroditica	Yes		Y	Y	
Callitriche truncata	Yes				Y
Chara globularis	Yes		Y		Y
Elodea canadensis	Yes	Non-native (Established)	Y	Y	Y
Filamentous algae	Yes		Y	Y	Y
Persicaria amphibia	Yes		Y		
Potamogeton berchtoldii	Yes		Y	Y	
Potamogeton pusillus	Yes				Y
Zannichellia palustris	Yes		Y	Y	Y
Acorus calamus	No	Non-native (Established)	Y	Y	Y
Alnus glutinosa	No		Y	Y	Y
Angelica sylvestris	No		Y		
Calamagrostis canescens	No				Y
Carex acutiformis	No		Y	Y	Y
Carex elata	No	Red List (England, post 2001) Near Threatened	Y		Y
Carex paniculata	No		Y		
Epilobium hirsutum	No		Y	Y	Y
Epilobium palustre	No		Y		Y
Eupatorium cannabinum	No			Y	
Filipendula ulmaria	No		Y	Y	Y
Galium palustre	No		Y		
Impatiens glandulifera	No	Non-native (Established)	Y	Y	
Iris pseudacorus	No		Y	Y	Y
Juncus effusus	No		Y		
Lycopus europaeus	No		Y	Y	
Lysimachia vulgaris	No		Y	Y	Y
Lythrum salicaria	No		Y	Y	Y
Mentha aquatica	No		Y	Y	Y
Myosotis scorpioides	No		Y		
Oenanthe aquatica	No			Y	
Oenanthe crocata	No				Y

Macrophytes - preferred Taxon Name	LEAFPACS Scoring Taxon	Conservation	2007	2015	2018
Persicaria hydropiper	No		Y		
Phalaris arundinacea	No		Y	Y	Y
Phragmites australis	No		Y	Y	
Ranunculus sceleratus	No		Y		
Rorippa nasturtium-aquaticum	No		Y		
Salix sp.	No		Y	Y	Y
Scutellaria galericulata	No				Y
Solanum dulcamara	No		Y	Y	Y
Sparganium erectum	No		Y	Y	Y
Typha angustifolia	No		Y	Y	Y
Typha latifolia	No			Y	Y
Urtica dioica	No		Y		

Table B11: Environment Agency macroinvertebrate data for Rostherne Mere

Macroinvertebrate surveys – site/station name	Litoral inverts –vegetation	Litoral inverts –vegetation	Litoral inverts – vegetation	Rostherne Mere, boat house area
NGR	SJ7440083831	SJ7440083831	SJ7440083831	SJ7430683816
Macroinvertebrate Taxa	25-Apr-2004	31-Aug-2004	17-Nov-2004	8-May-2009
Planariidae	7		2	3
Dugesiidae			10	
Valvatidae				3
Hydrobiidae		2	2	
Potamopyrgus antipodarum				7
Bithynia				4
Physidae				1
Lymnaeidae	51	34	6	2
Planorbidae	18	48	46	20
Ancylidae	3	16	9	
Acroloxidae				6
Sphaeriidae				16
Oligochaeta	16	1	5	1
Piscicolidae			1	
Glossiphoniidae	7	5	10	2
Helobdella stagnalis				3
Erpobdellidae				2
Hydracarina	1	2		
Daphnia		1000		
Bosmina		100		

Macroinvertebrate surveys – site/station name	Litoral inverts –vegetation	Litoral inverts –vegetation	Litoral inverts – vegetation	Rostherne Mere, boat house area
Asellidae	168	31	81	10
Crangonyctidae	8	5	162	30
Gammaridae	69	11	12	6
Baetidae	4	65	95	1
Caenidae	8		2	1
Coenagriidae	15	3	10	1
Aeshnidae	17			
Hydrometridae		3		
Gerridae		3		
Notonectidae	98		1	3
Corixidae	2	305	10	
Haliplidae	2			
Dytiscidae	7	5	1	2
Gyrinidae	19	3	2	
Hydrophilidae	2			
Psychomyiidae				1
Polycentropodidae			3	
Phryganeidae	20		3	
Limnephilidae	1		8	4
Molannidae				2
Leptoceridae	5		2	1
Tipulidae		4		
Ceratopogonidae	2			
Chironomidae	100	25	47	6
WHPT N-Taxa	24	18	24	25
WHPT ASPT	4.27	4.14	4.57	4.03

Annex C: Additional air quality information to inform a Habitats Regulations Assessment

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Annex C: Additional air quality information to inform a Habitats Regulations Assessment for Rostherne Mere Ramsar site

1 Purpose

This Annex provides additional air quality information in relation to impacts from vehicle emissions to support the document to inform a HRA for the Rostherne Mere Ramsar site.

2 Scope, assumptions and limitations

The scope, assumptions and limitations for the air quality assessment are set out in full in Volume 1 (Section 8), in the Environmental Impact Assessment Scope and Methodology Report (SMR) (see Volume 5: Appendix CT-001-00001) and accompanying SMR Technical note – Air quality: Guidance on the assessment methodology.

Key elements in relation to the assessment of vehicle emissions on ecologically sensitive sites are:

- screening of traffic data using the criteria set out in the SMR which is based on DMRB criteria[1], to identify where assessment is required;
- these criteria are the following for assessing the impacts of the scheme alone:
  - change in road alignment by 5m or more;
  - change in daily traffic flows by 1,000 vehicles or more as AADT;
  - change in daily flows of HDV by 200 AADT or more;
  - change in daily average speed by 10kph or more; or
  - change in peak hour speed by 20kph or more.
- these criteria are the following for assessing the impacts of the scheme in combination with other plans and projects:
  - change in daily traffic flows by 1,000 vehicles or more as AADT; or
  - change in daily flows of HDV by 200 AADT or more.
- ecological receptors included in the air quality assessment are designated sites with habitats sensitive to NO_x deposition. These could include, SAC, SPA and Ramsar sites;
- transects have been used within a designated site with modelled points at 0m, 10m, 20m, 30m, 40m, 50m, 75m, 100m, 150m and 200m from the edge of the road unless the shape of the site and potential impacts necessitates different distances to characterise the impacts;
- a deposition velocity relevant to the habitat of each site has used, as detailed in the IAQM ecological guidance[2]. Data on nitrogen deposition has been taken from the most recent information available on the APIS[3] website. No reduction in future background deposition rates has been applied;
- the following scenarios are assessed:
  - baseline;

[1] Highways England, Transport Scotland, Welsh Government & Department for Infrastructure (2019), *Design Manual for Roads and Bridges LA105 Air quality*.

[2] Holman et al. (2019), *A guide to the assessment of air quality impacts on designated nature conservation sites – version 1.0,* Institute of Air Quality Management, London. Available online at: https://iaqm.co.uk/text/guidance/air-quality-impacts-on-nature-sites-2019.pdf.

[3] UK Centre for Ecology and Hydrology (2021), *Air Pollution Information System*. Available online at: http://www.apis.ac.uk/.

  - selected year(s) within the construction period for the assessment of the effects of construction. The year(s) of assessment are selected based on the worse case peak period during the construction programme and on when significant effects might be expected; and
  - an operational scenario will be assessed for the first full operational year after construction is completed.
- for each assessment year, both the scenario without the Proposed Scheme in place and the scenario with the Proposed Scheme in place has been modelled. This comparison is used to assess the impacts of the Proposed Scheme alone;
- for the assessment of the Proposed Scheme in combination with other plans and projects, a different without scheme scenario is used and described as the 'do nothing' scenario. This uses traffic data from the 2018 baseline, but background pollutant concentrations/ deposition rates and emission factors representing the future year being assessed;
- the assessment incorporates HS2 Ltd's policy on construction vehicle emissions standards. These standards are published in Information Paper E31; Air Quality and include Euro VI for HGV, and Euro 6 and Euro 4 for diesel and petrol Light-Duty Vehicles (LDV), respectively;
- in-combination effects are largely taken into account in the traffic data used for the assessment which incorporates likely changes brought about by other proposed and committed developments[4]; and
- consideration is also given to relevant non-road plans and projects.

[4] A number of strategic traffic models have been sourced from key stakeholders, including Local Highway Authorities and Highways England. In combination, these models cover the areas that are expected to be affected by the proposed scheme and have been used as the basis of assessment for traffic flow analysis. The models have been developed by the relevant stakeholders in accordance with Transport Analysis Guidance (TAG) provided by the Department for Transport, with each model representing a Base Year position between 2016 and 2018.

Forecast year models have also been supplied by the above stakeholders which reflect committed and planned changes to the transport network and growth associated with committed and planned developments that are sufficiently certain to be introduced after the Base Year of the strategic model. Reviews of committed developments will have been undertaken by the relevant stakeholders at the same time as preparing and validating the Base Year model and developing future year models. Given that the models represent a Base Year position between 2016 and 2018, it is likely that the reviews of forecast committed developments will have been undertaken between 2016 and 2018 depending on when each model was last updated.

In order to account for traffic growth from 2018 to future years, growth factors were directly obtained from TEMPro version 7.2 which uses the National Trip End Model (NTEM 7.2 ((2017)) dataset and the National Transport Model (NTM) 2015. TEMPro inherently incorporates future planned development, being based on approved plans, irrespective of whether it is approved, committed, or simply included in approved plans. It includes all economic and population growth forecasts, and assumes growth in housing and commercial development, therefore providing a prediction of traffic growth by area.

3 Air quality standards

Air quality limit values and objectives are quality standards for clean air and to protect human health or harm to vegetation. The term 'air quality standards' will be used to refer to both the English air quality objectives and the air quality limit values and critical levels introduced in the UK based on EU Directives. Table C1 sets out the air quality standard for NO_x.

Table C1: Air quality standards

Pollutant	Averaging period	Standard
NO_x (for protection of vegetation)	Annual mean	30μg/m^3

For the assessment of changes in nitrogen, comparison has been made against the applicable lower critical load[5] for the site, as provided by APIS.

[5] The critical loads for nitrogen deposition vary and are specific to each qualifying feature. These are presented as a range of values (expressed as a rate, e.g. 10kg N/ha/yr - 20 kg N/ha/yr) and typically, as a precautionary approach, only the lowest value is used (unless there are compelling reasons to do otherwise) as this will emphasise any negative outcomes.

4 How significance is assessed

For the assessment of NO_x concentrations, the effect is considered to be not significant if the total predicted NO_x concentrations are below the air quality standard of 30μg/m^3.

For the assessment of nitrogen deposition, if the change in nitrogen deposition is predicted to be less than 1% of the lower critical load, then the effect is considered to be not significant. However, should the nitrogen deposition change by more than 1%, then the assessment of significance will be undertaken by an ecologist and reported within Section 3 of the main HRA report.

5 Assessment of construction traffic effects – Proposed Scheme alone

5.1 Screening of traffic data

The assessment of construction traffic impacts has used traffic data based on an estimate of the average daily flows in the peak year during the construction period (2025 - 2037). Traffic data are presented in Table C2.

The screening process identified a total of four roads in the area exceeding the screening thresholds:

- A556;
- Chester Road (between Millington Lane and Cherry Tree Lane);
- Cherry Tree Lane (between Chester Road and Birkinheath Lane); and
- on-site haul route, north of Cherry Tree Lane.

Further roads have been included in the assessment to account for their emissions at nearby receptors.

Rostherne Mere is located east of the A556, just south of M56 Junction 7 and 8. A planned HS2 construction traffic route runs adjacent to Rostherne Mere, along Chester Road and Cherry Tree Lane for part of the construction period, with approximately 200 HDV movements per day predicted. Traffic impacts, however, are primarily the result of increased traffic along the A556 from diversionary effects during the construction phase. Traffic data for construction vehicles using the site haul routes and moving between compounds has also been included in the assessment.

Table C2: Traffic data summary (construction phase)

Road ID	Road name	Annual Average Daily Traffic (AADT)					Heavy Duty Vehicles (HDV)				
		2018 baseline	2025 without the Proposed Scheme	2025 with the Proposed Scheme	Proposed Scheme alone change (2025 with Proposed Scheme – 2025 without Proposed Scheme)	In-combination change (2025 with the Proposed Scheme – 2018 baseline)	2018 baseline	2025 without the Proposed Scheme	2025 with the Proposed Scheme	Proposed Scheme alone change (2025 with the Proposed Scheme – 2025 without Proposed Scheme)	In-combination change (2025 with the Proposed Scheme – 2018 baseline)
8013_5006, 5006_8013	Cherry Tree Lane, Rostherne Mere	60	73	286	213	226	-	-	205	**205**	**205**
5006_5005, 5005_5006	Chester Road, Rostherne Mere	60	73	1,377	**1,305**	**1,317**	-	-	205	**205**	**205**
96017_96019	A556	28,029	35,316	36,678	**1,362**	**8,649**	2,081	2,555	3,264	**710**	**1,183**
96015_96017	A556	28,029	35,316	36,678	**1,362**	**8,649**	2,081	2,555	3,264	**710**	**1,183**
95029_96018	A556	31,147	32,931	36,163	**3,232**	**5,016**	2,061	2,334	2,957	**624**	**896**
96018_96016	A556	31,147	32,931	36,163	**3,232**	**5,016**	2,061	2,334	2,957	**624**	**896**
96020_95029	A556	31,147	32,931	36,163	**3,232**	**5,016**	2,061	2,334	2,957	**624**	**896**
8013_8010, 8010_8013	A556	60	73	286	213	226	-	-	205	**205**	**205**
8011_8013, 8013_8011	Marsh Lane, Rostherne Mere	-	-	-	-	-	-	-	-	-	-

Road ID	Road name	Annual Average Daily Traffic (AADT)					Heavy Duty Vehicles (HDV)				
		2018 baseline	2025 without the Proposed Scheme	2025 with the Proposed Scheme	Proposed Scheme alone change (2025 with Proposed Scheme – 2025 without Proposed Scheme)	In-combination change (2025 with the Proposed Scheme – 2018 baseline)	2018 baseline	2025 without the Proposed Scheme	2025 with the Proposed Scheme	Proposed Scheme alone change (2025 with the Proposed Scheme – 2025 without Proposed Scheme)	In-combination change (2025 with the Proposed Scheme – 2018 baseline)
96019_96021	Birkinheath Lane, Rostherne Mere	28,029	35,316	36,731	**1,415**	**8,702**	2,081	2,555	3,269	**715**	**1,188**
RM_D_2	On-site Haul Route	-	-	418	418	418	-	-	418	**418**	**418**

Note: Values in bold indicate change in traffic flow triggering for assessment

5.2 Receptors assessed and background concentrations

Figure C1 presents a detailed map of the modelled area including assessed roads (road network in blue, haul roads in green) and modelled receptors (yellow dots).

Table C3 presents the details of the receptor assessed, background concentrations, background deposition and relevant critical loads.

Figure C1: Map of Rostherne Mere construction transects, including modelled links and modelled ecological receptor points

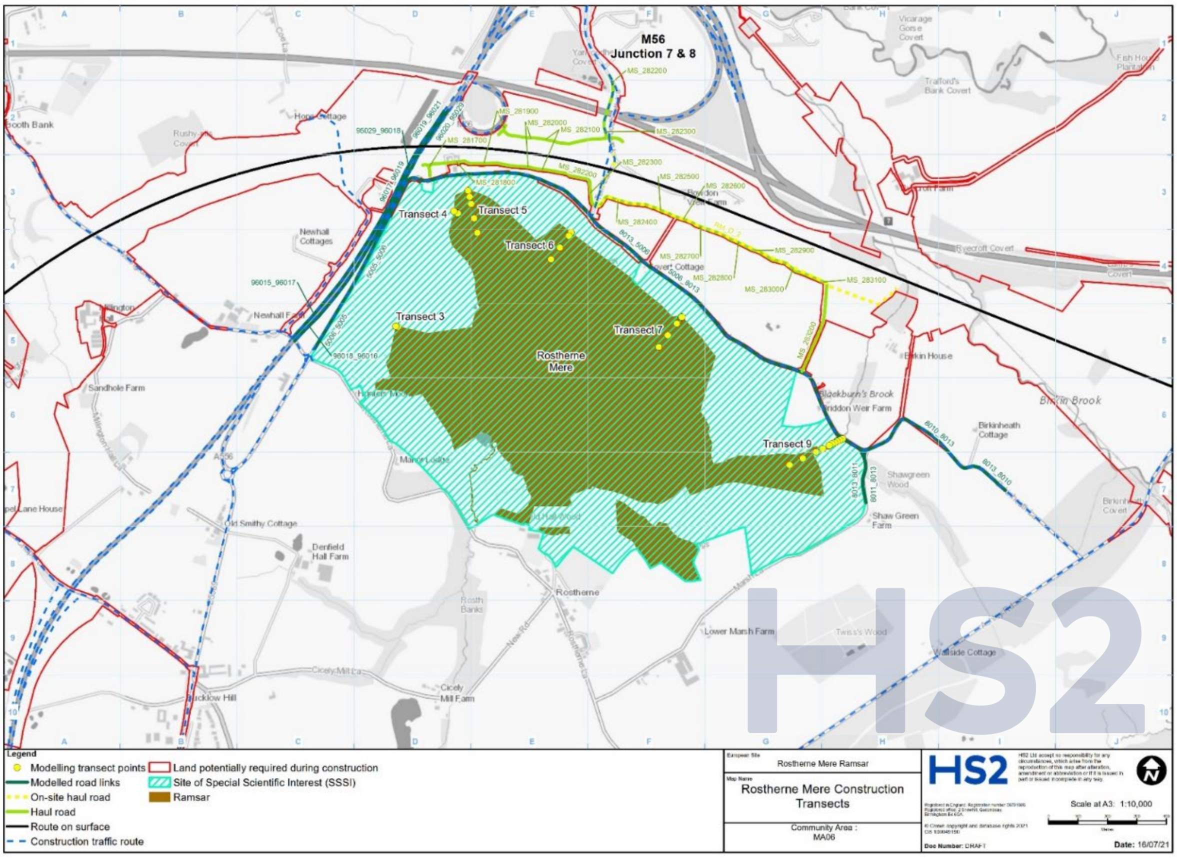

Table C3: Modelled ecological receptor backgrounds, APIS data and critical loads (construction phase, Proposed Scheme alone)

Receptor	Sensitive habitat	2018 NO_x background concentration ($\mu g/m^3$)	2025 NO_x background concentration ($\mu g/m^3$)	APIS data[3] of average total nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)
Rostherne Mere Transect 3	Broadleaved deciduous woodland	16.7	11.7	39.3	20
Rostherne Mere Transect 4	Poor Fen	16.7 - 19.1	11.7 - 13.3	23.8	10
Rostherne Mere Transect 5	Poor fen	19.1	13.3	23.8	10
Rostherne Mere Transect 6	Broadleaved deciduous woodland	19.1	13.3	39.3	20
Rostherne Mere Transect 7	Broadleaved deciduous woodland	19.1	13.3	39.3	20
Rostherne Mere Transect 9	Broadleaved deciduous woodland	16.0 - 30.8	11.6 - 20.1	39.3	20

5.3 Assessment results

Table C4 presents a summary of the modelled NO_x concentrations for the ecological site, the change in concentration and a comparison against the air quality standard (30$\mu g/m^3$).

Table C5 presents a summary of the modelled nitrogen deposition, change in deposition and percentage change in relation to the lower critical load.

Table C4: Predicted annual mean of NO_x concentrations at ecological sites (construction phase, Proposed Scheme alone)

Ecological site	Distance to road (m)	NO_x concentrations (μg/m³)			Change in NO_x concentrations (μg/m³)	Comparison against air quality standard (30μg/m³)
		2018 baseline	2025 without the Proposed Scheme	2025 with the Proposed Scheme		
Rostherne Mere Transect 3	194	20.29	13.62	13.77	0.15	Within standard
	200	20.17	13.56	13.70	0.14	Within standard
Rostherne Mere Transect 4	184	22.15	14.63	14.89	0.26	Within standard
	200	24.08	15.97	16.21	0.24	Within standard
Rostherne Mere Transect 5	53	24.11	15.99	16.26	0.27	Within standard
	75	23.8	15.82	16.07	0.25	Within standard
	100	23.47	15.65	15.88	0.23	Within standard
	150	22.93	15.36	15.56	0.20	Within standard
	200	22.47	15.12	15.30	0.18	Within standard
Rostherne Mere Transect 6	86	20.55	14.10	14.27	0.17	Within standard
	100	20.56	14.11	14.27	0.16	Within standard
	150	20.6	14.13	14.27	0.14	Within standard
	200	20.63	14.14	14.27	0.13	Within standard
Rostherne Mere Transect 7	72	19.71	13.65	13.74	0.09	Within standard
	75	19.71	13.65	13.74	0.09	Within standard
	100	19.71	13.65	13.73	0.08	Within standard
	150	19.71	13.65	13.72	0.07	Within standard
	200	19.71	13.65	13.72	0.07	Within standard
Rostherne Mere Transect 9	0	31.29	20.39	20.81	0.42	Within standard
	10	31.18	20.32	20.50	0.18	Within standard
	20	31.16	20.31	20.44	0.13	Within standard
	30	31.15	20.30	20.41	0.11	Within standard

Ecological site	Distance to road (m)	NO_x concentrations (µg/m³)			Change in NO_x concentrations (µg/m³)	Comparison against air quality standard (30µg/m³)
		2018 baseline	2025 without the Proposed Scheme	2025 with the Proposed Scheme		
	40	31.15	20.30	20.40	0.10	Within standard
	50	31.15	20.30	20.39	0.09	Within standard
	75	16.36	11.77	11.85	0.08	Within standard
	100	16.36	11.77	11.84	0.07	Within standard
	150	16.36	11.77	11.83	0.06	Within standard
	200	16.37	11.77	11.82	0.05	Within standard

Table C5: Assessment of nitrogen deposition at ecological sites (construction phase, Proposed Scheme alone)

Ecological site	Distance to road (m)	Dry deposition (kg N/ha/yr)			Change in nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)	% Change in relation to lower critical load
		2018 baseline	2025 without the Proposed Scheme	2025 with the Proposed Scheme			
Rostherne Mere Transect 3	194	39.91	39.64	39.66	0.02	20	0.1%
	200	39.89	39.63	39.65	0.02	20	0.1%
Rostherne Mere Transect 4	184	24.23	24.03	24.05	0.02	10	0.2%
	200	24.19	24.01	24.03	0.02	10	0.2%
Rostherne Mere Transect 5	53	24.20	24.01	24.03	0.02	10	0.2%
	75	24.17	24.00	24.02	0.02	10	0.2%
	100	24.15	23.99	24.00	0.01	10	0.2%
	150	24.10	23.96	23.98	0.02	10	0.2%
	200	24.07	23.94	23.96	0.02	10	0.1%
Rostherne Mere Transect 6	86	39.58	39.47	39.50	0.03	20	0.1%
	100	39.58	39.47	39.49	0.02	20	0.1%
	150	39.58	39.47	39.49	0.02	20	0.1%

Ecological site	Distance to road (m)	Dry deposition (kg N/ha/yr)			Change in nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)	% Change in relation to lower critical load
		2018 baseline	2025 without the Proposed Scheme	2025 with the Proposed Scheme			
	200	39.59	39.47	39.49	0.02	20	0.1%
Rostherne Mere Transect 7	72	39.44	39.39	39.41	0.02	20	<0.1%
	75	39.44	39.39	39.41	0.02	20	<0.1%
	100	39.44	39.39	39.41	0.02	20	<0.1%
	150	39.44	39.39	39.41	0.02	20	<0.1%
	200	39.44	39.39	39.41	0.02	20	<0.1%
Rostherne Mere Transect 9	0	39.41	39.38	39.45	0.07	20	0.3%
	10	39.39	39.37	39.40	0.03	20	0.1%
	20	39.39	39.37	39.39	0.02	20	0.1%
	30	39.39	39.37	39.39	0.02	20	<0.1%
	40	39.39	39.37	39.38	0.01	20	<0.1%
	50	39.39	39.37	39.38	0.01	20	<0.1%
	75	39.39	39.37	39.38	0.01	20	<0.1%
	100	39.39	39.37	39.38	<0.01	20	<0.1%
	150	39.39	39.37	39.38	<0.01	20	<0.1%
	200	39.39	39.37	39.37	<0.01	20	<0.1%

5.4 Assessment of significance (construction phase, Proposed Scheme alone)

NO_x concentrations are predicted to be within the air quality standard in 2025 at all locations with or without the Proposed Scheme.

Nitrogen deposition is predicted to be above the lower critical load in all scenarios. However, the changes in nitrogen deposition due to the Proposed Scheme are lower than 1% of the lower critical load at all modelled receptors. No potentially significant effects are therefore predicted.

6 Assessment of construction traffic effects – Proposed Scheme in combination with other plans and projects

6.1 Screening of traffic data

The assessment of construction traffic impacts has used traffic data based on an estimate of the average daily flows in the peak year during the construction period (2025-2037). Traffic data is presented in Table C2.

The screening process identified a total of four roads in the area exceeding the screening thresholds:

- A556;
- Chester Road (between Millington Land and Cherry Tree Lane);
- Cherry Tree Lane (between Chester Road and Birkinheath Lane); and
- on-site haul route, north of Cherry Tree Lane.

Further roads have been included in the assessment to account for their emissions at nearby receptors. Rostherne Mere is located east of the A556, just south of M56 Junction 7/8. A planned HS2 construction traffic route runs adjacent to Rostherne Mere, along Chester Road and Cherry Tree Lane for part of the construction period, with approximately 200 HDV movements per day predicted. Traffic impacts, however, are primarily the result of traffic growth along the A556 from the 2018 Base Year.

6.2 Non-road plans and projects

No non-road plans or projects have been identified that require further consideration within the in-combination assessment.

6.3 Receptors assessed and background concentrations

Figure C2 presents a detailed map of the modelled area including assessed roads (road network in blue, haul roads in green) and modelled receptors (yellow dots).

Table C6 presents the details of the receptor assessed, background concentrations, background deposition and relevant critical loads.

Table C6: Modelled ecological receptor backgrounds, APIS data and critical loads

Receptor	Sensitive habitat	2018 NO_x background concentration (μg/m³)	2025 NO_x background concentration (μg/m³)	APIS data[3] of average total nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)
Rostherne Mere Transect 3	Broadleaved deciduous woodland	16.7	11.7	39.3	20
Rostherne Mere Transect 4	Poor Fen	16.7 - 19.1	11.7 - 13.3	23.8	10
Rostherne Mere Transect 5	Poor fen	19.1	13.3	23.8	10
Rostherne Mere Transect 6	Broadleaved deciduous woodland	19.1	13.3	39.3	20
Rostherne Mere Transect 7	Broadleaved deciduous woodland	19.1	13.3	39.3	20
Rostherne Mere Transect 9	Broadleaved deciduous woodland	16.0 - 30.8	11.6 - 20.1	39.3	20

6.4 Assessment results

Table C7 presents a summary of the modelled NO_x concentrations for the ecological site, the change in concentration and a comparison against the air quality standard (30μg/m³).

Table C8 presents a summary of the modelled nitrogen deposition, change in deposition and percentage change in relation to the lower critical load.

Table C7: Predicted annual mean of NO_x concentrations at ecological sites (construction phase, Proposed Scheme in-combination)

Ecological site	Distance to road (m)	NO_x concentrations (µg/m³)			Change in NO_x concentrations (µg/m³)	Comparison against air quality standard (30µg/m³)
		Baseline 2018	2025 do nothing	2025 with the Proposed Scheme		
Rostherne Mere Transect 3	194	20.29	13.39	13.77	0.38	Within standard
	200	20.17	13.34	13.70	0.36	Within standard
Rostherne Mere Transect 4	184	22.15	14.26	14.89	0.63	Within standard
	200	24.08	15.62	16.21	0.59	Within standard
Rostherne Mere Transect 5	53	24.11	15.64	16.26	0.62	Within standard
	75	23.80	15.50	16.07	0.57	Within standard
	100	23.47	15.35	15.88	0.53	Within standard
	150	22.93	15.10	15.56	0.46	Within standard
	200	22.47	14.89	15.30	0.41	Within standard
Rostherne Mere Transect 6	86	20.55	14.00	14.27	0.27	Within standard
	100	20.56	14.00	14.27	0.27	Within standard
	150	20.60	14.02	14.27	0.25	Within standard
	200	20.63	14.03	14.27	0.24	Within standard
Rostherne Mere Transect 7	72	19.71	13.61	13.74	0.13	Within standard
	75	19.71	13.61	13.74	0.13	Within standard
	100	19.71	13.61	13.73	0.12	Within standard
	150	19.71	13.61	13.72	0.11	Within standard
	200	19.71	13.61	13.72	0.11	Within standard
Rostherne Mere Transect 9	0	31.29	20.35	20.81	0.46	Within standard
	10	31.18	20.29	20.50	0.21	Within standard
	20	31.16	20.28	20.44	0.16	Within standard
	30	31.15	20.28	20.41	0.13	Within standard

Ecological site	Distance to road (m)	NO_x concentrations (μg/m³)			Change in NO_x concentrations (μg/m³)	Comparison against air quality standard (30μg/m³)
		Baseline 2018	2025 do nothing	2025 with the Proposed Scheme		
	40	31.15	20.28	20.40	0.12	Within standard
	50	31.15	20.27	20.39	0.12	Within standard
	75	16.36	11.75	11.85	0.10	Within standard
	100	16.36	11.75	11.84	0.09	Within standard
	150	16.36	11.75	11.83	0.08	Within standard
	200	16.37	11.75	11.82	0.07	Within standard

Table C8: Assessment of Nitrogen deposition at ecological sites (construction phase, Proposed Scheme in-combination)

Ecological site	Distance to road (m)	Dry deposition (kg N/ha/yr)			Change in nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)	% Change in relation to lower critical load
		Baseline 2018	2025 do nothing	2025 with the Proposed Scheme			
Rostherne Mere Transect 3	194	39.91	39.60	39.66	0.06	20	0.3%
	200	39.89	39.59	39.65	0.06	20	0.3%
Rostherne Mere Transect 4	184	24.23	24.00	24.05	0.05	10	0.5%
	200	24.19	23.98	24.03	0.05	10	0.5%
Rostherne Mere Transect 5	53	24.20	23.99	24.03	0.04	10	0.5%
	75	24.17	23.97	24.02	0.05	10	0.4%
	100	24.15	23.96	24.00	0.04	10	0.4%
	150	24.10	23.94	23.98	0.04	10	0.4%
	200	24.07	23.93	23.96	0.03	10	0.3%
Rostherne Mere Transect 6	86	39.58	39.45	39.50	0.05	20	0.2%
	100	39.58	39.45	39.49	0.04	20	0.2%
	150	39.58	39.46	39.49	0.03	20	0.2%
	200	39.59	39.46	39.49	0.03	20	0.2%

Ecological site	Distance to road (m)	Dry deposition (kg N/ha/yr)			Change in nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)	% Change in relation to lower critical load
		Baseline 2018	2025 do nothing	2025 with the Proposed Scheme			
Rostherne Mere Transect 7	72	39.44	39.39	39.41	0.02	20	0.1%
	75	39.44	39.39	39.41	0.02	20	0.1%
	100	39.44	39.39	39.41	0.02	20	0.1%
	150	39.44	39.39	39.41	0.02	20	<0.1%
	200	39.44	39.39	39.41	0.02	20	<0.1%
Rostherne Mere Transect 9	0	39.41	39.38	39.45	0.07	20	0.3%
	10	39.39	39.37	39.40	0.03	20	0.2%
	20	39.39	39.37	39.39	0.02	20	0.1%
	30	39.39	39.37	39.39	0.02	20	0.1%
	40	39.39	39.36	39.38	0.02	20	0.1%
	50	39.39	39.36	39.38	0.02	20	<0.1%
	75	39.39	39.36	39.38	0.02	20	<0.1%
	100	39.39	39.36	39.38	0.02	20	<0.1%
	150	39.39	39.36	39.38	0.02	20	<0.1%
	200	39.39	39.36	39.37	0.01	20	<0.1%

6.5 Assessment of significance (construction phase, Proposed Scheme in-combination)

NO_x concentrations are predicted to be within the air quality standard in 2025 at all locations with or without the Proposed Scheme.

Nitrogen deposition is predicted to be above the lower critical load in all scenarios. However, the changes in nitrogen deposition due to the Proposed Scheme in-combination are lower than 1% of the lower critical load at all modelled receptors. No potentially significant effects are therefore predicted.

7 Assessment of operational traffic effects – Proposed Scheme alone

7.1 Screening of traffic data

The assessment of operational traffic impacts has used traffic data based on an estimate of the average daily flows in the opening year of operation (2038). Traffic data are presented in Table C9.

The screening process identified one road in the area exceeding the screening thresholds: the A556.

Further roads have been included in the assessment to account for their emissions at nearby receptors.

Rostherne Mere is located east of the A556, just south of M56 Junction 7/8. Traffic impacts are primarily the result of increased traffic along the A556.

Table C9: Traffic data summary (operational phase)

Road ID	Road name	Annual Average Daily Traffic (AADT)			Proposed Scheme alone change (2038 with Proposed Scheme – 2038 without Proposed Scheme)	In-combination change (2038 with Scheme – 2018 baseline)	Heavy Duty Vehicles (HDV)			Proposed Scheme alone change (2038 with Proposed Scheme – 2038 without Proposed Scheme)	In-combination change (2038 with Scheme – 2018 baseline)
		2018 baseline	2038 without the Proposed Scheme	2038 with the Proposed Scheme			2018 baseline	2038 without the Proposed Scheme	2038 with the Proposed Scheme		
5006_5005, 5005_5006	Chester Road, Rostherne Mere	60	174	183	9	123	-	-	183	183	183
96017_96019	A556	28,029	37,081	38,575	**1,494**	**10,546**	2,081	2,671	2,666	-5	**585**
96015_96017	A556	28,029	37,081	38,575	**1,494**	**10,546**	2,081	2,671	2,666	-5	**585**
95029_96018	A556	31,147	34,220	34,847	627	**3,700**	2,061	2,461	2,445	-16	**384**
96018_96016	A556	31,147	34,220	34,847	627	**3,700**	2,061	2,461	2,445	-16	**384**
96020_95029	A556	31,147	34,220	34,847	627	**3,700**	2,061	2,461	2,445	-16	**384**
8013_5006, 5006_8013	Cherry Tree Lane, Rostherne Mere	60	174	183	9	123	-	-	183	183	183
96019_96021	A556	28,029	37,081	38,575	**1,494**	**10,546**	2,081	2,671	2,666	-5	**585**

Note: Values in bold indicate change in traffic flow triggering for assessment

7.2 Receptors assessed and background concentrations

Figure C2: Map of the site, assessed roads and modelled receptors

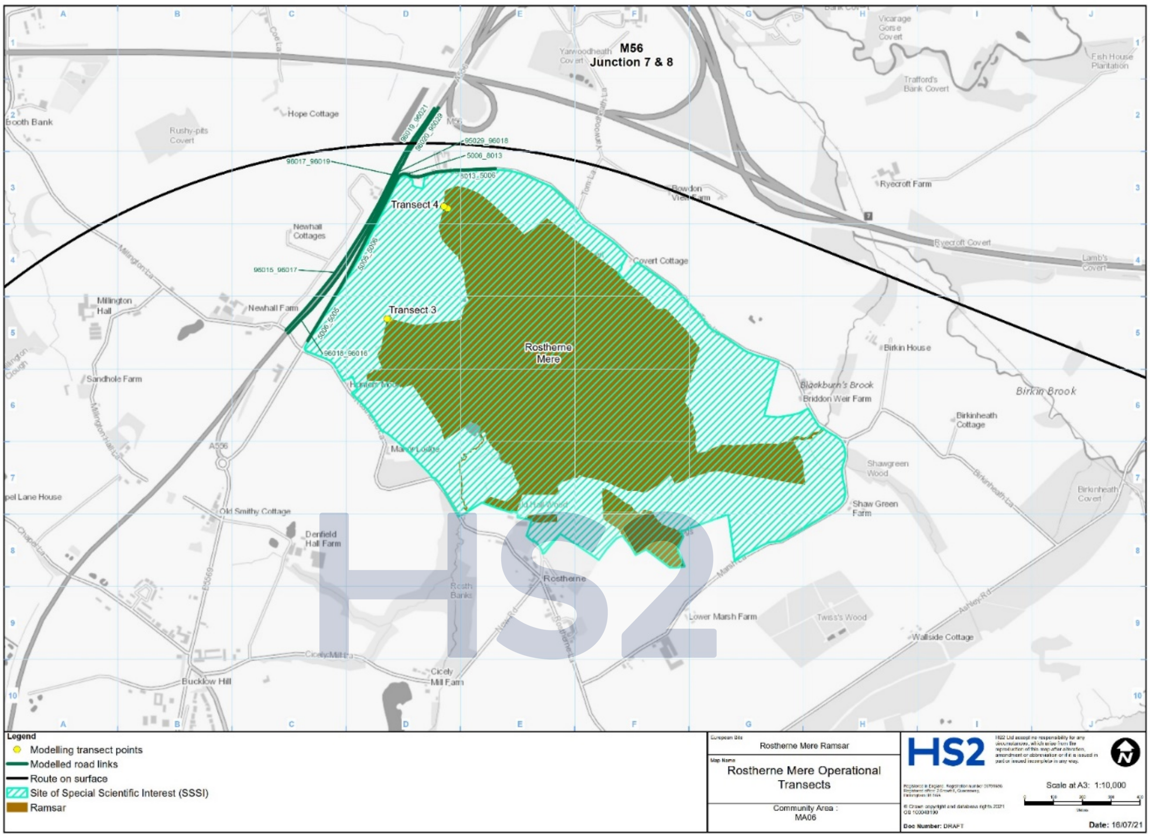

Table C10: Modelled ecological receptor backgrounds, APIS data and critical loads

Receptor	Sensitive habitat	2018 NO_x background concentration (µg/m³)	2038 NO_x background concentration (µg/m³)	APIS data[3] of average total nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)
Rostherne Mere Transect 3	Broadleaved deciduous woodland	16.7	10.1	39.3	20
Rostherne Mere Transect 4	Poor Fen	16.7 - 19.1	10.1 - 11.2	23.8	10

7.3 Assessment results

Table C11 presents a summary of the modelled NO_x concentrations for the ecological site, the change in concentration and a comparison against the air quality standard (30μg/m^3).

Table C12 presents a summary of the modelled nitrogen deposition, change in deposition and percentage change in relation to the lower critical load.

Table C11: Predicted annual mean of NO_x concentrations at ecological sites (operational phase, Proposed Scheme alone)

Ecological site	Distance to road (m)	NO_x concentrations (µg/m³)			Change in NO_x concentrations (µg/m³)	Comparison against air quality standard (30µg/m³)
		2018 Baseline	2038 without the Proposed Scheme	2038 with the Proposed Scheme		
Rostherne Mere Transect 3	194	20.29	10.86	10.88	0.02	Within standard
	200	20.17	10.84	10.86	0.02	Within standard
Rostherne Mere Transect 4	184	22.15	11.28	11.31	0.03	Within standard
	200	24.08	12.25	12.28	0.03	Within standard

Table C12: Assessment of nitrogen deposition at ecological sites (operational phase, Proposed Scheme alone)

Ecological site	Distance to road (m)	Dry deposition (kg N/ha/yr)			Change in nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)	% Change in relation to lower critical load
		2018 baseline	2038 without the Proposed Scheme	2038 with the Proposed Scheme			
Rostherne Mere Transect 3	194	39.91	39.46	39.46	<0.01	20	<0.1%
	200	39.89	39.45	39.46	<0.01	20	<0.1%
Rostherne Mere Transect 4	184	24.23	23.89	23.89	<0.01	10	<0.1%
	200	24.19	23.88	23.89	<0.01	10	<0.1%

7.4 Assessment of significance (operational phase, Proposed Scheme alone)

NO_x concentrations are predicted to be within the air quality standard in 2038 at all locations with or without the Proposed Scheme.

Nitrogen deposition is predicted to be above the lower critical load in all scenarios. However, the changes in nitrogen deposition due to the Proposed Scheme are lower than 1% of the lower critical load at all modelled receptors. No potentially significant effects are therefore predicted.

8 Assessment of operational traffic effects – Proposed Scheme in combination with other plans and projects

8.1 Screening of traffic data

The assessment of operational traffic impacts has used traffic data based on an estimate of the average daily flows in the opening year of operation (2038). Traffic data are presented in Table C9.

The screening process identified one road in the area exceeding the screening thresholds: the A556.

Further roads have been included in the assessment to account for their emissions at nearby receptors.

Mere is located east of the A556, just south of M56 Junction 7/8. Traffic impacts are primarily the result of increased traffic growth along the A556 from the 2018 Base Year.

8.2 Non-road plans and projects

No non-road plans or projects have been identified that require further consideration within the in-combination assessment.

8.3 Receptors assessed and background concentrations

Figure C2 presents a map of the sites, assessed roads and modelled receptors.

Table C13 presents the details of the receptor assessed, background concentrations, background deposition and relevant critical loads.

Table C13: Modelled ecological receptor backgrounds, APIS data and critical loads

Receptor	Sensitive habitat	2018 NO_x background concentration (µg/m3)	2038 NOx background concentration (µg/m3)	APIS data[3] of average total nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)
Rostherne Mere Transect 3	Broadleaved deciduous woodland	16.7	10.1	39.3	20
Rostherne Mere Transect 4	Poor Fen	16.7 - 19.1	10.1 - 11.2	23.8	10

8.4 Assessment results

Table C14 presents a summary of the modelled NO_x concentrations for the ecological site, the change in concentration and a comparison against the air quality standard (30µg/m^3).

Table C15 presents a summary of the modelled nitrogen deposition, change in deposition and percentage change in relation to the lower critical load.

Table C14: Predicted annual mean of NO_x concentrations at ecological sites (operational phase, Proposed Scheme in-combination)

Ecological site	Distance to road (m)	NO_x concentrations (µg/m³)			Change in NO_x concentrations (µg/m³)	Comparison against air quality standard (30µg/m³)
		Baseline 2018	2038 do nothing	2038 with the Proposed Scheme		
Rostherne Mere Transect 3	194	20.29	10.74	10.88	0.14	Within standard
	200	20.17	10.72	10.86	0.14	Within standard
Rostherne Mere Transect 4	184	22.15	11.08	11.31	0.23	Within standard
	200	24.08	12.07	12.28	0.22	Within standard

Table C15: Assessment of nitrogen deposition at ecological sites (operational phase, Proposed Scheme in-combination)

Ecological site	Distance to road (m)	Dry deposition (kg N/ha/yr)			Change in nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)	% Change in relation to lower critical load
		Baseline 2018	2038 do nothing	2038 with the Proposed Scheme			
Rostherne Mere Transect 3	194	39.91	39.44	39.46	0.02	20	0.1%
	200	39.89	39.43	39.46	0.03	20	0.1%
Rostherne Mere Transect 4	184	24.23	23.87	23.89	0.02	10	0.2%
	200	24.19	23.87	23.89	0.02	10	0.2%

8.5 Assessment of significance (operational phase, Proposed Scheme in-combination)

NO_x concentrations are predicted to be within the air quality standard in 2038 at all locations with or without the Proposed Scheme.

Nitrogen deposition is predicted to be above the lower critical load in all scenarios. However, the changes in nitrogen deposition due to the Proposed Scheme in-combination are lower than 1% of the lower critical load at all modelled receptors. No potentially significant effects are therefore predicted.

Annex D: Additional air quality information to inform a Habitats Regulations Assessment Midland Meres and Mosses Phase 1 Ramsar site

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Annex D: Additional air quality information to inform a Habitats Regulations Assessment Midland Meres and Mosses Phase 1 Ramsar site

1 Purpose

This Annex provides additional air quality information in relation to impacts from vehicle emissions to support the document to inform a HRA for Midland Meres and Mosses Phase 1 Ramsar site (The Mere, Mere).

2 Scope, assumptions and limitations

The scope, assumptions and limitations for the air quality assessment are set out in full in Volume 1 (Section 8), in the Environmental Impact Assessment SMR (see Volume 5: Appendix CT-001-00001) and accompanying SMR Technical note – Air quality: Guidance on the assessment methodology.

Key elements in relation to the assessment of vehicle emissions on ecologically sensitive sites are:

- screening of traffic data using the criteria set out in the SMR which is based on the DMRB criteria[1], to identify where assessment is required;
- these criteria are the following for assessing the impacts of the scheme alone:
  - change in road alignment by 5m or more;
  - change in daily traffic flows by 1,000 vehicles or more as AADT;
  - change in daily flows of HDV by 200 AADT or more;
  - change in daily average speed by 10kph or more; or
  - change in peak hour speed by 20kph or more.
- these criteria are the following for assessing the impacts of the scheme in combination with other plans and projects:
  - change in daily traffic flows by 1,000 vehicles or more as AADT; or
  - change in daily flows of HDV by 200 AADT or more.
- ecological receptors included in the air quality assessment are designated sites with habitats sensitive to NO_x. These could include, SAC, SPA and Ramsar sites;
- transects have been used within a designated site with modelled points at 0m, 10m, 20m, 30m, 40m, 50m, 75m, 100m, 150m and 200m from the edge of the road unless the shape of the site and potential impacts necessitates different distances to characterise the impacts;
- a deposition velocity relevant to the habitat of each site has been used, as detailed in the IAQM ecological guidance[2]. Data on nitrogen deposition has been taken from the most recent information available on the APIS[3] website. No reduction in future background deposition rates has been applied;
- the following scenarios are assessed:

[1] Highways England, Transport Scotland, Welsh Government & Department for Infrastructure (2019), *Design Manual for Roads and Bridges LA105 Air quality*.

[2] Holman et al. (2019), *A guide to the assessment of air quality impacts on designated nature conservation sites – version 1.0,* Institute of Air Quality Management, London. Available online at: https://iaqm.co.uk/text/guidance/air-quality-impacts-on-nature-sites-2019.pdf.

[3] UK Centre for Ecology and Hydrology (2021), *Air Pollution Information System*. Available online at: http://www.apis.ac.uk/.

  - baseline;
  - selected year(s) within the construction period for the assessment of the effects of construction. The year(s) of assessment are selected based on the worse case peak period during the construction programme and on when significant effects might be expected; and
  - an operational scenario will be assessed for the first full operational year after construction is completed.
- for each assessment year, both the scenario without the Proposed Scheme in place and the scenario with the Proposed Scheme in place will be modelled. This comparison is used to assess the impacts of the Proposed Scheme alone;
- for the assessment of the Proposed Scheme in combination with other plans and projects, a different without scheme scenario is used and described as the 'do nothing' scenario. This uses traffic data from the 2018 baseline, but background pollutant concentrations/ deposition rates and emission factors representing the future year being assessed;
- the assessment incorporates HS2 Ltd's policy on construction vehicle emissions standards. These standards are published in Information Paper E31; Air Quality and include Euro VI for HGVs, and Euro 6 and Euro 4 for diesel and petrol Light-Duty Vehicles (LDV) respectively;
- in-combination effects are largely taken into account in the traffic data used for the assessment which incorporates likely changes brought about by other proposed and committed developments[4]; and
- consideration is also given to relevant non-road plans and projects.

[4] A number of strategic traffic models have been sourced from key stakeholders, including Local Highway Authorities and Highways England. In combination, these models cover the areas that are expected to be affected by the proposed scheme and have been used as the basis of assessment for traffic flow analysis. The models have been developed by the relevant stakeholders in accordance with Transport Analysis Guidance (TAG) provided by the Department for Transport, with each model representing a Base Year position between 2016 and 2018.

Forecast year models have also been supplied by the above stakeholders which reflect committed and planned changes to the transport network and growth associated with committed and planned developments that are sufficiently certain to be introduced after the Base Year of the strategic model. Reviews of committed developments will have been undertaken by the relevant stakeholders at the same time as preparing and validating the Base Year model and developing future year models. Given that the models represent a Base Year position between 2016 and 2018, it is likely that the reviews of forecast committed developments will have been undertaken between 2016 and 2018 depending on when each model was last updated.

In order to account for traffic growth from 2018 to future years, growth factors were directly obtained from TEMPro version 7.2 which uses the National Trip End Model (NTEM 7.2 (2017)) dataset and the National Transport Model (NTM) 2015. TEMPro inherently incorporates future planned development, being based on approved plans, irrespective of whether it is approved, committed, or simply included in approved plans. It includes all economic and population growth forecasts, and assumes growth in housing and commercial development, therefore providing a prediction of traffic growth by area.

3 Air quality standards

Air quality limit values and objectives are quality standards for clean air and to protect human health or harm to vegetation. The term 'air quality standards' will be used to refer to both the English air quality objectives and the air quality limit values and critical levels introduced in the UK based on EU Directives. Table D1 sets out the air quality standard for NO_x.

Table D1: Air quality standards

Pollutant	Averaging period	Standard
NO_x (for protection of vegetation)	Annual Mean	30µg/m^3

For the assessment of changes in nitrogen, comparison has been made against the applicable lower critical load[5] for the site, as provided by APIS.

[5] The critical loads for nitrogen deposition vary and are specific to each qualifying feature. These are presented as a range of values (expressed as a rate, e.g. 10kg N/ha/yr - 20 kg N/ha/yr) and typically, as a precautionary approach, only the lowest value is used (unless there are compelling reasons to do otherwise) as this will emphasise any negative outcomes.

4 How significance is assessed

For the assessment of NO_x concentrations, the effect is considered to be not significant if the total predicted NO_x concentrations are below the air quality standard of 30μg/m^3.

For the assessment of nitrogen deposition, if the change in nitrogen deposition is predicted to be less than 1% of the lower critical load, then the effect is considered to be not significant. However, should the nitrogen deposition change by more than 1%, then the assessment of significance will be undertaken by an ecologist and reported within Section 3 of the main HRA report.

5 Assessment of construction traffic effects – Proposed Scheme alone

5.1 Screening of traffic data

The screening process identified one road in the area exceeding the screening thresholds: the A50 Warrington Road, Mere.

Further roads have been included in the assessment to account for their emissions at nearby receptors.

Table D2 presents the traffic data used in the assessment. The Mere, Mere is located east of the A556 Chester Road. Traffic impacts, however, are primarily the result of increased traffic along the A50 Warrington Road from diversionary effects during the construction phase.

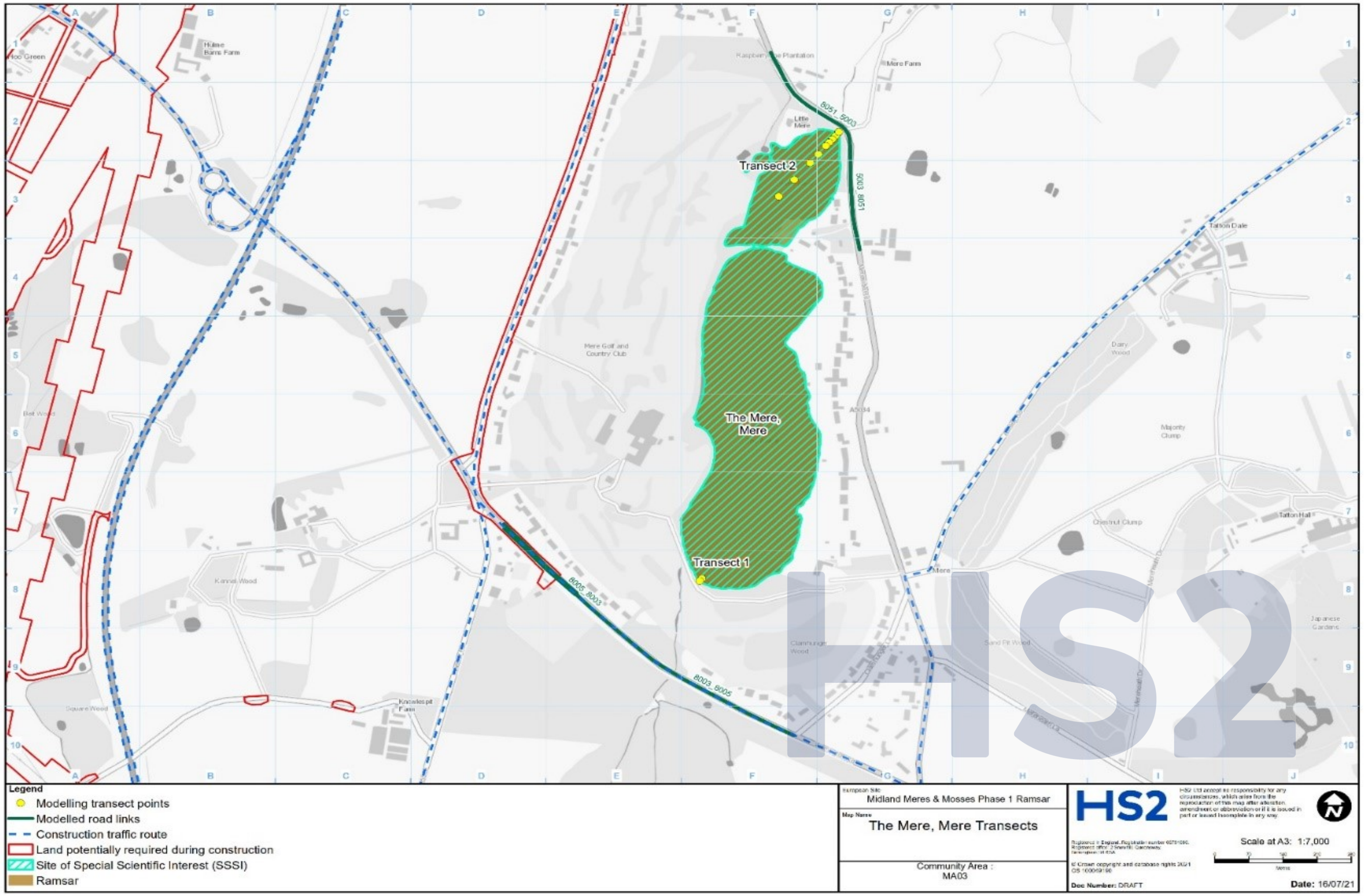
Figure D1 present maps of the site, assessed roads and modelled receptors.

Table D2: Traffic data summary (construction phase)

Road ID	Road name	Annual Average Daily Traffic (AADT)					Heavy Duty Vehicles (HDV)				
		2018 baseline	2025 without the Proposed Scheme	2025 with the Proposed Scheme	Proposed Scheme alone change (2025 with Proposed Scheme – 2025 without Proposed Scheme)	In-combination change (2025 with the Proposed Scheme – 2018 baseline)	2018 baseline	2025 without the Proposed Scheme	2025 with the Proposed Scheme	Proposed Scheme alone change (2025 with Proposed Scheme – 2025 without Proposed Scheme)	In-combination change (2025 with the Proposed Scheme – 2018 baseline)
8005_8003, 8003_8005	A50 Warrington Road	13,382	14,879	16,259	**1,379**	**2,877**	332	214	523	**309**	191
8051_5003, 5003_8051	A5034 Mereside Road	6,112	5,392	4,593	-799	**-1,519**	85	84	80	-4	-5

Note: Values in bold indicate change in traffic flow triggering for assessment

Figure D1: Map of The Mere, Mere Transect 1, including modelled links and modelled ecological receptor points



5.2 Receptors assessed and background concentrations

Table D3: Modelled ecological receptor backgrounds, APIS data and critical loads (construction phase)

Receptor	Sensitive habitat	2018 NO_x background concentration (μg/m[3])	2025 NO_x background concentration (μg/m[3])	APIS data[3] of average total nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)
The Mere, Mere Transect 1	Poor fen	15.3	11.1	23.8	10
The Mere, Mere Transect 2	Poor fen	15.4	11.1	23.8	10

5.3 Assessment results

Table D4: Predicted annual mean of NOx concentrations at ecological sites (construction phase, Proposed Scheme alone)

Ecological site	Distance to road	NO_x concentrations (µg/m^3)			Change in NO_x concentrations (µg/m3)	Comparison against air quality standard (30µg/m^3)
		2018 baseline	2025 without the Proposed Scheme	2025 with the Proposed Scheme		
The Mere, Mere Transect 1	193	17.26	12.10	12.20	0.10	Within standard
	200	17.18	12.06	12.15	0.09	Within standard
The Mere, Mere Transect 2	9	22.76	14.39	14.44	0.05	Within standard
	10	22.35	14.21	14.26	0.05	Within standard
	20	20.34	13.30	13.34	0.04	Within standard
	30	19.28	12.82	12.86	0.04	Within standard
	40	18.60	12.52	12.55	0.03	Within standard
	50	18.12	12.30	12.34	0.04	Within standard
	75	17.36	11.96	11.99	0.03	Within standard
	100	16.89	11.75	11.78	0.03	Within standard
	150	16.37	11.52	11.55	0.03	Within standard
	200	16.11	11.41	11.43	0.02	Within standard

Table D5: Assessment of nitrogen deposition at ecological sites (construction phase, Proposed Scheme alone)

Ecological Site	Distance to road	Dry deposition (kg N/ha/yr)			Change in nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)	% Change in relation to lower critical load
		2018 baseline	2025 without the Proposed Scheme	2025 with the Proposed Scheme			
The Mere, Mere Transect 1	193	23.95	23.88	23.89	<0.01	10	<0.1%
	200	23.95	23.88	23.89	<0.01	10	<0.1%
The Mere, Mere Transect 2	9	24.38	24.06	24.07	<0.01	10	<0.1%
	10	24.35	24.05	24.05	<0.01	10	<0.1%
	20	24.19	23.98	23.98	<0.01	10	<0.1%
	30	24.11	23.94	23.94	<0.01	10	<0.1%
	40	24.05	23.92	23.92	<0.01	10	<0.1%
	50	24.02	23.90	23.90	<0.01	10	<0.1%
	75	23.96	23.87	23.87	<0.01	10	<0.1%
	100	23.92	23.85	23.86	<0.01	10	<0.1%
	150	23.88	23.84	23.84	<0.01	10	<0.1%
	200	23.86	23.83	23.83	<0.01	10	<0.1%

5.4 Assessment of significance (construction phase, Proposed Scheme alone)

NO_x concentrations are predicted to be within the air quality standard in all scenarios with or without the Proposed Scheme.

Nitrogen deposition is predicted to be above the lower critical load in all scenarios. However, the changes in nitrogen deposition as a result of the Proposed Scheme are lower than 1% of the lower critical load at all modelled receptors.

No potentially significant effects are therefore predicted.

6 Assessment of construction traffic effects – Proposed Scheme in combination with other plans and projects

6.1 Screening of traffic data

The screening process identified two roads in the area exceeding the screening thresholds:

- the A50 Warrington Road, Mere; and
- the A5034 Mereside Road.

Table D2 presents the traffic data used in the assessment. The Mere, Mere is located east of the A556 Chester Road. Traffic impacts however, are primarily the result of increased traffic along the A50 Warrington Road and A5034 Mereside Road from diversionary effects during the construction phase.

Figure D1 present maps of the site, assessed roads and modelled receptors.

6.2 Non-road plans and projects

No non-road plans or projects have been identified that require further consideration within the in-combination assessment.

6.3 Receptors assessed and background concentrations

Table D6: Modelled ecological receptor backgrounds, APIS data and critical loads (construction phase)

Receptor	Sensitive habitat	2018 NO_x background concentration (μg/m³)	2025 NOx background concentration (μg/m³)	APIS data[3] of average total nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)
The Mere, Mere Transect 1	Poor fen	15.34	11.1	23.8	10
The Mere, Mere Transect 2	Poor fen	15.38	11.1	23.8	10

6.4 Assessment results

Table D7: Predicted annual mean of NOx concentrations at ecological sites (construction phase, Proposed Scheme in-combination)

Ecological site	Distance to road (m)	NO_x concentrations (µg/m³)			Change in NO_x concentrations (µg/m³)	Comparison against air quality standard (30µg/m³)
		Baseline 2018	2025 do nothing	2025 with the Proposed Scheme in-combination		
The Mere, Mere Transect 1	193	17.26	11.99	12.20	0.21	Within standard
	200	17.18	11.96	12.15	0.19	Within standard
The Mere, Mere Transect 2	9	22.76	14.81	14.44	<0.01	Within standard
	10	22.35	14.61	14.26	<0.01	Within standard
	20	20.34	13.58	13.34	<0.01	Within standard
	30	19.28	13.04	12.86	<0.01	Within standard
	40	18.60	12.69	12.55	<0.01	Within standard
	50	18.12	12.45	12.34	<0.01	Within standard
	75	17.36	12.06	11.99	<0.01	Within standard
	100	16.89	11.82	11.78	<0.01	Within standard
	150	16.37	11.56	11.55	<0.01	Within standard
	200	16.11	11.42	11.43	<0.01	Within standard

Table D8: Assessment of Nitrogen deposition at ecological sites (construction phase, Proposed Scheme in-combination)

Ecological site	Distance to road (m)	Dry deposition (kg N/ha/yr)			Change in nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)	% Change in relation to lower critical load
		Baseline 2018	2025 do nothing	2025 with the Proposed Scheme in-combination			
The Mere, Mere Transect 1	193	23.95	23.87	23.89	0.02	10	0.2%
	200	23.95	23.87	23.89	0.02	10	0.2%
The Mere, Mere Transect 2	9	24.38	24.10	24.07	<0.01	10	<0.1%
	10	24.35	24.08	24.05	<0.01	10	<0.1%
	20	24.19	24.00	23.98	<0.01	10	<0.1%
	30	24.11	23.96	23.94	<0.01	10	<0.1%
	40	24.05	23.93	23.92	<0.01	10	<0.1%
	50	24.02	23.91	23.90	<0.01	10	<0.1%
	75	23.96	23.88	23.87	<0.01	10	<0.1%
	100	23.92	23.86	23.86	<0.01	10	<0.1%
	150	23.88	23.84	23.84	<0.01	10	<0.1%
	200	23.86	23.83	23.83	<0.01	10	<0.1%

6.5 Assessment of significance (construction phase, Proposed Scheme in-combination)

NO_x concentrations are predicted to be within the air quality standard in all scenarios with or without the Proposed Scheme.

Nitrogen deposition is predicted to be above the lower critical load in all scenarios. However, the changes in nitrogen deposition as a result of the Proposed Scheme in-combination are lower than 1% of the lower critical load at all modelled receptors.

No potentially significant effects are therefore predicted.

7 Assessment of operational traffic effects – Proposed Scheme alone

7.1 Screening of traffic data

The screening process identified one road in the area exceeding the screening thresholds: the A50 Warrington Road, Mere.

Further roads have been included in the assessment to account for their emissions at nearby receptors.

Table D9 presents the traffic data used in the assessment. The Mere, Mere is located east of the A556 Chester Road. Traffic impacts however, are primarily the result of rerouting of traffic along the A50 Warrington Road as a result of the Proposed Scheme.

Figure D1 present maps of the site, assessed roads and modelled receptors.

Table D9: Traffic data summary (operational phase)

Road ID	Road name	Annual Average Daily Traffic (AADT)					Heavy Duty Vehicles (HDVs)				
		2018 baseline	2038 without the Proposed Scheme	2038 with the Proposed Scheme	Proposed Scheme alone change (2038 with Proposed Scheme – 2038 without Proposed Scheme)	In-combination change (2038 with Proposed Scheme – 2018 baseline)	2018 baseline	2038 without the Proposed Scheme	2038 with the Proposed Scheme	Proposed Scheme alone change (2038 with Proposed Scheme – 2038 without Proposed Scheme)	In-combination change (2038 with the Proposed Scheme – 2018 baseline)
8005_8003, 8003_8005	A50 Warrington Road	13,382	15,320	16,332	**1,012**	**2,950**	332	246	255	9	-77
8051_5003, 5003_8051	A5034 Mereside Road	6,112	4,978	4,502	-476	**-1,610**	85	83	82	-1	-3

Note: Values in bold indicate change in traffic flow triggering for assessment

7.2 Receptors assessed and background concentrations

Table D10: Presents the relevant habitat types, backgrounds and critical loads (operation phase, Proposed Scheme alone)

Receptor	Sensitive habitat	2018 NOx background concentration (µg/m³)	2038 NO_x background concentration (µg/m³)	APIS data[3] of average total nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)
The Mere, Mere Transect 1	Poor fen	15.3	9.6	23.8	10
The Mere, Mere Transect 2	Poor fen	15.4	9.6	23.8	10

7.3 Assessment results

Table D11: Predicted annual mean of NOx concentrations at ecological sites (operation phase, Proposed Scheme alone)

Ecological site	Distance to road (m)	NO_x concentrations (µg/m^3)			Change in NOx concentrations (µg/m^3)	Comparison against air quality standard (30µg/m^3)
		2018 baseline	2038 without the Proposed Scheme	2038 with the Proposed Scheme		
The Mere, Mere Transect 1	193	17.26	10.05	10.08	0.03	Within standard
	200	17.18	10.03	10.06	0.03	Within standard
The Mere, Mere Transect 2	9	22.76	10.85	10.74	<0.01	Within standard
	10	22.35	10.79	10.68	<0.01	Within standard
	20	20.34	10.45	10.37	<0.01	Within standard
	30	19.28	10.27	10.21	<0.01	Within standard
	40	18.60	10.16	10.11	<0.01	Within standard
	50	18.12	10.07	10.04	<0.01	Within standard
	75	17.36	9.95	9.92	<0.01	Within standard
	100	16.89	9.87	9.85	<0.01	Within standard
	150	16.37	9.78	9.78	<0.01	Within standard
	200	16.11	9.74	9.74	<0.01	Within standard

Table D12: Assessment of nitrogen deposition at ecological sites (operation phase, Proposed Scheme alone)

Ecological site	Distance to road (m)	Dry deposition (kg N/ha/yr)			Change in nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)	% Change in relation to lower critical load
		2018 baseline	2038 without the Proposed Scheme	2038 with the Proposed Scheme			
The Mere, Mere Transect 1	193	23.95	23.83	23.83	<0.01	10	<0.1%
	200	23.95	23.83	23.83	<0.01	10	<0.1%
The Mere, Mere Transect 2 *	9	24.38	23.90	23.89	<0.01	10	<0.1%
	10	24.35	23.89	23.88	<0.01	10	<0.1%
	20	24.19	23.87	23.86	<0.01	10	<0.1%
	30	24.11	23.85	23.85	<0.01	10	<0.1%
	40	24.05	23.84	23.84	<0.01	10	<0.1%
	50	24.02	23.84	23.83	<0.01	10	<0.1%
	75	23.96	23.83	23.82	<0.01	10	<0.1%
	100	23.92	23.82	23.82	<0.01	10	<0.1%
	150	23.88	23.81	23.81	<0.01	10	<0.1%
	200	23.86	23.81	23.81	<0.01	10	<0.1%

*Notes: * indicates that points in this Transect cause a reduction in concentrations as a result of the Proposed Scheme – alone and therefore these Transects are not considered within the Proposed Scheme in-combination*

7.4 Assessment of significance (operational phase, Proposed Scheme alone)

NO_x concentrations are predicted to be within the air quality standard in all scenarios with or without the Proposed Scheme.

Nitrogen deposition is predicted to be above the lower critical load in all scenarios. However, the changes in nitrogen deposition as a result of the Proposed Scheme are lower than 1% of the lower critical load at all modelled receptors.

No potentially significant effects are therefore predicted.

8 Assessment of operational traffic effects – Proposed Scheme in combination with other plans and projects

8.1 Screening of traffic data

The screening process identified two roads in the area exceeding the screening thresholds. The in-combination assessment uses the same transects as the construction 'Proposed Scheme -alone' assessment, except where the Proposed Scheme reduces nitrogen deposition. As indicated within Table D12 Transect 2 is therefore not considered for the in-combination assessment.

Table D9 presents the traffic data used in the assessment. The Mere, Mere is located east of the A556 Chester Road. Traffic impacts however, are primarily the result of rerouting of traffic along the A50 Warrington Road and the A5034 Mereside Road as a result of the Proposed Scheme.

Figure D1 and present maps of the site assessed roads and modelled receptors.

Non-road plans and projects

No non-road plans or projects have been identified that require further consideration within the in-combination assessment.

Receptors assessed and background concentrations

Table D13: Presents the relevant habitat types, backgrounds and critical loads (operational phase, Proposed Scheme in-combination)

Receptor	Sensitive habitat	2018 NO_x background concentration (µg/m³)	2038 NOx background concentration (µg/m³)	APIS data[3] of average total nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)
The Mere, Mere Transect 1	Poor fen	15.3	9.6	23.8	10

8.2 Assessment results

Table D14: Predicted annual mean of NOx concentrations at ecological sites (operational phase, Proposed Scheme in-combination)

Ecological site	Distance to road (m)	NO_x concentrations (µg/m^3)			Change in NO_x concentrations (µg/m^3)	Comparison against air quality standard (30µg/m^3)
		Baseline 2018	2038 do nothing	2038 with the Proposed Scheme		
The Mere, Mere Transect 1	193	17.26	10.00	10.08	0.08	Within standard
	200	17.18	9.99	10.06	0.07	Within standard

Table D15: Assessment of nitrogen deposition at ecological sites (construction phase, Proposed Scheme in-combination)

Ecological site	Distance to road (m)	Dry deposition (kg N/ha/yr)			Change in nitrogen deposition (kg N/ha/yr)	Lower critical load (kg N/ha/yr)	% Change in relation to lower critical load
		Baseline 2018	2038 do nothing	2038 with the Proposed Scheme			
The Mere, Mere Transect 1	193m	23.95	23.83	23.83	<0.01	10	<0.1%
	200m	23.95	23.83	23.83	<0.01	10	<0.1%

8.3 Assessment of significance (operational phase, Proposed Scheme in-combination)

NO_x concentrations are predicted to be within the air quality standard in all scenarios with or without the Proposed Scheme.

Nitrogen deposition is predicted to be above the lower critical load in all scenarios. However, the changes in nitrogen deposition as a result of the Proposed Scheme in-combination are lower than 1% of the lower critical load at all modelled receptors.

No potentially significant effects are therefore predicted.

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