MOTT MACDONALD

Norwich Northern Distributor Road (Broadland Northway)

One Year After Report

September 2019

Norfolk County Council

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Executive summary

Introduction

The Norwich Northern Distributor Road (now known as Broadland Northway but referred to in this report as the NDR) One Year After (OYA) Report is the second formal report of the Monitoring and Evaluation Plan (M&EP) for the scheme. The purpose of this OYA Report is to build upon the Norwich NDR Baseline Report by analysing and reporting the outcomes and impacts of the Norwich NDR on its surrounding area one year after it opened.

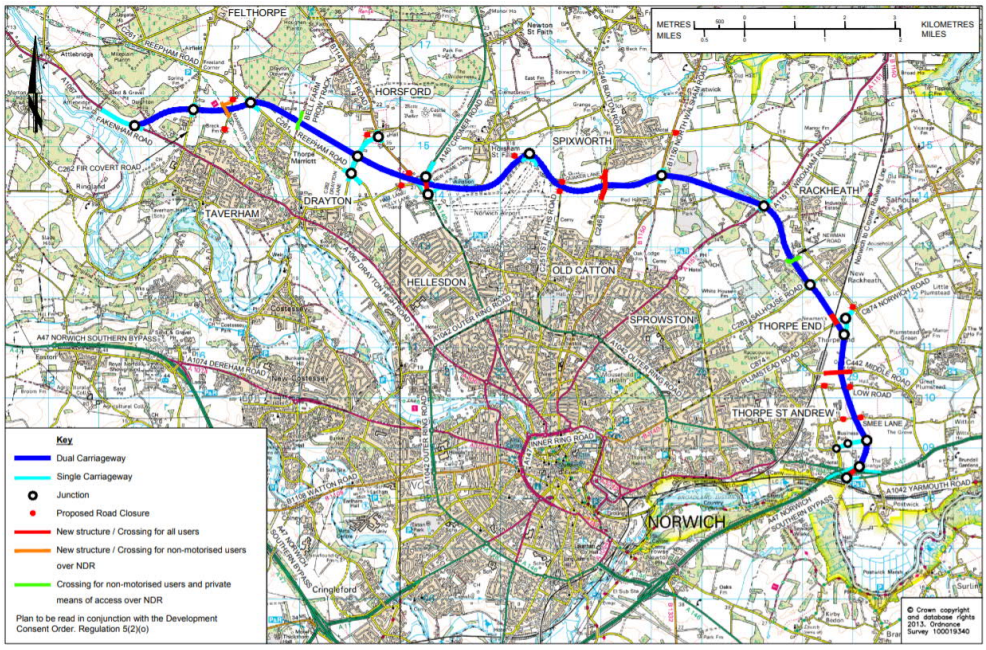
The scheme

The NDR is a dual carriageway, all-purpose strategic distributor road, which links the A1067 Fakenham Road, near Attlebridge and Norwich Airport, to the A47 Trunk Road at Postwick. The entire length of the route is approximately 20km and includes at-grade roundabout junctions at intersections with existing radial routes. Most of the route of the NDR is within the administrative boundary of Broadland District, apart from the stretch of road closest to Norwich Airport which is within the administrative boundary of Norwich City Council. A small part of the works at Postwick fall within the administrative area of The Broads Authority.

The NDR forms part of a package aimed to deliver sustainable transport measures, including bus rapid transit, walking and cycling measures, as well as a comprehensive transport plan aimed to boost and sustain the Norwich city centre economy. The NDR scheme is a key piece of infrastructure necessary to enable the overall delivery of the Broadland, Norwich and South Norfolk Joint Core Strategy (JCS) for housing and jobs targets by opening up development land.

The map below outlines the final route of the NDR scheme.

Figure 1: Final route of the NDR scheme



Source: NCC

The NDR scheme was part financed by two funding streams as follows:

- A dual carriageway distributor road from the A47 at Postwick to the A140 junction near Norwich Airport was awarded partial funding through the Department for Transport (DfT) Development Pool Major Scheme funding process (it is approximately 14km in length and includes at-grade roundabout junctions at intersections with existing radial routes).
- The section of the NDR from the grade-separated A140 junction west to the A1067 Fakenham Road was funded by Norfolk County Council (NCC). In view of this, the documents presented to the DfT as part of the Best and Final Funding Bid (BAFB) in the 'Development Pool' process refer to a scheme from Postwick to the A140 whilst the documents for the Development Consent Order (DCO) application refer to the entire scheme including the section between the A140 and the A1067.

This report

Throughout this NDR OYA report, the NDR scheme is assessed and evaluated in terms of its impact on the surrounding areas through a number of indicators.

The indicators detailed in this report will give a broad view of how the NDR scheme has affected the local environment and altered acute congestion problems. These indicators remain the same throughout the monitoring and evaluation process (up to 15 years after the opening of the scheme) to allow for consistent reporting. The indicators are listed below, grouped by theme:

- Environment
  - Indicator 1: Landscape Integration
  - Indicator 2: Biodiversity and Nature Conservation
  - Indicator 3: Road drainage and water quality
- Traffic
  - Indicator 4: Reduce traffic levels and congestion
  - Indicator 5: Improved transport connectivity
- Economic
  - Indicator 6: Houses developed on sites identified as dependent upon the NDR. This has grown substantially since the business case for the scheme was approved, with future growth plans to the north east of the city fully reliant on the new road
  - Indicator 7: Employment land developed on sites identified as dependent upon the NDR
- Process and governance
  - Indicator 8: Project costs
  - Indicator 9: Project programme
  - Indicator 10: Consultation for Process Evaluation

The findings for each indicator are outlined in the sections below. However, it should be noted that the economic indicators are not included in this NDR OYA Report as the results of these indicators require more time to materialise.

Table 1: Key findings from OYA Report

Indicator	Y1 position
Indicator 1: Landscape integration	The comparison between the Y1 photomontages and Y1 photographs illustrate that across the majority of the key viewpoint locations, the Y1 photograph largely mirrors the Y1 photomontage. The one exception is photomontage location 1. Here the single carriageway has been retained as there was a need to maintain access to BT manholes , with a bund provided to the north to screen and

Indicator	Y1 position
	separate the old carriageway. This means the photomontage, which shows that this area should have been seeded with a species-rich wildflower mix, does not wholly match the Y1 photograph.
Indicator 2: Biodiversity and Nature Conservation	Based on the monitoring to date the scheme has not had a significant adverse impact on the biodiversity of the area. Mitigation measures appear to have had a positive impact (for instance, the installation of bat boxes and barn owl boxes have resulted in these being used). However, with only one year's worth of post-construction data it is impossible to comment upon long-term trends – for example, the observed amount of GCN is high, but this could be due to factors such as the sustained cold period prior to the breeding season and the warm weather during the data collection period.
	Bats • Across all 2019 bats surveys, nine species were recorded (common pipistrelle; soprano pipistrelle; nathusius' pipistrelle; brown long-eared; natterer's; daubenton's; noctule; serotine; barbastelle). • Excluding noctules, five species were observed using the bat crossings during the surveys. • While more bats are crossing the NDR at a safe height than those crossing at an unsafe height, there is still a notable proportion of bats crossing at lower levels,and are therefore at risk of vehicle collision mortality. No dead bats were found during any of the bat vehicle collision surveys. • Out of the four surveyed locations, Quaker Farm was the only area to have no uptake in any of the bat boxes. Nine out of the 23 boxes were either in use or showed evidence of use.
	Hibernating bats • Hibernating bats observed at three locations (note the military buildings in Rackheath had no bats or signs of bat activity present).
	Great Crested Newts (GCN) • 13 ponds surveyed (ponds where GCN had previously been identified in baseline). • The number of GCN recorded within each meta-population was higher in 2018 than in 2017 (except for Quaker Farm) and in previous years. • A large population (102 peak count) was identified within the ponds at Rackheath, with medium populations identified at Dog Lane (93 peak count) and Quaker Farm (27 peak count). The counts of GCN recorded in 2018 at Dog Lane and Quaker Farm are significantly higher than average.
	Breeding birds • 55 species of breeding birds. • 14 species were recorded that are on the Red List of Birds of Conservation Concern. Of these, 9 species showed evidence of breeding. • A further 18 species were recorded that are on the Amber List of Birds of Conservation Concern. Of these, 10 species showed evidence of breeding. • Whilst broad patterns may be observable in the data, long-term trends and the natural between-year variation means it is difficult to attribute any observed changes to any factor, either environmental or as a result of the construction of the road.
	Barn Owls • 8 boxes have been erected along the route at 2km intervals. • 2 additional boxes have been erected on land owned by Anglian Water at Taverham Mill • Several of the Barn Owl boxes were installed further than 5km from the road. • 1 Active Roost Site (ARS). • It was not possible to inspect three of the boxes. • Boxes damaged by Storm Doris (February 2017) have been replaced
	Aquatic invertebrates • The results indicate that the area is of moderate conservation value for aquatic invertebrates, reflected in the absence of species of interest – seven 'local' species were found - and supported by the results of Site Analysis of Freshwater Invertebrate Surveys analysis. • Species composition was generally similar to the baseline surveys conducted in 2008 (and subsequent re-surveys in 2013); however, a greater number of taxa recorded across the sample locations. • Vertigo moulinsiana were found to be absent from the survey area, but these was a very significant decline in population between 2008 and the construction of the scheme
Indicator 3: Road drainage and water quality	The drainage performance of all lagoons should be monitored to ensure that they are performing as expected • There were a number of lagoons that are not draining down quickly enough to meet the discharge requirements originally agreed with the Environment Agency – Following additional site investigations by Norfolk County Council the Environment Agency has agreed that the current operation of the lagoons is acceptable to the EA.

Indicator	Y1 position
	• There is a remaining operational issue of the lagoons in the vicinity of Norwich International Airport, in that standing water has attracted seagulls, thereby increasing the potential for bird strikes at the airport. The Council is revising the levels on Lagoon 5 and carrying out wetland planting on Lagoons 5, 6, 8 and 14 to reduce the likelihood of seagull using these lagoons. These works will be carried out by the end of 2019. In the interim the Council has funded the provision of additional bird scarers at the airport to reduce the risk of birdstrikes. The effectiveness of the hydrobrake and erosion protection measures at the discharge points from Lagoons 17, 18 and 18A and all culverts conveying overland flow beneath the Scheme will be regularly monitored by NCC to ensure their effectiveness. • Monitoring has confirmed no issue to date with the effectiveness of the hydrobrake and erosion protection measures Monitoring of the effective functioning of the drainage features improved or reinstated, particularly those upstream of the scheme to address sediment input into the River Wensum, will be carried out in conjunction with the ongoing maintenance. This will be in line with the requirements of the Habitats Regulations Assessment Addendum and the Mitigation Measures Management Plan therein. • The requisite improvement measures to address sediment input to the River Wensum were effectively put in place during construction, and water quality monitoring during construction that confirmed that the measures are working. • Monitoring at The Springs was only required up to December 2018, and so this Indicator is not now being monitored. • Water quality monitoring during construction has shown no negative impact on drainage discharge points such as The Springs.
Indicator 4: Reduce traffic levels and congestion	The NDR has caused some traffic increases near the western end of the scheme, as anticipated, but these are the subject of DCO Requirements 27 and 29 and being dealt with separately. Based on the extensive set of monitoring locations across the wider area, these results show that the NDR is achieving the following desirable objectives: • Reducing orbital rat running in the northern suburbs of Norwich. • Reducing orbital rat running on rural roads outside the built-up area of Norwich. • Reducing traffic flows on the roads just outside the Norwich Outer Ring Road. • Reducing traffic flows on the Norwich Outer Ring Road. • Traffic flows have decreased over the railway level crossing.
Indicator 5: Improved transport connectivity	*Information has been requested from Norfolk County Council's road network team, and will be inserted here once received.*
Indicator 8: Project cost	In 2011 it was estimated and validated by DfT that the NDR would have a total base cost of £88.1 million and a total quantified costs estimate of £111.14 million. Revised budget following approval for increased budget: £148.35m.
Indicator 9: Project programme	Although there were slippages and delays in the programme for certain elements, as discussed in detail in the Process Evaluation report, the overall aim of opening the NDR in Q1 of 2018 was achieved.
Indicator 10: Consultations for Process Evaluations	Based on this evidence reviewed and the stakeholder consultations undertaken, the following key conclusions can be drawn: • The NDR scheme has been received positively by the public and key stakeholders since it has been completed and opened to traffic. • The DCO process proved to be a difficult system through which to deliver a major infrastructure project according to many consultees involved given the inability to make any changes post submission and the lack of experience in completing the process. • The NDR scheme was well managed on the whole but suffered from delays/slippages in the programme as well as financial issues resulting in additional spend. • The NDR scheme had an excellent safety record with very few minor injuries and no major injuries recorded during construction. • Confidence in scheme benefits realisation is high.

Source: Mott MacDonald

Conclusion

The OYA report has established that many of the indicators used to demonstrate the effects of the NDR scheme are delivering as predicted or better than predicted. This shows that the NDR scheme is meeting its objectives in these areas. This is especially shown by Indicator 4 as the NDR scheme has been shown to contribute towards reducing orbital rat running and reducing traffic flows in key areas of the road network. Some indicators (such as some elements of Indicator 2) are more long-term and it was not expected that they would reach their full potential in the first year.

It has not been possible to review data for Indicator 5 (Improved Transport Connectivity) as no information has been made available for review. Journey time and journey reliability data has been requested, and a revision to this report will be provided once the data has been assessed.

In this NDR OYA Report the results of the monitoring process for Indicator 6 and Indicator 7 have not been presented as they are not required for the One Year After report. This is because the impact of the NDR scheme on these indicators will take more time to become evident. However, it is evident that future housing delivery to the north-east of Norwich is heavily reliant on the direct access and road capacity that the NDR has provided.

The Process Evaluation (Indicators 8-10) developed a nuanced and detailed picture of the design and delivery of the NDR.

1 Introduction

1.1 Purpose of this report

The Norwich Northern Distributor Road (NDR) One Year After (OYA) Report is the second formal report of the Monitoring and Evaluation Plan (M&EP) for this scheme.

The schedule for the M&EP was agreed with the Department for Transport (DfT) and Norfolk County Council (NCC) prior to its publication in August 2015. The schedule was subsequently revised by agreement. The requirement for Norwich NDR to be subject to a fuller evaluation was made by DfT and the M&EP has been structured to reflect this requirement.

In September 2017, the first formal report, the Norwich NDR Baseline Report was published. This OYA report will be followed by a subsequent Five Years After Report and a Fifteen Years After Report scheduled to be published in 2023 and 2033 respectively.

The purpose of this OYA Report is to build upon the Norwich NDR Baseline Report by analysing and reporting the outcomes and impacts of the Norwich NDR on its surrounding area one year after it opened.

1.2 M&EP summary

Post-construction evaluations are carried out for most major road transport schemes, especially those which require a fuller evaluation to take place. The aim of undertaking a fuller evaluation is to generate evidence on the efficiency of the delivery, the causal effect of the scheme and whether it had any unintended adverse or positive effects. Triangulating this data with other bespoke evaluation data collected will demonstrate the causal pathway between the scheme and the observed outcomes and impacts.

Having approved the construction of the NDR scheme, the DfT chose to provide a grant of £67.5 million towards the overall cost of the scheme. This required that an M&EP be drafted and subsequently implemented. The M&EP was structured to follow DfT guidance. The findings and conclusions of the M&EP will be reported through four separate reports:

- Baseline Report (published in September 2017).
- Process Evaluation
- One Year After Report (this report)
- Five Years After Report.
- Fifteen Years After Report.

A Theory of Change Evaluation Approach was adopted with four logic maps produced to analyse the causal effects of the NDR scheme. Ten separate indicators have been designed to establish a broad yet in-depth understanding of the outcomes and impacts from the NDR scheme. These indicators are divided into environmental, economic, congestion and process evaluation. When combined they give a full picture of the impacts of the NDR scheme.

1.3 Baseline Report summary

The Baseline Report sets out the baseline conditions in Norwich prior to construction commencing on the NDR scheme. The baseline position is the comparison point for future monitoring and evaluation effort for the scheme.

A pre-construction baseline was chosen as, although impacts of construction will be sought to be minimised, a scheme of this size will affect the surrounding area which could provide a false baseline for future comparisons if data were taken immediately prior scheme opening.

Following the recommendations of the scheme's M&EP, produced by Mott MacDonald and agreed by the scheme sponsors, including the DfT, seven initial indicators have been established to monitor the impact of the road scheme. These seven indicators span the potential environmental, traffic and economic impacts of the NDR scheme and include

- Indicator 1 Landscape integration.
- Indicator 2 Biodiversity and nature conservation.
- Indicator 3 Road drainage, water storage and water quality.
- Indicator 4 Reduce traffic levels and congestion.
- Indicator 5 Improved transport connectivity.
- Indicator 6 Houses developed on sites identified as dependent upon the NDR.
- Indicator 7 Employment land developed on sites identified as dependent upon the NDR.

In addition, three further indicators intended to assess the process of delivering the NDR scheme have also been identified which include:

- Project costs.
- Project programme.
- Consultations for Process Evaluation.

1.4 Assessment indicators

The ten indicators, including sub-indicators essential to monitoring environmental and traffic impacts, established to monitor the impact of the NDR scheme in the Baseline Report all have differing schedules for monitoring. Therefore, not all of the indicators will be presented in the One Year After Report, Five Years After Report and Fifteen Years After Report.

Table 2 below outlines which indicators are included in each report.

Table 2: NDR Scheme assessment indicators

Indicator		One Year After Report (this report)	Five Year After Report	Fifteen Year After Report
Indicator 1: Landscape Integration		X	X	
Indicator 2: Biodiversity and Nature Conservation	Unmanned static bat monitoring, at the 12 locations as during 2013 survey season.	X	X	X
	Manned static monitoring of bat bridge and bat tunnel locations.	X	X	X
	Bat vehicle collision mortality surveys at 10 selected monitoring locations.	X	X	X
	Bat roost counts of known roosts within 50m of the works area.	X	X	X
	Monitoring counts of each bat house.	X	X	X
	Bat box occupancy checks.	X	X	X
	Bat hibernation roost surveys of known roosts within 2km.	X	X	X
	Radio-tracking of barbastelles	X	X	
	GCN population surveys of known existing breeding pond at Quaker Lane, Spixworth and the four new ponds would be carried out.	X	X	
	Breeding Bird Surveys of the scheme prior to and after construction.	X	X	
	Occupation of the ten barn owl boxes should be monitored by a suitably qualified ecologist holding a valid Natural England or British Trust for Ornithology licence to disturb breeding barn owl in Norfolk.	X	X	
	Monitoring of the aquatic invertebrate communities should be carried out during and following construction to establish whether there has been any change from the baseline.	X	X	
	Monitoring of the Desmoulin's whorl snail population should be carried out during and following construction to establish whether there has been any change from the baseline.	X	X	
	The reseeded areas of Hoary Mullein at the Fakenham Road Roadside Nature Reserve will be monitored to ensure establishment.	X		
Indicator 3: Road drainage and water quality	The drainage performance of all lagoons should be monitored to ensure that they are performing as expected.	X		
	The effectiveness of the hydrobrake and erosion protection measures at the discharge points from Lagoons 17, 18 and 18A and all culverts conveying overland flow beneath the Scheme will be regularly monitored by NCC to ensure their effectiveness.	X		
	Monitoring of the effective functioning of the drainage features improved or reinstated, particularly those upstream of the scheme to address sediment input into the River Wensum, will be carried out in conjunction with the ongoing maintenance. This will be in line with the requirements of the Habitats Regulations Assessment Addendum and the Mitigation Measures Management Plan therein.	X		

Indicator	One Year After Report (this report)	Five Year After Report	Fifteen Year After Report
Indicator 4: Reduce traffic levels and congestion	X	X	
Indicator 5: Improved transport connectivity	X	X	
Indicator 6: Houses developed on sites identified as dependent upon the NDR		X	
Indicator 7: Employment land developed on sites identified as dependent upon the NDR		X	
Indicator 8: Project costs	X		
Indicator 9: Project programme	X		
Indicator 10: Consultation for Process Evaluation	X		

Source: Mott MacDonald

1.5 Report structure

The Norwich NDR OYA Report is divided into the following sections:

- **Section 2: The scheme** – description of the NDR scheme and its objectives.
- **Section 3: Logic Maps** – presents the four revised Logic Maps.
- **Section 4: Environment** – presents the findings of the monitoring process for the three environmental indicators.
- **Section 5: Traffic** - presents the findings of the monitoring process for the two traffic indicators.
- **Section 6: Process and governance** - presents the findings of the monitoring process for the three process and governance indicators.
- **Section 7: Conclusions and evaluation summary** – presents the key conclusions of this report.

2 The scheme

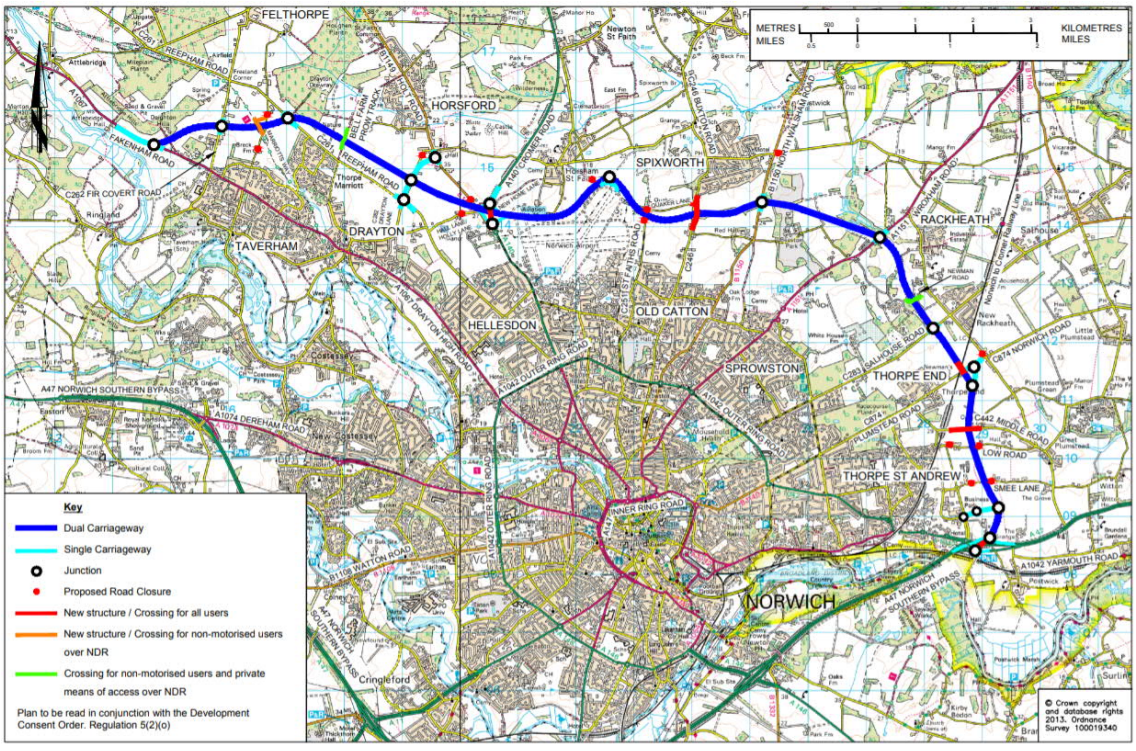
2.1 Scheme description

The NDR scheme is a dual carriageway, all-purpose strategic distributor road, which links the A1067 Fakenham Road, near Attlebridge and Norwich Airport, to the A47 Trunk Road at Postwick. This entire length of the route is approximately 20km and includes at-grade roundabout junctions at intersections with existing radial routes. Most of the route of the NDR is within the administrative boundary of Broadland District, apart from the stretch of road closest to Norwich Airport which is within the administrative boundary of Norwich City Council. A small part of the works at Postwick fall within the administrative area of The Broads Authority.

The NDR scheme forms part of a package aimed to deliver sustainable transport measures, including bus rapid transit, walking and cycling measures, as well as a comprehensive transport plan aimed to boost and sustain the Norwich city centre economy. The NDR scheme is a key piece of infrastructure necessary to enable the overall delivery of the Joint Core Strategy (JCS) housing and jobs targets.

The map below outlines the route of the NDR scheme.

Figure 2: Final route of the NDR scheme



Source: NCC

The NDR scheme was part financed by two funding streams as follows:

- A dual carriageway distributor road from the A47 at Postwick to the A140 junction near Norwich Airport was awarded partial funding through the DfT Development Pool Major

Scheme funding process (it is approximately 14km in length and includes at-grade roundabout junctions at intersections with existing radial routes).

- The section of the NDR from the split-grade A140 junction west to the A1067 Fakenham Road was funded by NCC. In view of this, the documents presented to the DfT as part of the Best and Final Funding Bid (BAFB) in the 'Development Pool' process refer to a scheme from Postwick to the A140 whilst the documents for the DCO application refer to the entire scheme including the section between the A140 and the A1067.

The NDR scheme forms part of a package of sustainable transport measures, including bus rapid transit, measures to promote walking and cycling and, a comprehensive transport plan to boost and sustain the Norwich city centre economy. The NDR scheme is a key piece of infrastructure necessary to enable the overall delivery of the JCS housing and jobs targets (the link between the scheme objectives and JCS objectives is shown in Table 3).

2.2 Scheme objectives

NDR's scheme objectives cover economic growth and development ambitions for the area (through jobs, housing and sustainable travel options). The scheme seeks to relieve traffic congestion on the existing road network within the urban area and to the north of the city centre and to facilitate planned growth.

The NDR is also intended to unlock new business sites, particularly in north east Norwich and Broadland, as well as improving access to existing industrial and commercial sites. Allied to the NDR scheme are city centre traffic management measures that will discourage through traffic and enable the implementation of improvements for public transport, walking and cycling including enhancements to the public realm.

The full scheme objectives are detailed in Table 3, alongside the associated objectives from the JCS and the Greater Norwich Economic Strategy (GNES).

Table 3: NDR scheme objectives

NDR scheme objectives	JCS Spatial Planning Objective (SPO)	Greater Norwich Economic Strategy (GNES) Action Plan Performance
1: Reduce traffic levels, and thereby relieve congestion, on the existing road network within the urban area and beyond to the north of the city centre	SPO 7 To enhance transport provision to meet the needs of existing and future populations while reducing travel need and impact	Objective 1: To strengthen the area's economy, maximise diverse employment opportunities and ensure the right environment exists for business to flourish Objective 3: Ensure that the area has necessary infrastructure and quality of environment to attract investment and support business growth
2: Facilitate journeys that are already difficult and congested and require traffic to use residential and minor roads that are in appropriate for the type and volume of traffic that is currently accommodated	SPO 6 To make sure people have ready access to services SPO 7 To enhance transport provision to meet the needs of existing and future populations while reducing travel need and impact	
3: Provide access to and thereby help to deliver, planned and potential areas of growth, and enable those areas to be free of the need to incorporate provision for extraneous through traffic	SPO 7 To enhance transport provision to meet the needs of existing and future populations while reducing travel need and impact	
4: Provide improved transport	SPO 6 To make sure people have	

NDR scheme objectives	JCS Spatial Planning Objective (SPO)	Greater Norwich Economic Strategy (GNES) Action Plan Performance
connections between existing and future areas of residential and employment development and with the national strategic road network as well as improving connections with Norwich Airport and the wider area of North Norfolk	ready access to services SPO 7 To enhance transport provision to meet the needs of existing and future populations while reducing travel need and impact	
5: Increase the opportunities for improving provision for public transport and other sustainable forms of transport and for improving traffic management within the city centre, thereby encouraging modal shift	SPO 7 To enhance transport provision to meet the needs of existing and future populations while reducing travel need and impact	
6: Improve traffic related environmental conditions for those communities in the northern suburbs of Norwich and outlying villages whilst minimising the environmental impact of the NDR	SPO 1 To minimise the contributors to climate change and address its impact	

Source: NCC (2014): 'The Norwich Northern Distributor Road Scheme Benefits Realisation Plan' and Norwich Northern Distributer Road Application for Full Approval, August 2015.

2.2.1 Link to the Postwick Hub scheme

The Postwick Hub scheme was progressed as a stand-alone project in advance of the main NDR scheme to unlock constraints on allocated development land in the vicinity of the junction.

Work commenced on the upgrade of the A47 Postwick junction (and an improved access to the Postwick Park and Ride site to allow for its expansion) following Full Approval for the Postwick Hub Junction from DfT in April 2014.

2.3 Contract arrangement and procurement

The procurement process was overseen by a Procurement Board consisting of a member from each political party advised by a Procurement Team consisting of experienced NCC officers. All decisions were ratified by NCC Cabinet.

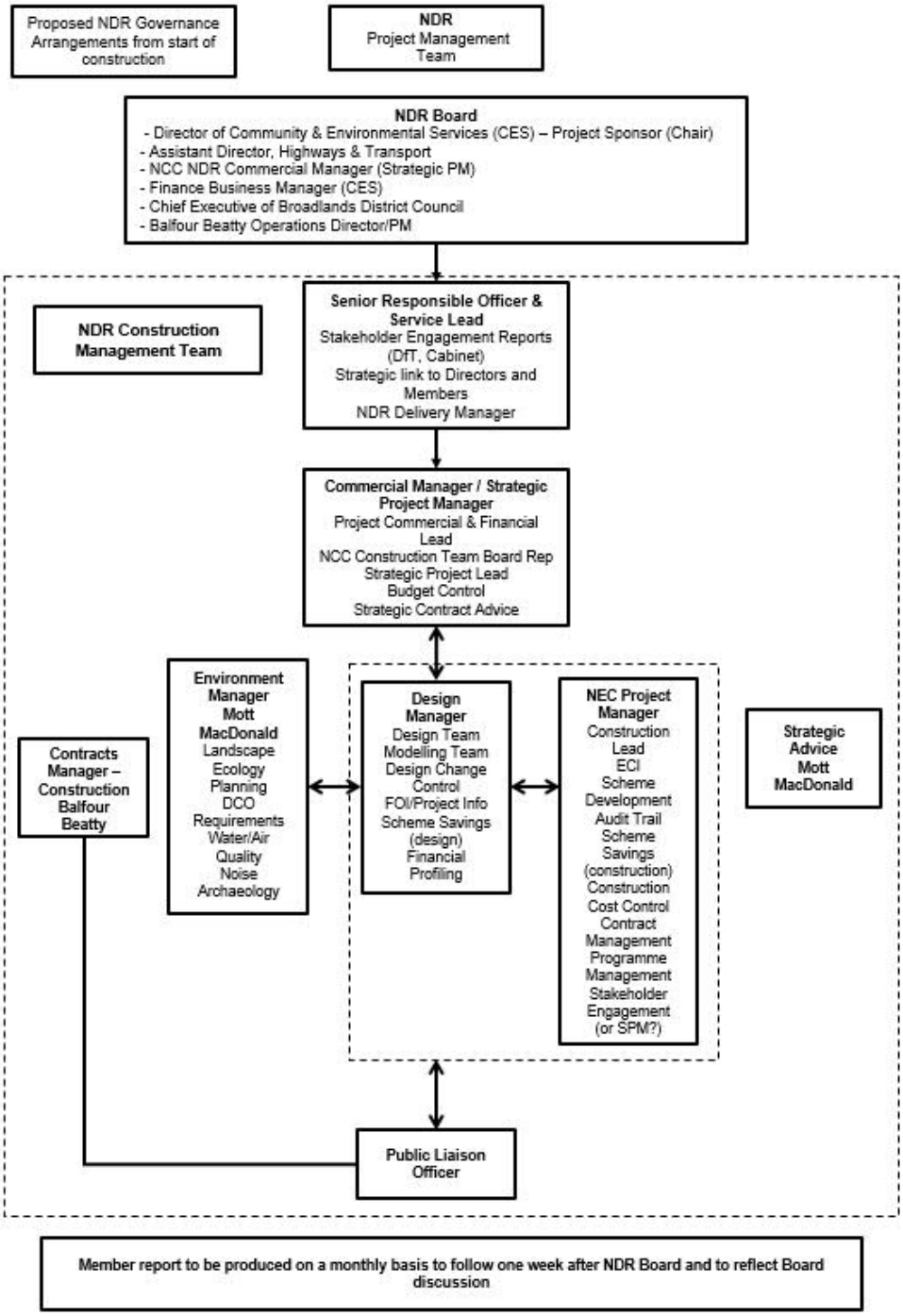
Birse Civils Ltd which was part of the Balfour Beatty group was originally appointed as preferred contractor for Postwick Hub and the NDR using a two stage New Engineering Contract (NEC 3) by NCC on 16th February 2009. In December 2014 the Birse Civils Ltd trading name was changed to Balfour Beatty Civils Ltd.

The Contractor was appointed for Stage 1, Early Contractor Involvement (ECI) to assist with the development of the scheme through the statutory process phases. The Contractor was also instructed to construct Postwick Hub (Stage 2a) and the NDR (Stage 2b) once the Secretaries of State confirmed the DCO and funding.

2.4 Governance

The NDR scheme had an internal governance arrangement structure in place from the early stages of delivery. The structure of these governance arrangements is outlined in Figure 3 below.

Figure 3: Project governance structure



Source: NCC

3 Logic maps

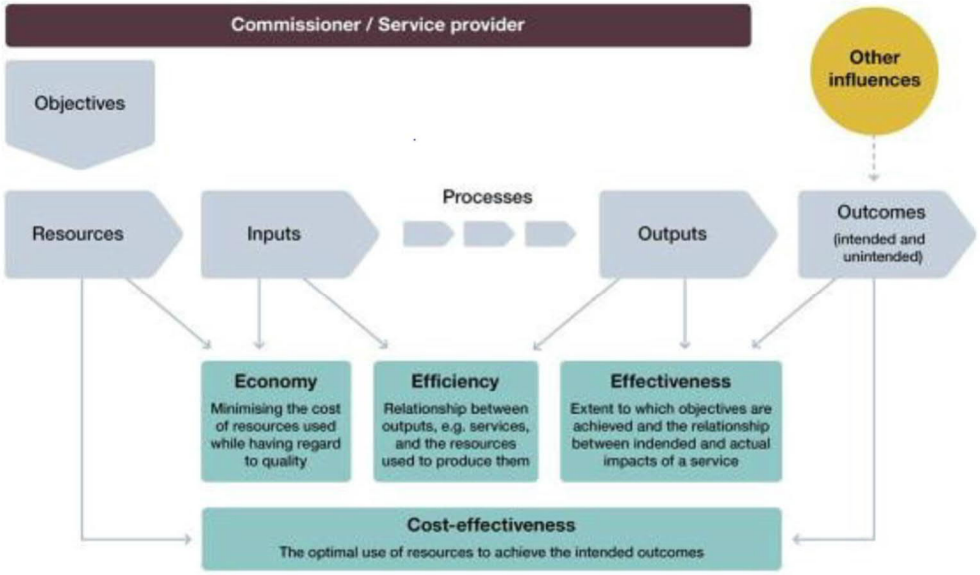
3.1 Introduction to logic mapping

A logic map can be constructed to reflect a programme's theory of how it is going to produce change within a specified target system. This is termed a Theory Approach Logic Model.

In essence, logic maps are a tool for charting the causal effects between inputs, outputs, outcomes and the relationship these have back to stated objectives, and the initial rationale for intervention.

Theory Approach Logic Models are often used in government organisations in the absence of a direct link between investment and financial benefit, they make a case for how the elements of the programme fit together to produce downstream outcomes and impacts. An illustrative logic map is presented below.

Figure 4: Illustrative logic map for an evaluation process



Source: National Audit Office

3.2 NDR logic maps

For the NDR scheme, four logic maps were produced for the M&EP published in August 2015. These logic maps demonstrate how the NDR scheme was expected to impact upon various aspects of the environment, traffic and economic growth.

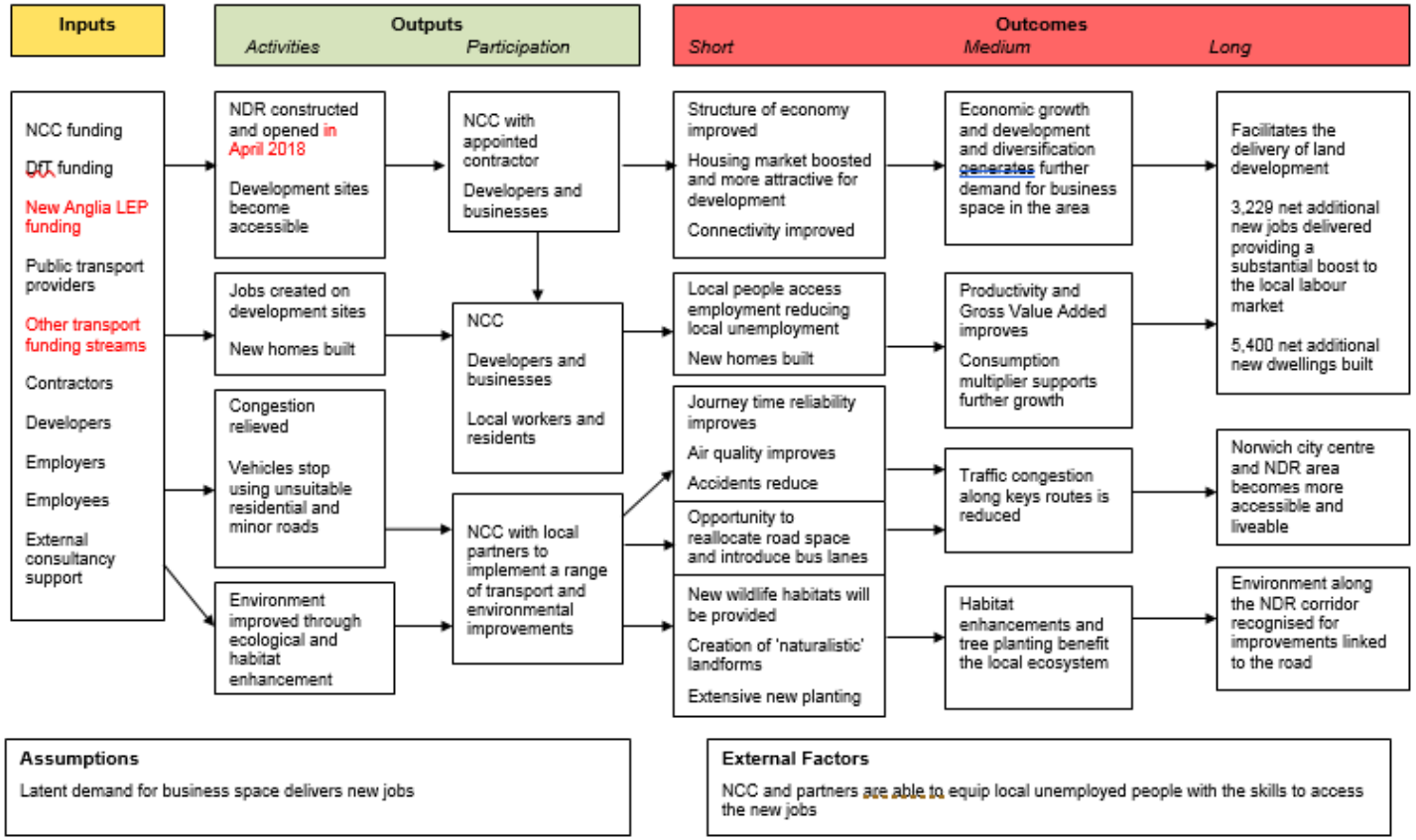
As part of the Process Evaluation for NDR, there was a need to revisit these logic maps to consider whether changes to the maps were necessary. These four logic maps are shown below and have been updated following comments made by consultees as part of the Process Evaluation (updates are shown in red text).

Figure 5: NDR Overview Logic Map

Logic Map: NDR Overview

Context: The Scheme objectives for NDR broadly covers economic growth and development for the area (through jobs, housing and sustainable travel options) and reducing congestion and allowing for planned growth. A key objective of the NDR is to relieve traffic congestion on the existing road network within the urban area and to the North of the city centre. The NDR is also intended to unlock new business sites, thus opening access to existing industrial and commercial estates.

Objective: The NDR Scheme is set to be a necessary transport link that will both relieve current relieve traffic congestion on the existing road network within the urban area and to the north of the city centre and to facilitate planned growth. Provide additional capacity to unlock a number of further planned developments for new business sites set to generate economic growth in the Norwich Policy Area.

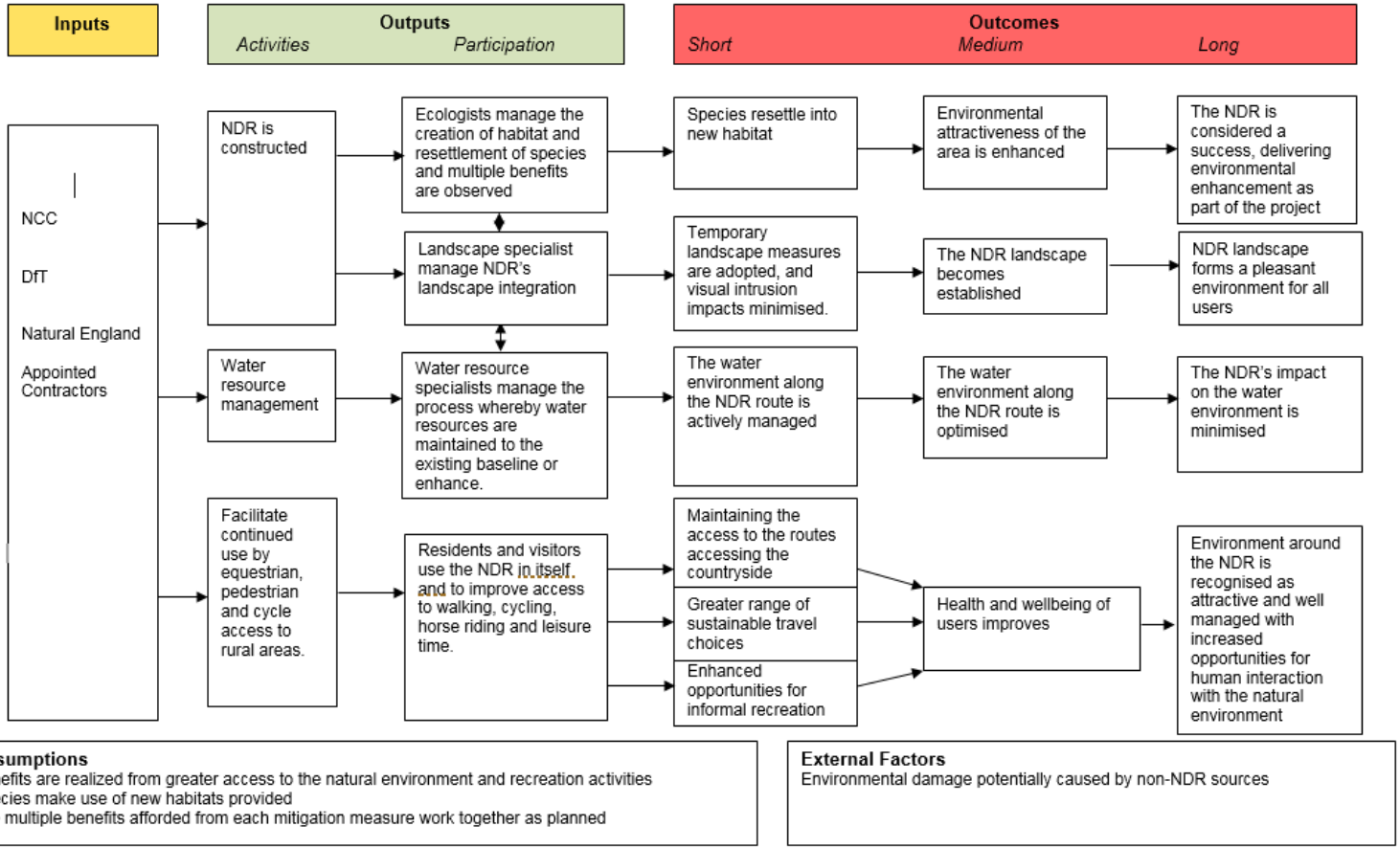


Source: Mott MacDonald

Figure 6: NDR and the environment

Logic Map: NDR and the environment
Context: Constructing the NDR has caused the permanent loss of 307.57 ha of land categorized as 'best and most versatile agricultural land'. A significant amount of work has been undertaken to minimize the environmental impact of the scheme.

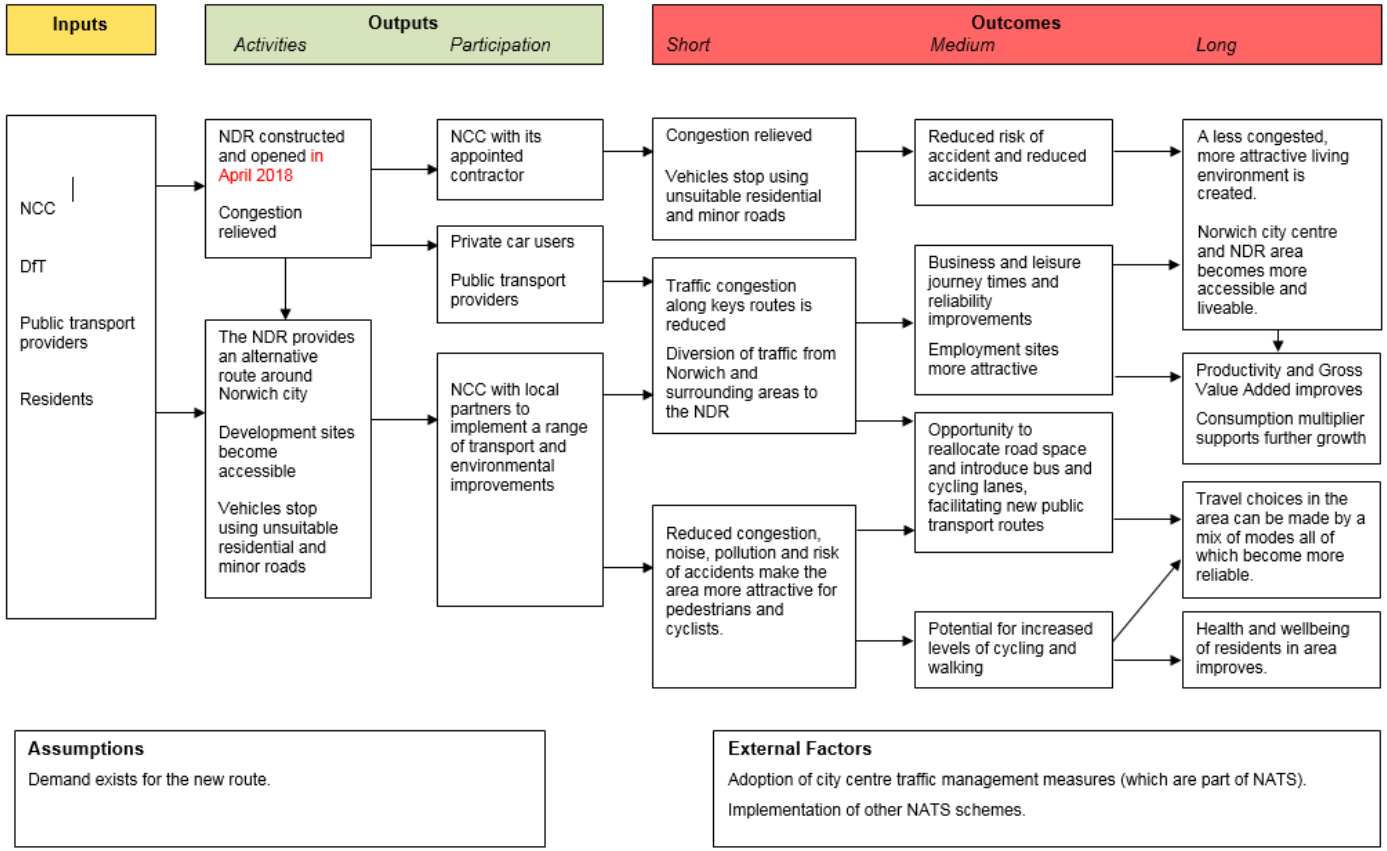
Objective: To reduce or minimize the environmental impacts of the NDR scheme.



Source: Mott MacDonald

Figure 7: NDR and congestion

Logic Map: NDR Congestion
Context: High levels of traffic congestion in Norwich and the surrounding area. High volumes of vehicles using residential and minor roads which are unsuitable for their needs.
Objective: Reduce traffic levels, and thereby relieve congestion, on the existing road network within the urban area and beyond to the north of the city centre. Facilitate journeys that are already difficult and congested and require traffic to use residential and minor roads that are inappropriate for the type and volume of traffic that is currently accommodated.



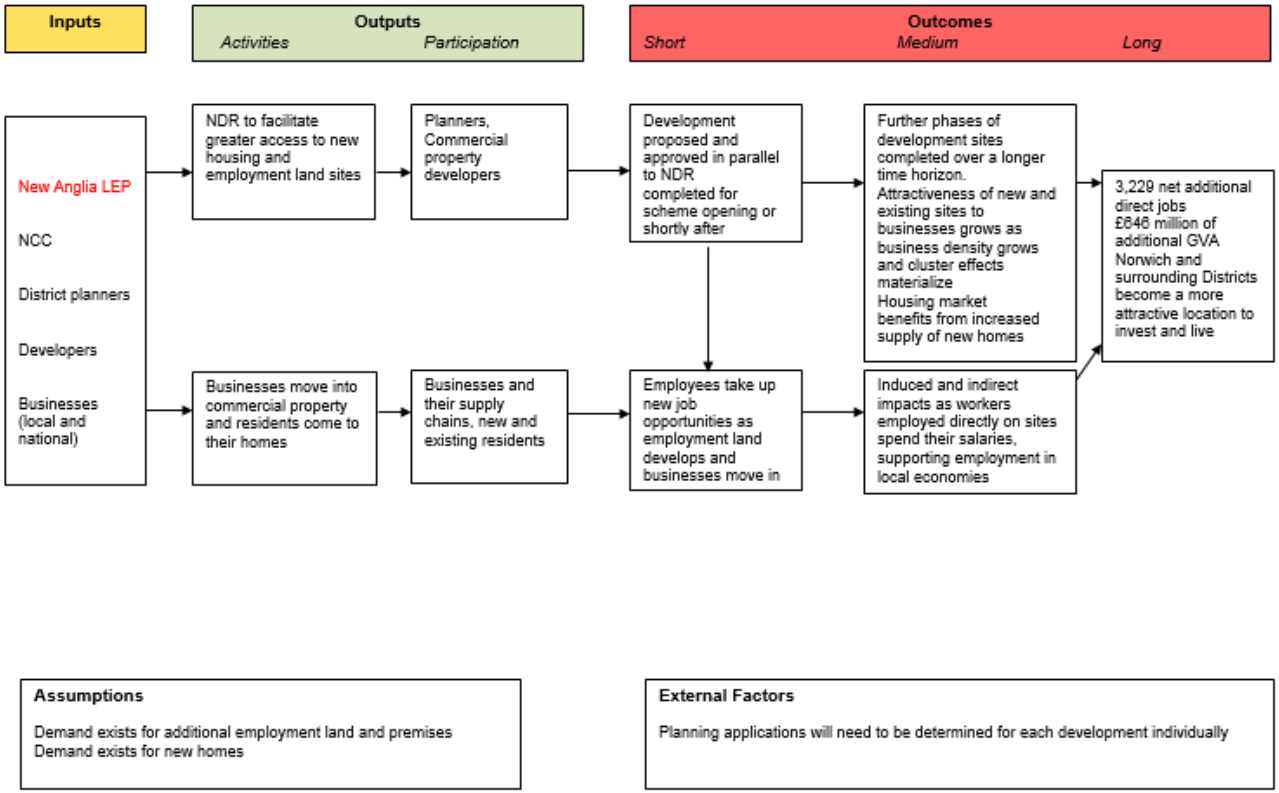
Source: Mott MacDonald

Figure 8: NDR economic growth and development sites

Logic Map: NDR economic growth and development sites

Context: The NDR is a key strategic piece of infrastructure and will play a key role in supporting the delivery of growth in housing and jobs over the next two decades. The NDR will bring the very substantial benefits including jobs, GVA and dwellings.

Objective: Provide access to and help to deliver, planned and potential areas of growth, and enable those areas to be free of the need to incorporate provision for extraneous through traffic.



Source: Mott MacDonald

4 Environment

This chapter presents the indicators which relate to the environment surrounding the scheme, including integration into the wider landscape, water quality and biodiversity.

4.1 Key points

Key findings from this chapter are presented in the summary box below.

- Overall the images included in Indicator 1 illustrate that the scheme is generally representative of the anticipated level of landscape integration at one year post-construction.
- For Indicator 2, it appears that the scheme has not had a significant adverse impact on the biodiversity of the area. Mitigation measures appear to have had a positive impact (for instance, the installation of bat boxes and barn owl boxes have resulted in these being used). However, with only one year's worth of post-construction data it is impossible to comment upon long-term trends – for example, the observed amount of GCN is high, but this could be due to factors such as the sustained cold period prior to the breeding season and the warm weather during the data collection period.
- Across all 2019 bats surveys, nine species were recorded (common pipistrelle; soprano pipistrelle; nathusius' pipistrelle; brown long-eared; natterer's; daubenton's; noctule; serotine; barbastelle).
- Excluding noctules, five species were observed using the bat crossings during the surveys. While more bats are crossing the NDR at a safe height than those crossing at an unsafe height, there is still a large proportion of bats crossing unsafely, these bats are at risk of vehicle collision mortality.
- The quick uptake of Soprano pipistrelles using the small bat house for roosting is encouraging and shows the potential for these structures to be an important roosting facility for local species.
- Of the four hibernating roosts identified prior to construction only one of those, the military buildings in Rackheath, had no bats or signs of bat activity.
- The number of great-crested newts (GCN) recorded within each meta-population was higher in 2018 than in 2017 in all locations except for Quaker Farm.
- 55 species of breeding birds were recorded. 14 species were recorded that are on the Red List of Birds of Conservation Concern. Of these, 9 species showed evidence of breeding.
- Of the five Barn Owl boxes inspected a single box at Loke Farm was considered an Active Roost Site (ARS).
- The results indicate that the area is of moderate conservation value for aquatic invertebrates, reflected in the absence of species of interest – seven 'local' species were found - and supported by the results of SAFIS analysis. Species composition was generally similar to the baseline surveys conducted in 2008 (and subsequent re-surveys in 2013); however, a greater number of taxa recorded across the sample locations.

4.2 Introduction

This section documents the evaluation of the three environmental indicators:

- Indicator 1: Landscape integration.
- Indicator 2: Biodiversity and nature conservation.
- Indicator 3: Road drainage and water quality.

4.3 Indicator 1: Landscape integration

The results for Indicator 1 are used to determine how the landscape of the scheme has developed at Year One (Y1) post-construction. This was undertaken by taking photographs at Y1 of the scheme from the same locations as the photomontages prepared for the Environmental Statement and comparing them to the photomontages.

The study area encompasses the extents of the Zone of Visual Influence (ZVI) as identified within the Environmental Statement (2014).

4.3.1 Limitations

Due to the timing of the monitoring and reporting of Indicator 1 the photographs only provide a winter assessment.

The location of the 2013 photographs was not recorded with GPS, but the 2019 photographs have been taken from the location that best represents the 2013 views. Planting and grass seeding has been ongoing over the past three years, but due to construction constraints, the landscape works have not been implemented as a continuous process. The works began in 2016 and have not been completed across the scheme to date.

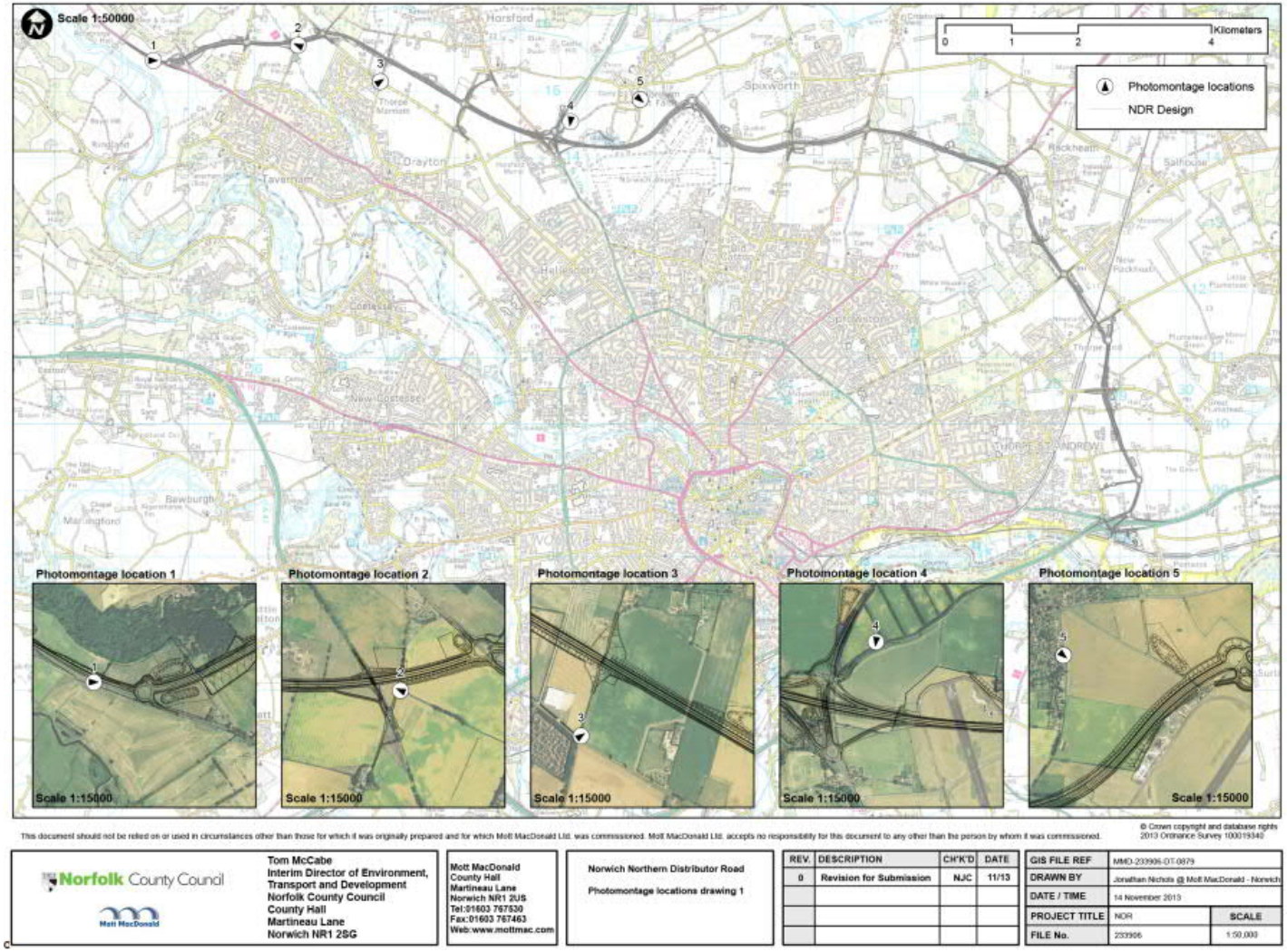
4.3.2 Photograph locations

Photographs were taken at nine key locations for the Environmental Statement and these locations are shown in Figure 9 and Figure 10.

4.3.3 Results

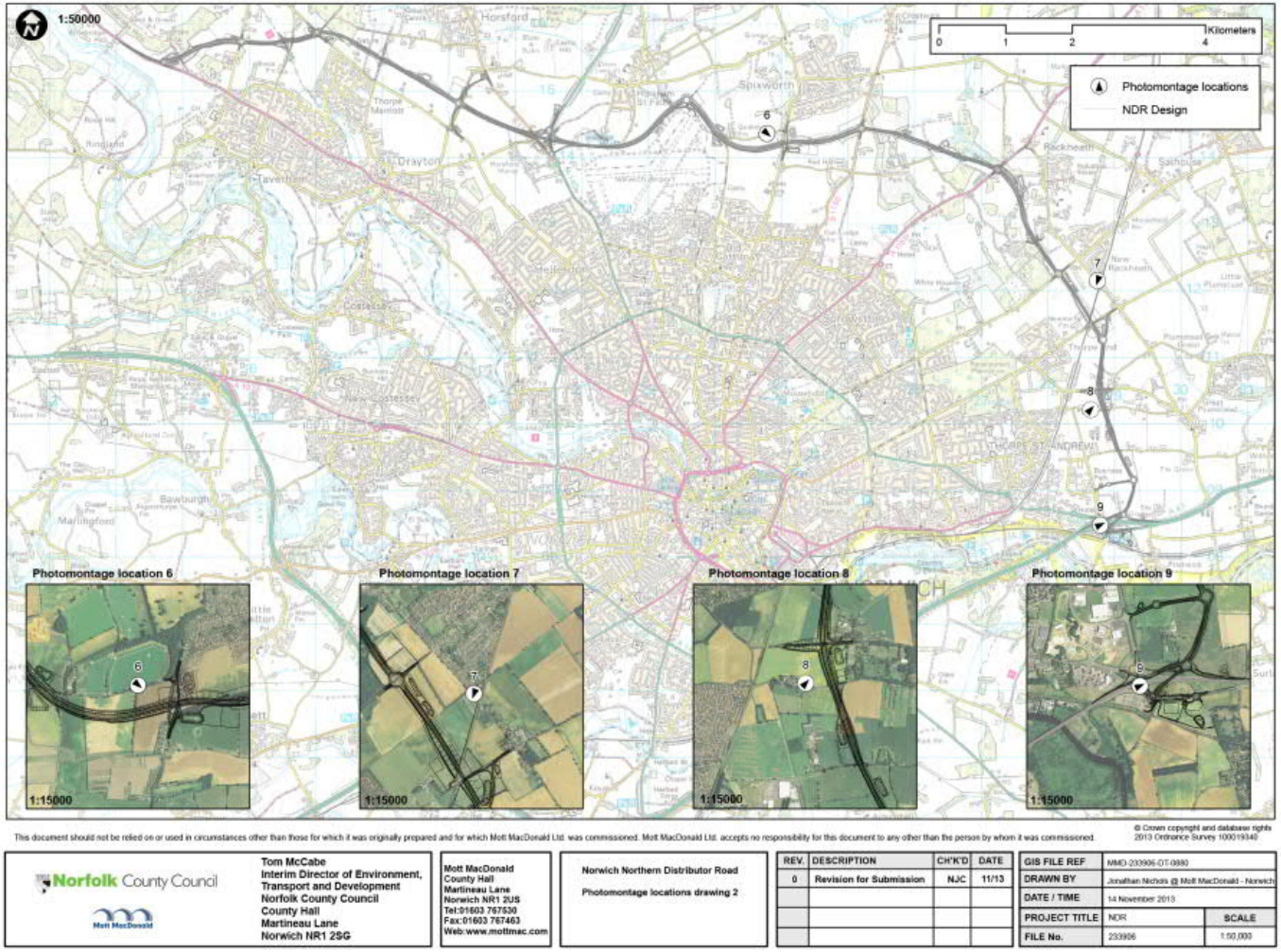
A visual comparison of the photomontages has been provided, with images of the original 2013 photograph, the Y1 photomontage and the 2019 Y1 post-construction photograph. A commentary on the comparison is provided alongside the imagery.

Figure 9: Photograph locations map 1



Source: Mott MacDonald

Figure 10: Photograph locations map 2



Source: Mott MacDonald

Figure 11: Photomontage location 1

Photomontage Location 1

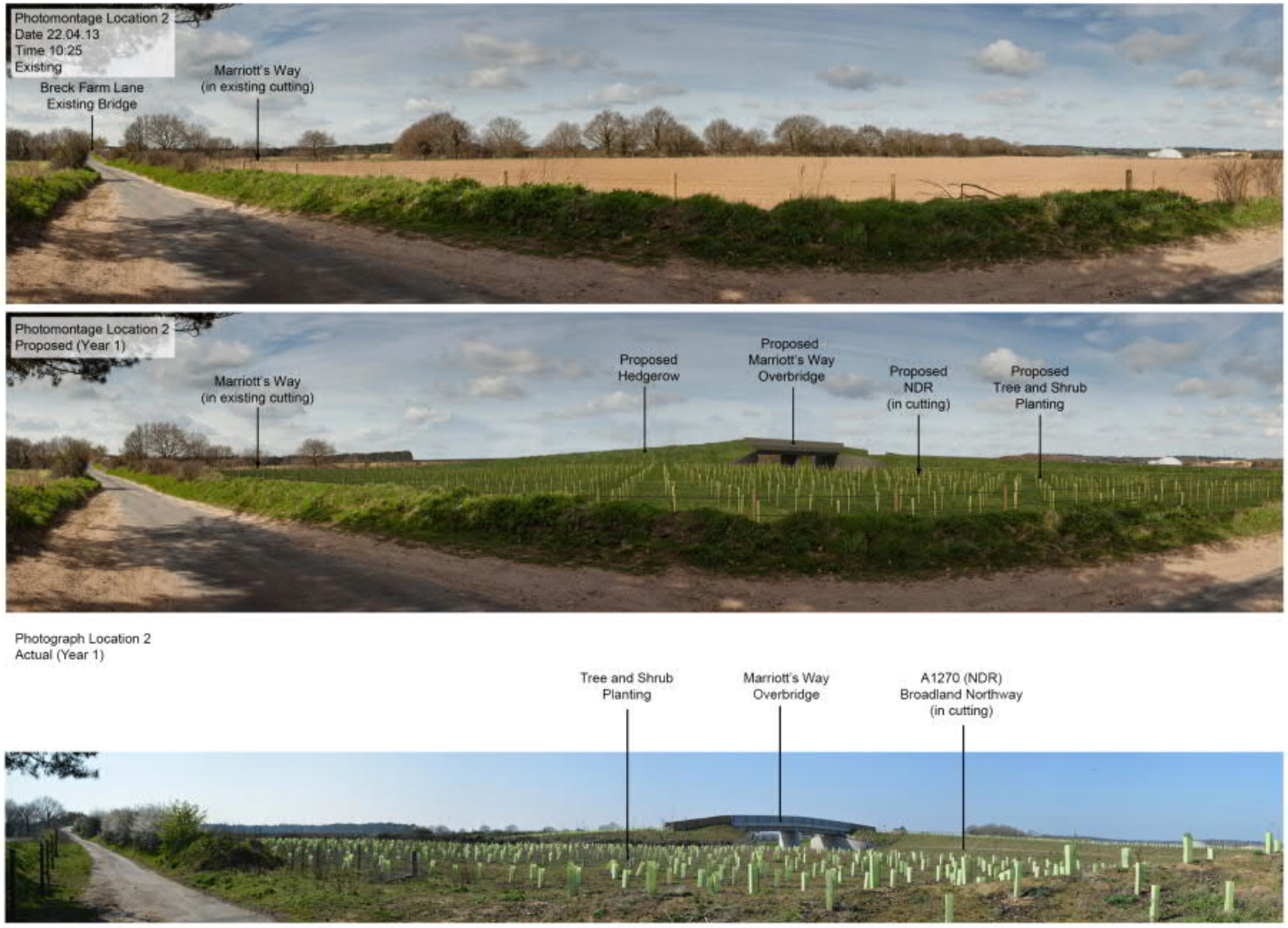
This viewpoint is located on the A1067, Fakenham Road looking east along the road. The Y1 photomontage illustrates a grassed area in the foreground in the location of the existing A1067 Fakenham Road. Tree and shrub shelters are just evident in the background of the view, to the north of the diverted A1067 Fakenham Road (southwest of Deighton Hills) and on the proposed A1067 Fakenham Road roundabout.

The Y1 photomontage illustrates how in the foreground of the view a single carriageway of the existing A1067 Fakenham Road carriageway has been retained and a low bund has been provided to the north of the carriageway separating the old Fakenham Road from the new, with scrub and bramble colonising the bund. This conflicts with the Detailed Grass Seeding Proposals (drawing MMD-339156-DT-0125), which proposes the entirety of this area to be seeded with Mix A- EM2 Standard General Purpose Meadow Mix. This is due to the need to retain the old road to maintain access to BT manholes.

In the background of the view, the tree and shrub shelters are visible to the north of the diverted A1067 Fakenham Road (southwest of Deighton Hills). The pine trees planted on the Fakenham Road roundabout can be seen in the background of the photograph. Generally, levels of growth of trees and shrubs cannot be determined from this location due to distance.

Source: Mott MacDonald

Figure 12: Photomontage location 2



Photomontage Location 2

The viewpoint is located on Furze Lane, looking northwest towards the proposed Marriott's Way. The Y1 photomontage shows tree and shrub shelters in the foreground of the view, with the proposed Marriott's Way overbridge clearly visible in the background of the view and the proposed tree and shrub shelters on the embankments either side of the overbridge.

The Y1 photograph illustrates the tree and shrub shelters in the foreground of the view, which compares favourably with the Y1 photomontage. In the Y1 photograph, the embankments differ either side of the overbridge to the photomontage, with the embankments on the Y1 photograph only extending to the base of the overbridge and fencing tying into the hedgerow planting. Whereas the embankments appear to extend to the top of the overbridge parapets on the photomontage, with the embankment planted. The embankment to the south-east of the overbridge is shown as planted on the photomontage, as per the Detailed Planting Proposals (drawing MMD-339156-DT-0080). However, in Y1 photograph the embankment has only been partially planted with trees and requires additional shrub planting to be considered complete. In terms of levels of growth, the planting shown on the photograph was undertaken in the 2017/18 season and, therefore, is appropriate for this period of time.

Source: Mott MacDonald

Figure 13: Photomontage location 3

Photomontage Location 3

This viewpoint is located at the entrance to Bell Farm track, looking north along the track towards the proposed Bell Farm overbridge in the background of the view. The view is largely open, across neighbouring fields, with vegetation screening views to the northwest. The east embankment and associated planting is partially visible in the background of the view, but the overbridge is screened by existing vegetation.

The Y1 photograph largely mirrors the photomontage, except the overbridge is visible in the background of the view due to the removal of vegetation in the foreground of the view. The tree and shrub shelters on the east embankment are similarly partially visible in the background of the view. The success and levels of growth of planting are not possible to determine over this distance. However, the photomontage and photograph are comparable in this respect.

Source: Mott MacDonald

Figure 14: Photomontage location 4

Photomontage Location 4

This viewpoint is located on New Home Lane, looking south towards the proposed Cromer Road overbridge. The view is open across fields, framed to the right by existing trees, with re-aligned New Home Lane notable to the right of the view.In the background of the view the Cromer Road overbridge is visible to the right, with the embankment on the south side of the proposed A1270, Broadland Northway (NDR) visible below the treeline.

The Y1 photograph largely mirrors the photomontage, with open fields in the foreground of the view. The re-aligned New Home Lane follows the same line as illustrated in the photomontage. The Cromer Road overrbridge is visible in the background to the right of the view, with the embankment on the south side of the proposed A1270, Broadland Northway (NDR) visible below the treeline and the tree and shrub shelters visible along the embankment

The success and levels of growth of planting are not possible to determine over this distance. However, the photomontage and photograph are comparable in this respect.

Source: Mott MacDonald

Figure 15: Photomontage location 5

Photograph Location 5
Actual (Year 1)

Photomontage Location 5

This viewpoint is located on Old Norwich Road looking southeast towards the road embankment north of Petans Offshore Fire Training Centre. In the Y1 photomontage the view is open across neighbouring fields in the foreground, with the grassed embankment visible in the background of the view changing to a planted embankment to the east.

The Y1 photograph largely mirrors the photomontage, with open fields in the foreground of the view. The grassed embankment and planted embankment are similarly partially visible in the background of the view.

The success and levels of growth of planting are not possible to determine over this distance. However, the photomontage and photograph are comparable in this respect.

Source: Mott MacDonald

Figure 16: Photomontage location 6

Photomontage Location 6

This viewpoint is looking southeast from Quaker Lane towards the Buxton Road Overbridge. The Y1 photomontage shows views across fields in the foreground, framed by hedging to the south and east. In the background of the view the proposed Buxton Road overbridge is notable. Also visible is the north side of the planted embankment running east to west along the A1270, Broadland Northway (NDR).

The Y1 photograph is largely representative of the Y1 photomontage. The view is across open fields, with the Buxton Road overbridge visible in the background of the view, between earth embankments, planted with trees and shrubs protected with shelters .

The success and levels of growth of planting are not possible to determine over this distance. However, the photomontage and photograph are comparable in this respect.

Source: Mott MacDonald

Figure 17: Photomontage location 7

Photograph Location 7
Actual (Year 1)

Photomontage Location 7

This viewpoint is from Broad Lane looking southwest towards the proposed bridge over the railway line and over Plumstead Road. In the Y1 photomontage the view is open in the foreground, across fields. In the background of the view the proposed bridge over the railway line is visible, although the bridge over Plumstead Road is barely noticeable. The proposed embankment to the northeast side of the A1270, Broadland Northway (NDR) is prominent in the view, although the planting upon the embankment is not distiguishable from this distance.

The Y1 photograph closely resembles the Y1 photomontage. The bridge over the railway line is noticeable in the background of the view. However, the bridge over Plumstead Road is screened by a new fence that has been located along the west side of the railway line. The embankment to the northeast of the A1270, Broadland Northway (NDR) is prominent, as in the Y1 photomontage, and the tree and shrub shelters on the embankment are also visible.

The success and levels of growth of planting are not possible to determine over this distance. However, the photomontage and photograph are comparable in this respect.

Source: Mott MacDonald

Figure 18: Photomontage location 8

Photomontage Location 8

This viewpoint is from Low Road looking northeast towards Middle Road overbridge. In the Y1 photomontage the view is open, across fields in the foreground framed by a tree-lined hedgerow to the east and by hedging, vegetation and buildings associated with Laurel Farm to the west. In the background of the view the proposed Middle Road overbridge is clearly visible. The proposed embankment west and east of the overbridge and the proposed embankment running along the west side of the A1270, Broadland Northway (NDR) are clearly visible. The embankemnts are planted with trees and shrubs.

The Y1 photograph closely resembles the Y1 photomontage. Middle Road overbridge is notable in the background of the view and the associated embankments described in the Y1 photomontage closely resemble the actual Y1 photograph, with tree and shrub shelters visible on the embankments.

The success and levels of growth of planting are not possible to determine over this distance. However, the photomontage and photograph are comparable in this respect.

Source: Mott MacDonald

Figure 19: Photomontage location 9

Photograph Location 9
Actual (Year 1)

Photomontage Location 9

This viewpoint is from the Postwick junction looking east towards the proposed A47 slip road and Postwick overbridge. In the Y1 photomontage the view is open in the foreground looking along the road towards Postwick bridge and across a field planted with trees and shrubs. To the right of the view the proposed Postwick overbridge and embankment are visible in the background. The proposed A47 slip road can be glimpsed in the middle ground of the view.

The Y1 photograph closely resembles the Y1 photomontage, albeit there is an absence of signage and barriers present in the Y1 photograph. The planting in the foreground of the view is clearly apparent, although the growth of grass around the planting partially screens the planting and tree and shrub shelters. Planting can be seen coming out of the top of the shelters which contrasts with the Y1 photomontage. The difference in growth rates is likely to be due to the advance planting for the Postwick junction carried out in 2015, prior to the opening of the full A1270, Broadland Northway (NDR), once the construction of the Postwick junction had been completed. To the right of the view the Postwick overbridge is visible in the background. The proposed A47 slip road can be glimpsed in the centre of the view, mirroring the Y1 photomontage.

Source: Mott MacDonald

4.3.4 Conclusion

The comparison between the Y1 photomontages and Y1 photographs of the actual position illustrate that across the majority of the key viewpoint locations, the Y1 photograph largely mirrors the Y1 photomontage. The one notable exception is photomontage location 1. Here the single carriageway has been retained, with a bund provided to the north, to allow access to the BT manholes on the old road. This means the photomontage, which shows that this area should have been seeded with a species-rich wildflower mix, does not wholly match the Y1 photograph. However, overall the images illustrate that the scheme is generally representative of the anticipated level of landscape integration at one-year post-construction. NDR OYA Appendix A presents the detailed planting proposals (as-built) for the Norwich NDR scheme that were submitted as part of the reporting for Indicator 1.

4.4 Indicator 2: Biodiversity and Nature Conservation

4.4.1 NDR Ecological Post-Construction Monitoring – Bats

4.4.1.1 Introduction

As part of the environmental impact assessment, extensive bat surveys were undertaken over a six year period (between 2008 and 2013), by a team of experienced surveyors comprised of ecologists from Mott MacDonald and various sub-consultancies; 2008 (EcoGraphics, Mott MacDonald and Kepwick Ecological Surveys), 2009 and 2010 (Mott MacDonald and BSG, with Greena Ecological Consultancy, Geckoella and Corylus Ecology) and 2012 (Mott MacDonald and Greena Ecological Consultancy). These surveys were to support the assessment of the potential impacts of the NDR on local bat populations and to determine required mitigation and licencing requirements. Detailed information can be found in the Norwich Northern Distributer Road – Technical Appendix for Bats from the Environmental Statement (available on the PINS website).

Study area

Due to the nature of the surveys, the study areas differ between tasks. The survey locations for each task are listed in Table 4.

Table 4: Survey type and location for 2019 monitoring surveys

Survey	Locations
Manned static monitoring of bat crossings	12 bat crossing points, both inside and outside of the NDR.
Un-manned static monitoring of bat crossings	12 bat crossing points, both inside and outside of the NDR.
Roost counts of known bat roosts	Known roosts identified in baseline surveys within 50m of the Scheme.
Roost counts of bat houses	Two bat house locations.
Bat box occupancy check	All bat boxes locations. Bat box locations were originally chosen to mitigate for the loss of tree roosts associated with the Scheme. These are all within 150m of the Scheme.
Bat vehicle collision checks	12 bat crossing points, both inside and outside of the highway, 30m either side of the crossing point.

Source: NDR Ecological Post-Construction Monitoring - Bats

The locations of each of the 12 crossing points can be found in Figures B4 to B6 in NDR OYA Appendix B. The names of the crossing points are as follows:

- G1 – Gantry 1 (Shooting school access, near Attlebridge).
- G2 – Gantry 2 (Glebe Farm access, near Horsford).
- G3 – Gantry 3 (St Faiths Road, near Spixworth).
- G4 – Gantry 4 (near Beeston Hall cottages).
- G5 – Gantry 5 (near Beeston Hall).
- G6 – Gantry 6 (access off Middle Road, near Great Plumstead).
- G7 – Gantry 7 (Smee Lane, near Great Plumstead).
- GB1 – Green Bridge 1 (Marriots Way, near Taverham).
- GB2 – Green Bridge 2 (Middle Road, near Great Plumstead).
- DC1 – Dark Corridor 1 (Buxton Road, near Spixworth).
- DC2 – Dark Corridor 2 (Newman Road, near Rackheath).
- UN1 – Underpass, (near Rackheath).

Legislation

All bats in the UK are protected under Schedule 5 of the Wildlife and Countryside Act 1981. Since 2007, the effective protection for bats now comes from Schedule 2 of the Conservation (Natural Habitats & co) Regulations 1994. This makes all bats a European Protected Species (EPS). In effect, this legal protection makes it an offence to:

- Deliberately capture, injure or kill a bat.
- Damage or destroy a breeding or resting place of a bat.
- Obstruct access to a bat's resting or sheltering places.
- Possess, sell, control or transport live or dead bats.
- Intentionally or recklessly disturb a bat while it is in a structure or place of shelter or protection.
- Intentionally or recklessly disturb a bat at a roost.

4.4.1.2 Methodology

All surveys were undertaken in accordance with the DCO mitigation table for ecological post-construction monitoring surveys with specific methods being based on BCT Bat Surveys for Professional Ecologists: Good Practice Guidelines 3rd Edition (2016), hereafter referred to as the 'BCT guidelines'.

Manned static monitoring of bat crossings

Dusk and dawn crossing surveys were undertaken on all 12 crossing points (Figures B4 to B6 in NDR OYA Appendix B). Dusk surveys began 15 minutes before sunset and ended 90 minutes after and dawn surveys began 90 minutes before sunrise, ending 15 minutes after.

Surveys were completed with a space of at least two weeks between each survey and were conducted in suitable weather conditions. Those being:

- Temperatures above 10ºC.
- No or sporadic light rain.
- Low wind speeds.

Dates and weather conditions for each survey can be found in Table B1 in NDR OYA Appendix B.

At each crossing point a surveyor was positioned on the verge on either side of the road, equipped with time synchronised Batlogger Ms (handheld bat detectors) with built in temperature recording capability. Vertical distance from the crossing, horizontal distance from the crossing, direction of travel and time of crossing were recorded for each bat. Records were then combined, with duplicate recordings being removed. Measured points of reference were used to encourage more precise distance estimations, which were given to the nearest metre. For all bat gantries, the flight height from the road was then calculated from taking the vertical distance from the gantry away from the overall height of the gantry (bottom wire which crosses the road at the lowest point).

Activity of bats not crossing the road was also recorded.

Data analysis - Manned static monitoring of bat crossings

Based on methodology used in Berthinussen & Altringham (2012), 'safe' and 'unsafe' crossing heights were defined as being greater or less than 5m from the road surface. This is due to the maximum height of heavy goods vehicles being 4.9m in the UK (Department of Transport, 2011). Bats crossing at unsafe heights are therefore at risk of collision.

For bats which were crossing at a safe height, two definitions of using the gantries were used, bats flying within either 2m or 5m of the gantry (Berthinussen & Altringham, 2012). These classifications are based on species observations within the literature. Holderied et al. (2006) observed whiskered bats (myotis mystacinus) flying within 1.7m of a hedgerow and Schaub & Schnitzler (2007) found that Daubenton's bat (myotis daubentoniid) flew within 2.1 - 4.5m from a linear feature.

Noctules were not included within analysis as individuals always flew at heights greater than 15m. Noctules were also not a target species for the bat gantries as they generally forage and commute at heights greater than 5m.

Data analysis was carried out using R version 3.5.2. The Wilcoxon sign test from the package coin (Hothorn et al., 2008) was used to find differences for three separate tests: between bats crossing at a safe heights and bats crossing at unsafe heights, bats using the bat gantries with the 2m classification and bats not using the gantry and bats using the gantries with the 5m classification and bats not using the gantry.

Survey limitations - Manned static monitoring of bat crossings

G2 was only able to be surveyed from inside of the NDR highway boundary during the manned surveys as land access was restricted. On these surveys a pair of surveyors positioned themselves on either side of the gantry to provide best possible coverage.

When light levels became low, bats became harder to see, especially when bats were flying in front of a dark landscape (e.g. woodland). It is therefore possible that some bats were missed during the surveys.

Un-manned static monitoring of bat crossings

Static acoustic detectors were deployed at the 12 bat crossing locations along the scheme. At each location, detectors were deployed on both sides of the NDR. Where possible, detector microphones were attached at the bat crossing facing away from the road. In areas where there is public access, or if works (i.e. landscaping) were ongoing in the immediate area then detectors were placed close to the crossing. The 12 locations can be found in Figures B4 to B6 in NDR OYA Appendix B.

At each location, detectors were deployed for four consecutive nights on three separate occasions between May and September.

Data analysis - Un-manned static monitoring of bat crossings

Once call analysis was completed, the total number of passes was calculated for each location for each species. Due to the failure of some detectors while out in the field, detectors were deployed for a differing number of days across the 12 locations a daily level of bat activity was calculated by dividing the passes by the number of full nights they were deployed. This allowed for a more accurate comparison of bat activity between the static detector locations.

Ecobat (Lintott et al., 2017) was used to provide a standardised method to interpret bat activity data. Once call analysis was complete and nightly data was submitted to Ecobat, the organisation provided percentiles for each species for each night of survey across all sites based on a large reference dataset.

The reference dataset was stratified to include:

- Records from within 30 days of the survey date.
- Records from within 100km2 of the survey location.
- Records using any make of bat detector.

Results therefore provided a comparison against bat activity in the surrounding area.

Survey limitations - Un-manned static monitoring of bat crossings

Due to the proximity to the road, static detectors would often record the noise from traffic resulting in memory cards becoming full before completion of the full survey period. Larger memory cards were purchased to combat this issue but on rare occasions a card would become full before the end of the allotted survey time. Two units malfunctioned during the surveys (UN1 inside and G1 outside) resulting in incorrectly recorded data. Two microphones were vandalised on GB2 on the final survey, therefore no data was recorded for either inside or outside locations for that survey. Table 5 shows the total number of surveys nights for each detector location.

Table 5: Number of survey nights each survey location received

Location	Inside	Outside
G1	12	8
G2	10	8
G3	10	12
G4	8	10
G5	12	12
G6	8	8
G7	12	12
GB1	12	12
GB2	7	8
DC1	12	12
DC2	12	12
UN1	8	12

Source: NDR Ecological Post-Construction Monitoring - Bats

Roost counts of known bat roosts

Dusk emergence surveys were undertaken on all known roosts within 50m of the scheme boundary. Surveys were completed by a team of experienced ecologists under the guidance of at least one licenced bat specialist.

Two surveys were undertaken between May and September for each of the roosts. As detailed earlier surveys were only conducted in suitable weather conditions. Dates and weather conditions for each survey can be found in Table B2 in NDR OYA Appendix B.

Surveyors were positioned around the tree or structure to provide coverage of all Potential Roost Features (PRFs), and bat activity was recorded using a combination of visual observation and aural full spectrum bat detectors. Each surveyor used a Batlogger M with built in GPS, clock and temperature recording capability. Bat activity, including emergence from roosting locations, passes and foraging activity were recorded as were bat species and numbers.

Dusk emergence surveys started 15 minutes before sunset and ended between 1.5 to 2 hours after sunset. Locations for each of the known roosts can be found in Figures B1 to B3 in NDR OYA Appendix B.

Survey limitations – Roost counts of known bat roosts

Roost 8 - W11B was recorded within the 2013 pre-construction bat report as being found felled by a third party, so could not be included in the surveys.

Roost counts of bat houses

Two dusk surveys were undertaken on each bat house. Surveys were undertaken in July and again in August. As detailed earlier surveys were only conducted in suitable weather conditions.

Surveyors were positioned around the bat houses to provide coverage of all the PRFs and bat activity was recorded using a combination of visual observation and aural full spectrum bat detectors. Each surveyor used a Batlogger M+ with built in GPS, clock and temperature recording capability. Bat activity, including emergence from roosting locations, passes and foraging activity were recorded as were bat species and numbers.

Dusk emergence surveys started 15 minutes before sunset and ended between 1.5 to 2 hours after sunset. Locations for the two bat houses can be found in Figures B12 in NDR OYA Appendix B.

Bat box occupancy checks

Across four separate sites, 23 bat boxes were surveyed for bat activity. The four sites were all located within 150m of the scheme (Figures B7 to B11 in NDR OYA Appendix B) and are as follows:

- Fakenham Road ‑ Boxes 1 – 3.
- Spring Farm ‑ Boxes 4 – 6.
- Quaker Farm ‑ Boxes 7 – 11.
- Spixworth Plantation ‑ Boxes 12 – 23.

Fakenham Road, Spring Farm and Quaker Farm bat boxes were surveyed on 01/10/18 and Spixworth Plantation bat boxes were surveyed on the 02/10/18. Surveys involved experienced ecologists opening each box and checking for bats or any evidence for bats (i.e. droppings).

Bat vehicle collision

Two bat vehicle collision surveys were undertaken at each of the crossing points (Figures B4 to B6 in NDR OYA Appendix B) between May and August. Surveys began approximately 20 minutes after sunrise and involved a pair of surveyors slowly searching the hard shoulder and bank vegetation for bat remains 30m either side of the crossing on both sides of the road.

Survey limitations – Bat vehicle collision

Long bank vegetation in some crossing areas made it difficult to effectively search for bat remains.

Call analysis

A bat call was identified as a series of individual pulses in quick succession as a bat passes the detector. Recordings would stop after one second of no pulses. All call analysis was undertaken by an experienced bat ecologist using Kaleidoscope Pro 4.0 to identify calls to species level where possible. Where needed, British Bat Calls: A Guide to Species Identification (Ross, 2012) was used to aid in analysis.

Survey limitations – Call analysis

In some bat species there is considerable overlap between call parameters, i.e. Myotis. This results in calls sometimes only being identified to genus level.

4.4.1.3 Results

Species

Across all 2019 bat surveys, nine species were recorded using the study area as shown in Table 6.

Table 6: Bat species recorded in the study area

Species	Status
Common pipistrelle *Pipistrellus pipistrellus*	Widespread and common throughout Britain. Common pipistrelles forage across a range of habitats including deciduous woodland, parkland, gardens and fresh water.
Soprano pipistrelle *Pipistrellus pygmaeus*	Widespread and common throughout Britain. Soprano pipistrelles are generally more specific in their habitat choice when compared to common pipistrelles, often choosing to forage over freshwater habitats.
Nathusius' pipistrelle *Pipistrellus nathusii*	An uncommon species although relatively widespread throughout England. Forages along woodland edges and over freshwater.
Daubenton's bat *Myotis daubentonii*	Common and widespread throughout Britain. Daubenton's bats will regularly forage over fresh water where they trawl insects from the water's surface. They can also be found in other habitats such as open woodland and tree lines.
Natterer's bat *Myotis nattereri*	Widespread throughout England. Natterer's bats can be found foraging close to vegetation gleaning insects from surfaces. Will often forage in deciduous woodland, along treelines and above water.
Barbastelle *Barbastella barbastellus*	A rare species generally confined to the southern half of Britain. Forages both beneath and over the tree canopy, often flying lower earlier in the night and moving higher later. Main foraging habitat is deciduous woodland but does forage in other areas.
Brown long-eared bat *Plecotus auratus*	Common and widespread throughout Britain. Brown long-eared bats will forage by gleaning insects off surfaces of vegetation. They are found in habitats that include deciduous and coniferous woodland, parkland and gardens.
Serotine *Eptesicus serotinus*	An uncommon species generally restricted to the south and south-east of England. Serotines generally forage between 4 and 12m from the ground. They will often feed along linear features including woodland edges and large hedgerows.
Noctule *Nyctalus noctule*	Widespread throughout England. The UK's largest bat, noctules will generally feed between 10 and 50m from the ground. They feed over a range of habitats including deciduous woodland, parkland and freshwater.

Source: NDR Ecological Post-Construction Monitoring - Bats

Manned static monitoring of bat crossings

Excluding noctules, five species were observed using the bat crossings during the surveys. Those being; common pipistrelle, soprano pipistrelle, barbastelle, brown long-eared and Myotis. 87 bats were observed crossing the NDR across all surveys. Information regarding other bat activity during these surveys can be found in Table B4 in NDR OYA Appendix B.

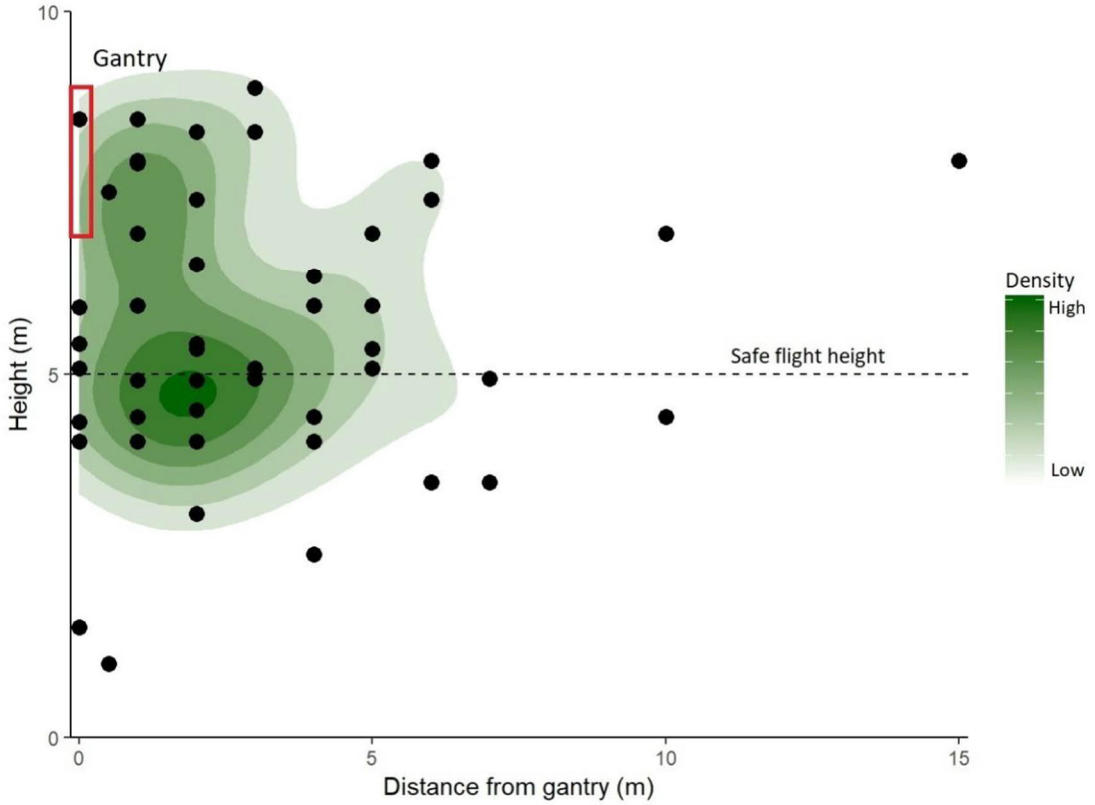
G5 was the only gantry to have no observations of crossing bats across all surveys. G4 was the most active crossing with 19 recorded crossings across all three surveys. Below there is a summary on crossing activity for each of the gantries across all three surveys:

- Gantry 1 – A total of three bats were recorded crossing at G1, two of those crossing at a safe height. Both soprano and common pipistrelles were recorded crossing.
- Gantry 2 – A total of nine bats were recorded crossing at G2, five of those crossing at a safe height. Soprano pipistrelle, common pipistrelle, brown long-eared bat and barbastelle were recorded crossing.
- Gantry 3 – A total of 11 bats were recorded crossing at G3, five of those crossing at a safe height. Soprano pipistrelle, common pipistrelle, brown long-eared bat and barbastelle were recorded crossing.
- Gantry 4 – A total of 18 bats were recorded crossing at G4, 14 of those crossing at a safe height. Soprano pipistrelle, common pipistrelle, and Mytois were recorded crossing.
- Gantry 5 – No bats were recorded crossing the road.
- Gantry 6 – A total of seven bats were recorded crossing at G6, six of those crossing at a safe height. Soprano pipistrelle, common pipistrelle, and barbastelle were recorded crossing.
- Gantry 7 – A total of ten bats were recorded crossing at G7 (excluding noctules, which fly at a height that cannot be considered as using the gantry), four of those crossing at a safe height. Soprano and common pipistrelles were both recorded crossing.

Appendix B (NDR Ecological Post- Construction Monitoring – Bats) shows a full list of gantry survey results.

Across all bat gantries, significantly more bats were observed to be crossing at safe heights than unsafe heights (58%; $Z = 6.6528$, $P < 0.01$). Significantly more bats were observed to be not using the gantry under the 2m classification (68%; $Z = 6.6842$, $P< 0.01$). There was minimal difference between the numbers of bats using the gantry with the 5m classification and not using the gantry (48%,52%) illustrating that approximately half of the crossing bats were using that gantries. Figure 20 shows the height from the road and horizontal distances from the gantries of crossing bats.

Figure 20: Height from the road and horizontal distance from gantries for all crossing bats (big bats excluded) for Gantries 1 to 7. The range in gantry height from the road is highlighted with the red box and the safe flight height is highlighted. Kernel density estimations have been applied.



Source: NDR Ecological Post-Construction Monitoring - Bats

While significantly more bats were observed to be flying at a safe height rather than an unsafe height, this does not necessarily mean that gantries are working in an effective manner. The impact on local bat populations depends on the proportion of bats killed while crossing at unsafe heights, and not the proportion of bats crossing safely.

As much of the vegetation surrounding the gantries was newly planted and not yet established, at some crossings there was not yet a natural guide (established vegetation) in raising up the flight height for bats before they reached the gantries. As vegetation becomes more established and increases in height, bats may be guided into flying at greater heights across the NDR, along the gantries.

Green bridges, dark corridors and underpass

Dark Corridor 1 was the only crossing to have no observed bats crossing. Underpass1 was also unsuccessful with three observed above road crossings but no bats flying through the underpass. Green Bridge1 performed the best of the bat crossings, with a total of 13 observed crossings. All bats which were observed crossing using Green Bridge1 were either common or soprano pipistrelles. Pipistrelles were also observed flying part way up the structure and then flying back down. See Table 7 for full details of survey results.

Table 7: Survey results for crossing bats at the green bridges, dark corridors and underpass

Location	Date	Species	Horizontal distance (m)	Distance above road	Direction
GB1	26.04.18	Common pipistrelle	0	4	In->Out
GB1	26.04.18	Common pipistrelle	0	2	Out->In
GB1	26.04.18	Common pipistrelle	0	3	Out->In
GB1	26.04.18	Common pipistrelle	0	3	In->Out
GB1	26.04.18	Common pipistrelle	0	4	Out->In
GB1	04.07.18	Soprano pipistrelle	0	3	In->Out
GB1	04.07.18	Common pipistrelle	0	2	Out->In
GB1	04.07.18	Common pipistrelle	0	2	Out->In
GB1	04.07.18	Common pipistrelle	0	3	Out->In
GB1	04.07.18	Common pipistrelle	0	1	Out->In
GB1	04.07.18	Common pipistrelle	0	2	Out->In
GB1	27.07.18	Soprano pipistrelle	0	0	Out->In
GB1	27.07.18	Common pipistrelle	0	3	Out->In
GB2	22.05.18	Noctule	0	20	Out->In
GB2	22.05.18	Noctule	10	30	Out->In
GB2	02.07.18	Soprano pipistrelle	0	5	In->Out
GB2	02.07.18	Common pipistrelle	0	2	In->Out
GB2	25.07.18	Noctule	0	5	In->Out
GB2	25.07.18	Noctule	2	4	In->Out
DC2	13.06.18	Common pipistrelle	0	8	
DC2	26.07.18	Noctule	0	15	
DC2	26.07.18	Noctule	20	5	
DC2	26.07.18	Common pipistrelle	0	1	
DC2	26.07.18	Common pipistrelle	0	1	
UN1	03.07.18	Noctule	10	2	Out->In
UN1	26.07.18	Soprano pipistrelle	50	4	Out->In
UN1	26.07.18	Soprano pipistrelle	50	10	Out->In

Source: NDR Ecological Post-Construction Monitoring - Bats

Much of the vegetation associated with the green bridges and dark corridors was newly planted. As there was considerable clearance of hedgerows and tree lines during construction it is

predicted that numbers of bats using these crossings will increase as new vegetation becomes established.

As drainage and landscaping work was still being undertaken close to the underpass during the survey period, the outside edge had not yet been planted. The underpass was flooded with approximately 15cm gap between the water and the top of the underpass due to works continuing downstream. The total clearance in the underpass when unimpeded is 1.8 metres, therefore this year's monitoring has not tested the effectiveness of this crossing.

Barbastelles

Three barbastelles were observed crossing the NDR during the manned crossing surveys. Barbastelles were observed crossing the road at G2, G3 and G6 and at all locations they were seen crossing at a safe height. Barbastelles crossing at G3 and G6 were also recorded crossing using the gantries within both the 2m and 5m classification. The barbastelle crossing at G2 crossed the road approximately 6m from the gantry.

Un-manned static monitoring of bat crossings

There is expected to be some variance in activity due to differences in foraging intensity, for the majority of species, most crossings showed relatively even numbers of bat calls between inside and outside NDR locations (Table B3 in NDR OYA Appendix B for full results). Table 8 shows static detectors results with calls being grouped into broader bat groups.

Table 8: Static detector results for all bat crossing locations. Call have been grouped into five species groups.

Location	Species	Total count (inside)	Total count (outside)	Nightly count (inside)	Nightly count (outside)
G1	Barbastelle	1	4	0.08	0.5
	Big bats	136	58	11.33	7.25
	Brown long-eared bat	48	68	4	8.5
	Pipistrelle	302	270	25.17	33.75
	Myotis	13	20	1.08	2.5
G2	Barbastelle	69	101	6.9	12.63
	Big bats	35	52	3.5	6.5
	Brown long-eared bat	31	41	3.1	5.13
	Pipistrelle	539	838	53.90	104.75
	Myotis	20	5	2	0.63
G3	Barbastelle	5	129	0.5	10.75
	Big bats	23	70	2.3	5.83
	Brown long-eared bat	6	64	0.6	5.33
	Pipistrelle	1873	552	187.3	46
	Myotis	4	17	0.4	1.42
G4	Barbastelle	1	18	0.13	1.8
	Big bats	39	24	4.88	2.4
	Brown long-eared bat	4	7	0.5	0.7
	Pipistrelle	710	2154	88.75	215.4
	Myotis	19	36	2.38	3.6

Location	Species	Total count (inside)	Total count (outside)	Nightly count (inside)	Nightly count (outside)
G5	Barbastelle	10	12	0.83	1
	Big bats	40	32	3.33	2.67
	Brown long-eared bat	4	7	0.33	0.58
	Pipistrelle	397	402	33.08	33.5
	Myotis	6	4	0.5	0.33
G6	Barbastelle	17	18	2.13	2.25
	Big bats	108	33	13.5	4.13
	Brown long-eared bat	23	12	2.88	1.5
	Pipistrelle	350	251	43.75	31.38
	Myotis	10	6	1.25	0.75
G7	Barbastelle	51	11	4.25	4.33
	Big bats	51	52	4.25	4.83
	Brown long-eared bat	16	6	1.33	0.5
	Pipistrelle	3591	3882	299.25	323.5
	Myotis	23	15	1.92	1.25
GB1	Barbastelle	3	4	0.25	0.33
	Big bats	57	58	4.75	4.83
	Brown long-eared bat	33	27	2.75	2.25
	Pipistrelle	1353	1244	112.75	103.67
	Myotis	9	8	0.75	0.67
GB2	Barbastelle	2	2	0.29	0.25
	Big bats	166	275	23.71	34.38
	Brown long-eared bat	4	5	0.57	0.63
	Pipistrelle	71	138	10.14	17.25
	Myotis	2	6	0.29	0.75
DC1	Barbastelle	9	7	0.75	0.58
	Big bats	55	36	4.58	3
	Brown long-eared bat	24	21	2	1.75
	Pipistrelle	673	503	56.08	41.92
	Myotis	4	7	0.33	0.58
DC2	Barbastelle	4	6	0.33	0.5
	Big bats	639	1441	53.25	120.08
	Brown long-eared bat	165	151	13.75	12.58
	Pipistrelle	564	529	47	44.08
	Myotis	28	17	2.33	1.42
UN1	Barbastelle	1	6	0.13	0.5
	Big bats	115	155	14.38	12.92
	Brown long-eared bat	17	8	2.13	0.67
	Pipistrelle	556	673	69.5	56.08
	Myotis	34	51	4.25	4.25

Source: NDR Ecological Post-Construction Monitoring - Bats

G3, G4 and G7, however, all showed large differences between bat activity for certain species. G3 had 22 times the number of Barbastelle calls on the outside of the NDR when compared to the inside. A similar pattern is shown in brown long-eared bats with nine times as many calls having been recorded on the outside of the NDR when compared to the inside. Due to the detector being located in a relatively open area on the embankment on the outside of G3 it is unlikely that the increased level of activity for these species is due to foraging. Such differences could be for one of three reasons:

- Bats are flying across the road but flying along the opposite side of the hedge to G3, resulting in the inside detector (attached to the gantry) being unable to pick up their echolocation calls.
- Bats are reaching the road and turning around.
- Bats are crossing the NDR away from G3 but passing the outside detector.

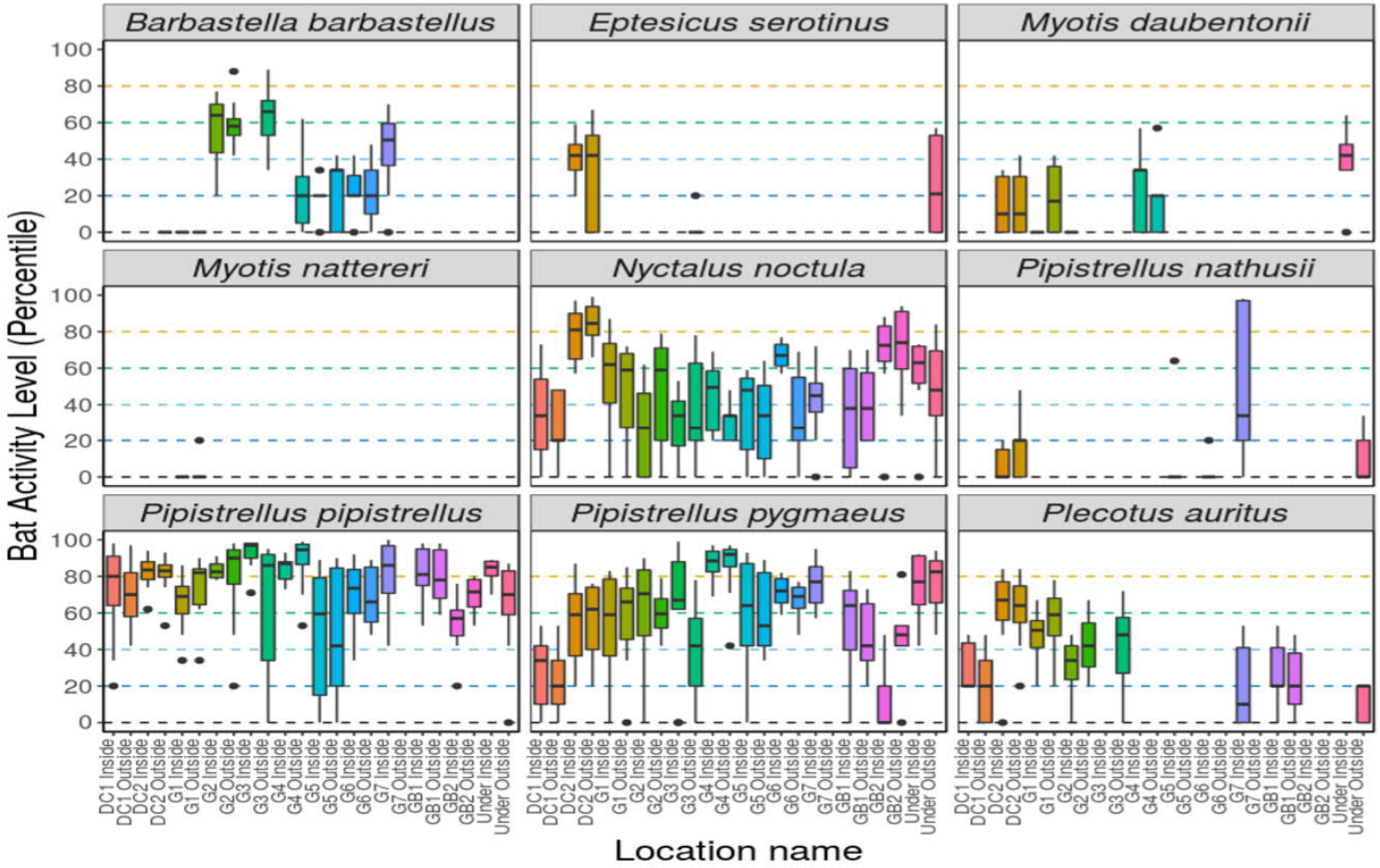
Both common and soprano pipistrelles had considerably more calls recorded on the inside location of G3 when compared to the outside location. As the inside location is ideal for foraging with an established hedgerow and some standing water down the track, it is likely that the differences in activity between the outside and inside detector locations are due to foraging.

G4 had 4.5 times the number of common pipistrelles calls on the outside detector when compared to the inside. The outside location was a foraging area for common pipistrelles as this was observed during the manned surveys.

Percentiles

Results from percentile analysis suggest that Common pipistrelles, Soprano pipistrelles and Noctules are the species least affected by the Scheme with percentile medians often over 50% with some locations being in the top 80%. This is not a finite conclusion however as without previous percentile data we are unable to compare. Brown long-eared bats are the next species found in the higher percentiles across the crossing locations followed by Barbastelles. It is likely that Daubenton's bats and Natterer's bats have been underrepresented within results due to a large proportion of Myotis only being identified to genus level and therefore excluded from percentile analysis. Figure 21 shows differences in species activity between static detector locations for percentiles. For individual species plots see Figures B12 to B22 in NDR OYA Appendix B.

Figure 21: Differences in activity between static detector locations, split by species and location. The centre line indicates the median activity level whereas the box represents the interquartile range (the spread of the middle 50% of nights of activity)



Source: NDR Ecological Post-Construction Monitoring - Bats

Roost counts of known bat roosts

Pre-construction bat surveys which took place during the environmental impact assessment (between 2008 and 2013) identified 17 bat roosts located within 50m of the Scheme. Roost 8 - W11B was found felled. Four of the remaining 16 roosts were found to have roosting bats during the 2018 summer surveys. See Table 9 for full survey results for all roosts.

Table 9: Survey results for known bat roosts

Roosts	Date	Bats roosting?	Roosting species	Bat activity recorded
Roost 1 – B5	12/06/2018	No		Barbastelle, Brown long eared, Common pipistrelle, Soprano pipistrelle, Myotis
	30/08/2018	No		Barbastelle, Daubenton's bat, Natterer's bat, Common pipistrelle, Soprano pipistrelle
Roost 2 – B55	13/06/2018	Yes	9 Brown long-eared bats	Noctule, common pipistrelle, soprano pipistrelle, brown long-eared bat
	25/07/2018	Yes	2 Common pipistrelle, 3 Brown long-eared bats	Noctule, Common pipistrelle, Soprano pipistrelle, Brown long-eared bat
Roost 3 – GB5	14/06/2018	Yes	1 Common pipistrelle	Serotine, Noctule, Common pipistrelle, Soprano pipistrelle
	17/09/2018	Yes	2 Common pipistrelle	Noctule, Common pipistrelle, Soprano pipistrelle
Roost 4 – B81	05/07/2018	No		Serotine, Noctule, Common pipistrelle, Soprano pipistrelle
	03/09/2018	No		Noctule, Common pipistrelle, Soprano Pipistrelle
Roost 5 – B82	05/07/2018	No		Noctule, Common pipistrelle, Soprano pipistrelle
	03/09/2018	Yes	2 Common pipistrelle, 2 Soprano pipistrelle	Noctule, Common pipistrelle, Soprano pipistrelle
Roost 6 – B85	04/07/2018	No		Serotine, Noctule, Common pipistrelle, Soprano pipistrelle, Brown long-eared bat
	18/09/2018	No		Noctule, Common pipistrelle, Soprano pipistrelle, Brown long-eared bat
Roost 7 – B90	04/07/2018	No		Serotine, Natterer's bat, Noctule, Common pipistrelle, Soprano pipistrelle
	15/08/2018	No		Noctule, Common pipistrelle, Soprano pipistrelle
Roost 8 – W11B	TREE FELLED			
	TREE FELLED			
Roost 9 – W11D	11/06/2018	No		Noctule, Common pipistrelle, Soprano pipistrelle, Daubenton's bat
	16/08/2018	No		Serotine, Noctule, Common pipistrelle, Soprano pipistrelle

Roosts	Date	Bats roosting?	Roosting species	Bat activity recorded
Roost 10 – W11N	11/06/2018	No		Noctule, Common pipistrelle, Soprano pipistrelle, Daubenton's bat
	16/08/2018	No		Serotine, Noctule, Common pipistrelle, Soprano pipistrelle
Roost 11 – 475B	24/07/2018	No		Noctule, Common pipistrelle, Soprano pipistrelle
	06/09/2018	No		Common pipistrelle, Brown long-eared bat
Roost 12 - 490	23/07/2018	No		Noctule, Common pipistrelle, Soprano pipistrelle
	16/08/2018	No		Noctule. Soprano pipistrelle
Roost 13 - 290	15/08/2018	No		Noctule. Soprano pipistrelle
	04/09/2018	Yes	3 Soprano pipistrelle	Myotis, Noctule, Common pipistrelle, Soprano pipistrelle
Roost 14 - 511	16/08/2018	No		Serotine, Noctule, Common pipistrelle, Soprano pipistrelle, Brown long-eared bat, Daubenton's bat, Barbastelle
	06/09/2018	No		Common pipistrelle, Soprano pipistrelle, Brown long-eared bat
Roost 15 - 380	24/07/2018	No		Noctule, Serotine, Common pipistrelle, Soprano pipistrelle
	14/08/2018	No		Noctule, Serotine, Common pipistrelle, Soprano pipistrelle
Roost 16 - 415	26/07/2018	No		Myotis, Noctule, Common pipistrelle, Soprano pipistrelle
	04/09/2018	No		Myotis, Noctule, Common pipistrelle, Soprano pipistrelle
Roost 17 - 451	26/07/2018	No		Common pipistrelle, Soprano pipistrelle
	04/09/2018	No		Common pipistrelle, Soprano pipistrelle

Source: NDR Ecological Post-Construction Monitoring - Bats

Roost counts of bat houses

On the final survey on the small bat house, two Soprano pipistrelles were observed emerging from the apex of the roof on the southern face. Such quick uptake, considering the scheme was only completed during 2018 is encouraging. No bats were found to be roosting in the larger bat house. For full survey results see Table 10.

Table 10: Result of bat box checks

Roosts	Date	Bats roosting?	Roosting species	Feature	Other activity
Rackheath bat house - large	30/07/2018	No			Noctule, Common pipistrelle, Daubenton's bat, Serotine, Myotis

Roosts	Date	Bats roosting?	Roosting species	Feature	Other activity
Rackheath bat house – small	31/07/2018	No			Noctule, Common pipistrelle, Brown long-eared bat, Soprano pipistrelle, Myotis
Rackheath bat house - large	28/08/2018	No			Noctule, Daubenton's bat, Common pipistrelle, Serotine
Rackheath bat house – small	29/08/2018	Yes	2 Soprano pipistrelle	Apex of roof (semi-circle access tile) on southern face	Noctule, Common pipistrelle, Soprano pipistrelle, Myotis

Source: NDR Ecological Post-Construction Monitoring - Bats

Bat box occupancy checks

Out of the four surveyed locations, Quaker Farm was the only area to have no uptake in any of the bat boxes. Eleven bats were found in total across 23 boxes, all being either soprano or common pipistrelles. Nine out of the 23 boxes were either in use or showed evidence of use. Table 11 shows results for all boxes.

Table 11: Result of bat box checks

Location	Box number	Activity	Notes
Fakenham Rd	1	One Common pipistrelle and one Soprano pipistrelle	
Fakenham Rd	2	Brown long-eared bat droppings	
Fakenham Rd	3		Inactive birds nest removed
Spring Farm	4	Pipistrelle droppings	
Spring Farm	5	Pipistrelle droppings	
Spring Farm	6		
Quaker Farm	7		
Quaker Farm	8		
Quaker Farm	9		
Quaker Farm	10		Inactive birds nest removed
Quaker Farm	11		
Spixworth Plantation	12		
Spixworth Plantation	13		
Spixworth Plantation	14		
Spixworth Plantation	15	Six Soprano pipistrelles	
Spixworth Plantation	16		Hornet nest
Spixworth Plantation	17		
Spixworth Plantation	18	Two Common pipistrelles	
Spixworth Plantation	19		
Spixworth Plantation	20	Pipistrelle droppings	
Spixworth Plantation	21	Pipistrelle droppings	
Spixworth Plantation	22		
Spixworth Plantation	23	One Common pipistrelle	

Source: NDR Ecological Post-Construction Monitoring - Bats

Bat vehicle collision

No bats were found during any of the bat vehicle collision surveys.

4.4.1.4 Conclusion

The bat surveys have revealed the following results:

- It appears that the NDR has not had a significant adverse impact on bat numbers and bat species diversity in the area (however, with only one year's worth of post-construction data it is impossible to comment upon long-term trends.
- Mitigation measures appear to have had a positive impact - the quick uptake of soprano pipistrelles in using the small bat house for roosting is encouraging and shows the potential for the structures to be an important roosting facility for local species. If there is no bat activity observed during the 2019 monitoring for the larger house, it may become necessary to make small changes to the inside of the structure to make it more attractive for roosting bats.
- Across all 2019 bat surveys, nine species were recorded (common pipistrelle; soprano pipistrelle; nathusius' pipistrelle; brown long-eared; natterer's; daubenton's; noctule; serotine; barbastelle).
- Excluding noctules, five species were observed using the bat crossings during the surveys.
- While more bats are crossing the NDR at a safe height than those crossing at an unsafe height, there is still a large proportion of bats crossing unsafely, these are at risk of vehicle collision mortality. As the effect on local bat populations will be dependent on the number of bats hit by moving vehicles, it is essential that as many bats as possible are guided to fly over the road at a safe height.
- Another impact the NDR may be having on local bats is the reduction in permeability through the landscape, especially for low flying species which rely on linear features. This seems evident at some of the crossing locations where the number of crossing bats is especially low.
- Although few Barbastelles crossing the road were observed throughout the surveys, it is encouraging that all observed were flying at a safe height. Relatively low levels of additional mortality in rare species has the potential to impact on the long-term sustainability of local populations.
- No bats were found during any of the bat vehicle collision surveys.

4.4.2 NDR Post-Construction Monitoring – Hibernating Bats

4.4.2.1 Introduction

Study area

The study area includes all structures identified within 2km of the scheme. Figure 2 (Section 6) shows the study area.

Legislation

All bats in the UK are protected under Schedule 5 of the Wildlife and Countryside Act 1981. This legislation is outlined in section 4.4.1 above.

4.4.2.2 Methodology

Hibernation surveys were undertaken on buildings and structures which had been identified prior to construction of the NDR, as having potential to support hibernating bats and were within 2km of the Scheme.

Surveys were completed by experienced, licenced ecologists between the 11th February 2019 to the 15th of February 2019 in accordance with Bat Conservation Trust best practice guidelines. The surveys included a close and systematic inspection of all cracks, crevices, voids or other cavities. Where needed, surveyor used torches and endoscopes. Any bats or evidences of bats was recorded (droppings or oil staining).

4.4.2.3 Results

A total of 24 buildings and structures were identified as having hibernation potential during hibernation surveys conducted in 2013 (Mott MacDonald, 2013). During 2019 surveys, it was not possible to survey Little Plumstead Hospital (which burnt down in 2016) or Hall Farm, which was demolished during construction of the NDR. Access to Crostwick Church, Postwick Church, the underground shelter at Newman's Farm, Rackheath bridge and Morton Hall was denied during the 2019 surveys.

Hibernating bats were observed in four buildings and structures in 2009;

- Ringland Church.
- Spixworth Hall ice house.
- Military buildings at Gazebo Farm.
- Whitlingham Country Park lime kiln.

Evidence of hibernating bats were observed in three buildings and structures in 2019;

- Ringland Church.
- Spixworth Hall ice house.
- Whitlingham Country Park lime kiln.

Bats were observed clinging to the walls inside Spixworth Hall ice house and Whitlingham Country Park lime kiln. More bats may have been present further inside the structures, but it was not possible to fully investigate all areas of the structures due to safety reasons. A small number of fresh bat droppings were observed on the altar cloth at Ringland church which were thought to be from Myotis. The church is cleaned weekly and the droppings were relatively fresh.

The results of the hibernation surveys on the 17 buildings and structures monitored in 2019 are shown below in Table 12 and the locations are recorded on Figure B27 in NDR OYA Appendix B.

Table 12: NDR bat hibernation monitoring results for 2009 and 2019

Building or structure	2009 survey findings	2019 survey findings
Attlebridge Bridges	No evidence of hibernating bats	No evidence of hibernating bats
Attlebridge Church	No evidence of hibernating bats	No evidence of hibernating bats
Drayton Church	No evidence of hibernating bats	No evidence of hibernating bats
Great Plumstead Church	No evidence of hibernating bats	No evidence of hibernating bats
Horsford Church	No evidence of hibernating bats	No evidence of hibernating bats
Horsham St Faith Church	No evidence of hibernating bats	No evidence of hibernating bats

Building or structure	2009 survey findings	2019 survey findings
Little Plumstead Church	No evidence of hibernating bats	No evidence of hibernating bats
Military Buildings, Gazebo Farm	Brown long-eared bats and Barbastelle observed	No evidence of hibernating bats
Old Catton Church	No evidence of hibernating bats	No evidence of hibernating bats
Ringland Church	1 Serotine and 5 Pipistrelle observed	Fresh bat droppings observed in the chancel
Spixworth Church	No evidence of hibernating bats	No evidence of hibernating bats
Spixworth Hall Ice House	Natterers and Daubenton's observed	1 Myotis observed
Sprowston Church	No evidence of hibernating bats	No evidence of hibernating bats
Rackheath Church	No evidence of hibernating bats	No evidence of hibernating bats
Tavernham Church	No evidence of hibernating bats	No evidence of hibernating bats
Witton Church	No evidence of hibernating bats	No evidence of hibernating bats
Whitlingham Country Park Lime Kiln	Myotis observed	5 Natterer's bats and 3 Daubenton's bats

Source: NDR Post-Construction Monitoring – Hibernating Bats

4.4.2.4 Conclusion

Of the four hibernation roosts identified prior to construction only one of those, the military buildings in Rackheath, had no bats or signs of bat activity present. Hibernating bats are often under recorded as they will crawl deep into crevices and can therefore be difficult to find. Some of the military buildings have collapsed; they have multiple crevices which go deep into the ground and out of the range of endoscopes and torches, so bats could have been missed. In many of the churches inspected, there were features within the roof or out of reach so there is some possibility that bats were under-recorded during these surveys.

4.4.3 NDR Ecological Post-Construction Monitoring – Great Crested Newts

4.4.3.1 Introduction

Mott MacDonald was commissioned by NCC to undertake great crested newt (GCN) Triturus cristatus surveys.

Legislation

GCN are protected under the Wildlife and Countryside Act 1981 (as amended) and the Conservation of Habitat and Species Regulations 2017 (as amended). They are also listed on Section 41 of the NERC Act 2006. In summary it is an offence to:

- Intentionally or deliberately kill, injure, disturb or capture a great crested newt; and
- Damage, destroy or obstruct access to any structure used for breeding or resting.

4.4.3.2 Methodology

Surveys

The surveys were undertaken in accordance with the GCN mitigation guidelines (English Nature, 2001). Three of the four following methods were undertaken on the ponds in 2018 on each visit. The exact method was decided on a case by case basis depending on what was suitable for the conditions found on site and suitability of the technique.

These included:

- Bottle trapping: Bottle traps (two litre soft drink bottles with the end cut off and inverted into the main body) are installed around the pond margin and left overnight with an air bubble above the surface of the water.
- Egg search: Searching suitable live and dead submerged vegetation for GCN eggs.
- Torch survey: Use of a high powered Clulite torch at night to illuminate the pond and visually see any newts in the pond.
- Netting: Use of a long-handled dip net and sweeping it through suitable vegetation to capture newts within the edges of the pond. Each pond was visited a total of six times within the relevant survey period as required by the guidelines. A total of two surveyors were used on each survey with at least one of the surveyors holding a Class 1 GCN survey licence.

Limitations

The results are likely to underestimate the GCN population for the following reasons:

- GCN surveys are only predicted to record between 2% and 30% of the population.
- No access was available to Pond 37 for 2018 and it is therefore not included within the survey results.
- Turbid water and/or the progressive bloom of pond weed meant that torching surveys were limited in Ponds 5, 42, 44, 45, 46 and 47.
- The vegetation cover of ponds 7 and NE limited torching surveys.
- Ponds 45 and 46 had areas of filamentous algae which restricted the survey effort.
- Bottle trapping of pond 5 was not completed during the third visit due to concerns of the welfare for great crested newts, due to high numbers being caught in single traps on the second visit. Trapping recommenced on the fourth visit, once numbers had reduced.
- Ponds NW, NE, SW and SE which have been installed as mitigation have a plastic liner and therefore traditional bottle traps cannot be used and instead floating bottle traps were used during surveys. It is unknown if these are more effective than traditional bottle traps.

4.4.3.3 Results

Results up to 2017

The presence of GCN has historically been identified in Ponds 5, 6 and 7 at Dog Lane, Horsford, in Pond 16 at Quaker Farm and Ponds 37, 42, 44, 45, 46, 47 and 48 at Rackheath between 2007 and 2013; maps of these sites are located in Appendix A.

Peak counts of GCN from 2007, 2009, 2012, 2013, 2016 and the previous 2017 monitoring are presented in Table 13.

Owing to the works being undertaken to construct NDR, ongoing monitoring of the GCN population is required to ensure the population is not affected as part of the mitigation licence granted by Natural England. Pond 48 was lost as part of the works in early 2017 and so four ponds have been created. These are known as Ponds SW, SE, NW and NE based on their location within the Site.

Table 13: Previous results from 2007, 2009, 2012, 2013, 2016 and 2017

Site name	Pond no.	Date	Peak count of GCN	Peak count per meta-population
Dog Lane	5	2017	13	2017 – 14
		2016	27	2016 – 38
		2013	14	2013 – 26

Site name	Pond no.	Date	Peak count of GCN	Peak count per meta-population
		2012	8	2012 – 8 (only 1 of 3 ponds surveyed)
		2007	28	2007 - 35
	6	2017	1	
		2016	1	
		2013	0	
		2007	1	
	7	2017	0	
		2016	10	
		2013	12	
		2007	6	
Quaker Farm	16	2017	30	2017 – 30
		2016	28	2016 – 28
		2012	27	2012 – 27
		2009	5	2009 – 5
		2007	7	2007 - 7
Rackheath	37	2016	17	
		2012	17	
		2009	2	
		2007	38	
	42	2017	0	2017 – 8
		2016	11	2016 – 68
		2013	19	2013 – 43
		2012	15	2012 – 51
		2009	2	2009 – 57
		2007	5	2007 - 45
	44	2017	0	
		2016	9	
		2013	9	
		2012	9	
		2009	6	
		2007	4	
	45	2017	8	
		2016	4	
		2013	2	
		2012	0	
		2009	1	
		2007	5	
	46	2017	0	
		2016	2	
		2013	1	
		2012	0	
	SW 2015	2017	2	
		2016	12	
	SE 2015	2017	3	
		2016	13	

Site name	Pond no.	Date	Peak count of GCN	Peak count per meta-population
	NW 2016	2017	2	
	NE 2016	2017	5	
	47	2013	19	
		2012	9	
		2009	24	
		2007	24	
	48	2013	5	
		2012	1	
		2009	24	
		2007	1	

Source: NDR Ecological Post-Construction Monitoring – Great Crested Newts

2018 Survey Results

The 2018 surveys took place on all ponds were GCN had previously been identified, including the new ponds created at Rackheath. The results are detailed in **Table 14**. Combined peak count results are shown in **Table 14**.

Table 14: Results from GCN surveys 2018

Site name	Pond no.	Date	Air temperature (ºC)	Amphibians recorded through bottle trapping	Amphibians recorded through torching	Egg search	GCN peak count
Dog Lane	5	17/04/2018	15	2 male and 16 female GCN	2 male and 16 female GCN	No	68
		10/05/2018	14	1 male and 43 female GCN	42 male and 26 female GCN	No	
		21/05/2018	12	Did not trap due to welfare concerns.	8 male and 5 female GCN; 1 female smooth newt	No	
		31/05/2018	14	3 male and 5 female GCN	10 male and 2 female GCN	No	
		04/06/2018	14	5 male and 14 female GCN	3 male and 4 female GCN	No	
		13/06/2018	18	1 male and 2 female GCN	Nothing found	No	
	6	17/04/2018	15	6 male and 1 female GCN	9 males and 3 female GCN; 2 male smooth newts	No	22
		10/05/2018	14	Nothing found	12 male and 2 female GCN; 5 male and 2 female smooth newts	No	
		21/05/2018	12	3 male and 1 female GCN; 2 female smooth newts	8 male and 14 female GCN; 3 male and 3 females smooth newt	No	
		31/05/2018	14	4 female smooth newts	10 male GCN	No	
		04/06/2018	14	2 male and 1 female GCN	Nothing found	No	
		13/06/2018	18	3 male and 5 female GCN; 1 male and 1 female smooth newt; 2 frogs	Nothing found	No	
	7	17/04/2018	15	1 female GCN; 6 male and 4 female smooth newts	9 males and 5 females smooth newt	No	3
		10/05/2018	14	1 female GCN; 4 male and 1 female smooth newt	4 female smooth newts	No	
		21/05/2018	12	1 male and 2 female smooth newts	Nothing found	No	
		31/05/2018	14	1 male GCN; 3 male smooth newts	Nothing found	No	

Site name	Pond no.	Date	Air temperature (ºC)	Amphibians recorded through bottle trapping	Amphibians recorded through torching	Egg search	GCN peak count
		04/06/2018	14	1 male and 2 female GCN; 1 male and 1 female smooth newt	Nothing found	No	
		13/06/2018	18	1 Frog	Nothing found	No	
Quaker Farm	16	17/04/2018	15	10 female GCN; 2 male and 1 female smooth newt	19 male and 5 female GCN; 1 frog and 1 toad	Yes	27
		10/05/2018	14	2 male and 5 female GCN	18 male and 9 female GCN	-	
		21/05/2018	12	2 male and 2 female GCN; 2 male smooth newts	12 male and 3 female GCN; 2 female smooth newts	-	
		31/05/2018	14	2 male and 2 female GCN	4 male GCN	-	
		04/06/2018	14	1 male and 1 female GCN	Nothing found	-	
		13/06/2018	18	1 male GCN	1 male smooth newt and 6 toads	-	
Rackheath	NW	18/04/2018	14	3 male and 2 females; 1 male and 2 female smooth newts	5 male and 4 female GCN; 2 female smooth newts; 15 frogs	No	9
		09/05/2018	14	1 female smooth newt	4 male and 3 female GCN; 1 male and 1 female smooth newt; 1 frog	No	
		23/05/2018	10	Nothing found	Nothing found	No	
		29/05/2018	10	1 female GCN; 3 male smooth newts	1 female smooth newt	No	
		06/06/2018	13	1 male GCN; 1 female smooth newt	1 female smooth newt; 3 frogs	No	
		11/06/2018	16	Nothing found	1 male and 1 female smooth newt; 2 frogs	No	
	NE	18/04/2018	14	Nothing found	8 male and 3 female GCN; 10 frogs	No	11
		09/05/2018	14	Nothing found	8 male and 3 female GCN; 1 frog	No	

Site name	Pond no.	Date	Air temperature (ºC)	Amphibians recorded through bottle trapping	Amphibians recorded through torching	Egg search	GCN peak count
		23/05/2018	10	Nothing found	Nothing found	No	
		29/05/2018	10	Nothing found	Nothing found	No	
		06/06/2018	13	1 female GCN	1 female GCN	No	
		11/06/2018	16	2 female smooth newts	1 male GCN; 1 Frog	No	
	SW	19/04/2018	16	3 male smooth newts	3 male and 2 female GCN; 1 male and 1 female smooth newt	No	5
		08/05/2018	18	2 male and 1 female; 7 male and 3 female smooth newts	Nothing found	No	
		22/05/2018	10	Nothing found	Nothing found	No	
		30/05/2018	17	1 male and 1 female GCN	1 male GCN	No	
		05/06/2018	12	Nothing found	Nothing found	No	
		12/06/2018	15	1 female GCN	Nothing found	No	
	SE	19/04/2018	16	2 female smooth newts	9 male GCN; 5 male and 6 female smooth newts	No	9
		08/05/2018	18	1 male smooth newt	1 Frog	No	
		22/05/2018	10	Nothing found	2 female smooth newts	No	
		30/05/2018	17	1 male and 1 female smooth newt	Nothing found	No	
		05/06/2018	12	1 male GCN; 3 male and 1 female smooth newt	Nothing found	No	
		12/06/2018	15	Nothing found	Nothing found	No	
	42	18/04/2018	14	1 female GCN; 1male and 2 female smooth newts	4 male and 2 female GCN; 2 male and 3 female smooth newts	Yes	8

Site name	Pond no.	Date	Air temperature (ºC)	Amphibians recorded through bottle trapping	Amphibians recorded through torching	Egg search	GCN peak count
		09/05/2018	14	4 male and 4 female GCN; 6 male and 1 female smooth newt	Nothing found	-	
		23/05/2018	10	2 male and 2 female GCN	2 female smooth newts; tadpoles	-	
		29/05/2018	10	2 male and 4 female GCN; 6 male smooth newts	Nothing found	-	
		06/06/2018	13	Nothing found	Tadpoles	-	
		11/06/2018	16	1 male smooth newt	1 male and 1 female smooth newt; tadpoles and 1 frog	-	
	44	19/04/2018	16	1 male and 2 female GCN; 1 male smooth newt	19 male GCN; 1 female smooth newt	No	19
		08/05/2018	18	1 male and 2 female GCN; 1 male smooth newt	2 male GCN; 3 male and 3 female smooth newts; 1 frog	No	
		22/05/2018	10	2 male and 1 female GCN	1 male GCN; 2 female smooth newts	No	
		30/05/2018	17	3 male GCN; 2 male smooth newts	2 male GCN	No	
		05/06/2018	12	Nothing found	Nothing found	No	
		12/06/2018	15	2 female GCN and 1 female smooth newt	Tadpoles	No	
	45	18/04/2018	14	2 male and 4 female GCN; 4 male and 1 female smooth newt	11 female GCN; 1 male and 10 female smooth newts	No	18
		09/05/2018	14	1 female GCN; 1 male smooth newt	15 male and 3 female GCN; 1 male and 2 female smooth newts; 1 frog	No	
		23/05/2018	10	1 male and 2 female GCN	4 male and 2 female GCN; 1 female smooth newt	No	

Site name	Pond no.	Date	Air temperature (ºC)	Amphibians recorded through bottle trapping	Amphibians recorded through torching	Egg search	GCN peak count
		29/05/2018	10	1 male GCN	3 male and 5 female GCN; 1 male and 2 female smooth newts	No	
		06/06/2018	13	1 female GCN	Tadpoles	No	
		11/06/2018	16	1 male GCN	7 male and 3 female GCN; 2 male and 1 female smooth newt; 1 Frog	No	
	46	18/04/2018	14	Nothing found	3 female GCN; 2 male and 5 female smooth newt; 2 frogs	No	3
		09/05/2018	14	1 female GCN; 1 male and 1 female smooth newt	1 frog and 1 toad	No	
		23/05/2018	10	Nothing found	2 male and 6 female smooth newts	No	
		29/05/2018	10	Nothing found	1 male and 1 female GCN; 2 male and 1 female smooth newt	No	
		06/06/2018	13	Nothing found	Nothing found	No	
		11/06/2018	16	1 female GCN; 1 male smooth newt	1 male GCN	No	
	47	19/04/2018	16	11 male and 9 female GCN; 10 male and 6 female smooth newts	11 male and 6 females GCN; 22 male and 8 female smooth newts; 1 frog	Yes	20
		08/05/2018	18	14 male and 5 females; 2 male smooth newt	7 male and 3 female GCN; 8 male and 6 smooth newts; 1 frog	-	
		22/05/2018	10	5 male and 3 female GCN; 2 male and 1 female smooth newt	8 male and 12 female GCN; 4 male and 8 female smooth newts; 1 frog and 1 toad	-	

Site name	Pond no.	Date	Air temperature (ºC)	Amphibians recorded through bottle trapping	Amphibians recorded through torching	Egg search	GCN peak count
		30/05/2018	17	2 male and 3 female GCN; 1 male smooth newt	4 male and 7 female GCN; 3 male and 2 female smooth newts	-	
		05/06/2018	12	3 female GCN; 1 male and 1 female smooth newt	1 frog	-	
		12/06/2018	15	1 male and 1 female GCN	Tadpoles	-	

Source: NDR Ecological Post-Construction Monitoring – Great Crested Newts

Table 15: Results from 2007 – 2018 combined

Site name	Pond no.	Date	Peak count of GCN	Peak count per meta-population
Dog Lane	5	2018	68	2018 – 93
		2017	13	2017 – 14
		2016	27	2016 – 38
		2013	14	2013 – 26
		2012	8	2012 – 8 (only 1 of 3 ponds surveyed)
		2007	28	2007 - 35
	6	2018	22	
		2017	1	
		2016	1	
		2013	0	
		2007	1	
	7	2018	3	
		2017	0	
		2016	10	
		2013	12	
		2007	6	
Quaker Farm	16	2018	27	2018 – 27
		2017	30	2017 – 30
		2016	28	2016 – 28

Site name	Pond no.	Date	Peak count of GCN	Peak count per meta-population
		2012	27	2012 – 27
		2009	5	2009 – 5
		2007	7	2007 - 7
Rackheath	371	2016	17	2018 – 102
		2012	17	2017 – 20
		2009	2	2016 – 68
		2007	38	2013 – 43
	42	2018	8	2012 – 51
		2017	0	2009 – 57
		2016	11	2007 - 45
		2013	19	
		2012	15	
		2009	2	
		2007	5	
	44	2018	19	
		2017	0	
		2016	9	
		2013	9	
		2012	9	
		2009	6	
		2007	4	
	45	2018	18	
		2017	8	
		2016	4	
		2013	2	
		2012	0	
		2009	1	
		2007	5	

Site name	Pond no.	Date	Peak count of GCN	Peak count per meta-population
	46	2018	3	
		2017	0	
		2016	2	
		2013	1	
		2012	0	
	NW	2018	9	
		2017	2	
	NE	2018	11	
		2017	5	
	SW	2018	5	
		2017	2	
		2016	12	
	SE	2018	9	
		2017	3	
		2016	13	
	47	2018	20	
		2013	19	
		2012	9	
		2009	24	
		2007	24	
	48	2013	5	
		2012	1	
		2009	24	
		2007	1	

Source: NDR Ecological Post-Construction Monitoring – Great Crested Newts

4.4.3.4 Conclusion

The number of GCN recorded within each meta-population was higher in 2018 than in 2017 (except for Quaker Farm) and in previous years. A large population (102 peak count) was identified within the ponds at Rackheath, with medium populations identified at Dog Lane (93 peak count) and Quaker Farm (27 peak count). The counts of GCN recorded in 2018 at Dog Lane and Quaker Farm are significantly higher than average.

A possible explanation is due to the sustained warm weather over the 2018 survey season, more GCN to the surface for breeding and therefore more likely to be found in bottle traps and viewed when torching. Another possible explanation is due to the sustained cold period prior to the breeding season kept GCN in hibernation longer. They then all moved at the same time to the breeding ponds creating a larger detectable peak due to the reduced season.

Monitoring will continue in 2019, with all construction works in the vicinity now complete and newt fencing removed. It is anticipated that following the 2018 results, GCN numbers will be higher than those recorded prior to the scheme's construction.

4.4.4 NDR Ecological Post-Construction Monitoring – Breeding bird survey

4.4.4.1 Introduction

This breeding bird survey has been undertaken in 2018 along the length of the NDR. The survey was completed as part of Requirement 7 of the DCO for the NDR (Norfolk County Council, 2014a). This survey describes the 2018 (Y1) monitoring survey and compares the results to the previously established baseline position.

4.4.4.2 Methodology

Comparison of methodology between 2018 survey and the baseline

As required by the DCO, the field methodology for the breeding birds monitoring survey was designed to replicate as close as possible the survey undertaken prior to construction (the 'baseline survey'). It was also designed to be easily repeatable over the following 4 years.

The pre-construction field survey involved visiting all parts of the zone of influence (ZOI) within 250m of the route centreline. Additionally, some areas slightly further from the centreline (>250m but <500m) were also visited where the surveyors considered the habitats were likely to "support specialist species or high densities of birds" (Mott MacDonald, 2013).

Post-construction, an exact replication of the baseline survey was not possible; the road had resulted in direct loss of habitats, and it was also not possible to access some areas where additional construction work, such as landscaping around drainage lagoon features, was still continuing (e.g. in the vicinity of Plumstead Road).

Therefore, in 2018 the survey was completed by walking broadly parallel to the road on either side. For much of its length, pedestrian and cycle paths adjacent to the road provided appropriate access. Other public roads/Public Rights of Way were used where appropriate, including Beeston Lane (near Buxton Road), Dog Lane and Bell Farm Track (Horsford), and Quaker Lane (Spixworth). As a result, almost all the survey was completed from publicly-accessible land. Where it was necessary to divert from the immediate periphery of the road, professional judgement of the surveyor was used to determine if a particular area had been included in the baseline survey.

It should be noted that there were a very few areas where access was limited, notably around the airport. In line with the baseline survey, the densely planted areas at the Postwick Park and Ride at the southern end of the road were excluded from the survey, and similarly the area at the far west of the road around the Wensum Valley Hotel and Golf Course was also excluded.

The baseline survey was actually undertaken over two years, with the northern/western section of the route surveyed between April and June 2012, and the eastern/southern section in May and June 2013. The baseline survey report also includes references to species recorded in an earlier survey undertaken in 2007. In contrast, the 2018 survey covered the whole route in a single season.

Field methodology

The field methodology involved three visits to all parts of the road corridor. Generally, the same route was walked on each visit at any given location, although minor variations in the route were undertaken to compensate for where bad weather had cut short an earlier survey, or where disturbance on an earlier visit had potentially affected birds.

Contacts with birds either by sight or sound were recorded on a map of the road overlaid on an Ordnance Survey Master Map base. The number of birds of each species was recorded together with breeding evidence (see section below), using the standard conventions used in the BTO Survey Atlas (often referred to as “the Breeding Bird Survey methodology” or “BBS methodology” (British Trust for Ornithology, 2018a)).

The survey was conducted by a surveyor with more than 25 years’ experience of undertaking bird surveys, between 30 April 2018 and 21 June 2018. The first survey was less than 2 weeks after the road opened. Each of the three survey visits to a given location were always at least two weeks apart.

In line with the baseline survey, surveying generally started between 5.30am and 6.00am, although where weather conditions were sub-optimal, some visits started at 7.00am or slightly later. Surveying was completed by 11.00am in most cases, although a few visits lasted until around 12.00pm. To complete the coverage in an appropriate timeframe, a very few evening visits were necessary. These started around 7.30pm and continued no later than 9.45pm.

Limitations of survey

Surveying was not completed when it was windy or in heavy rain. However, to survey the whole road corridor in an appropriate timeframe, some sections were surveyed in sub-optimal weather. Where weather was poor for short periods, surveys visits were delayed or stopped until the weather improved.

There was variation in the time when any given point was surveyed, with some areas being surveyed near to dawn when birds are generally more active, and some nearer to mid-day when birds become less active. The detectability of bird species varies considerably with the closeness to dawn; the chance of hearing some species reduces significantly the later a survey visit is made. For some species detectability may also decrease as the season progresses as birds sing less. However, as every point was visited three times, it is anticipated that these variations in the weather and in the timings of visit were not significant.

Some of the surveying was undertaken in the evening. It is not believed that this significantly affected the overall results. However, it is noted that Tawny Owls were only heard on the evening visits, so for this species the results may not be truly comparative across the whole route.

As described above, an exact replication of the survey area was not possible. As most of the 2018 survey was undertaken from publicly accessible areas, it is possible that some locations were not surveyed as intensively as in the baseline survey, for example where there are cross-field hedgerows or isolated trees some distant to the paths. Conversely, it is also possible that some areas not surveyed in the baseline survey were surveyed in 2018. By using routes such as Dog Lane and Beeston Lane, it is possible that areas outside of the original ZOI were surveyed. Nevertheless, overall it is believed that broadly the same area was subject to survey in both cases, and the results are therefore comparable.

Identification of breeding evidence

In the BBS methodology there are standard categories of evidence of breeding: 'possible', 'probably', and 'confirmed' (BTO, 2018a). In the current survey, the effort required to confirm breeding for all species could have been too time consuming (unlike the baseline survey, the 2018 survey had to be completed in a single year) and was considered of limited value. In practice it was only considered necessary to identify if breeding was likely.

The way this was determined varied depending on the ecology of the species. For example, the observation of a pair of Bullfinches or Partridges together in suitable habitats at an appropriate time, is strongly indicative of breeding. For other species, such as Song Thrushes, the presence of a singing male in a similar location on more than one visit indicates that the bird is holding a territory and breeding is likely.

For other species, determining the likelihood of breeding is more difficult. For example, species that hold large territories such as Kestrels or Buzzards, the breeding location could have been outside of the ZOI, and would not have been identified in the survey.

Some species, such as Linnets, continue to move in small groups even in spring, and so identifying likely breeding pairs is frequently very difficult if the male is not heard singing. Only singing males seen in a location on more than one visit were mapped, but this was a small proportion of the Linnets that were observed.

House Sparrows live in loose colonies, and where these occur, breeding is almost certain. However, identifying the number of pairs in each colony is difficult without intensive effort. Therefore, only colony locations were mapped.

For Skylarks, territories can vary in size, and the birds will call throughout their territories. The bird's calls are often made from a great height and can carry large distances in suitable weather conditions. Therefore, care was taken to distinguish territories of this species and only those territories that were wholly or largely within the road corridor were mapped.

Data analysis

The report on the baseline survey contained a map showing 'hotspots' for breeding birds along the (then proposed) route. This was created using Kernel Density Analysis (KDA). However, during the 2018 survey, it rapidly became apparent that hotspots could be readily identified. In simple terms, areas of open farmland with few or no trees and hedges had low numbers of breeding birds, whilst areas with greater tree cover or containing other diverse habitats (including, in some cases, gardens) held more birds. Analysis of the maps of the field survey data allowed these hotspots to be plotted without the need to resort to KDA.

In 2018, hotspots were categorised as having more than 5 species in close proximity showing evidence of breeding. These were further sub-divided into locations with 5-8 species and locations with more than 8 species.

It should be noted that although the two methods of identifying hotspots both show the areas of greatest breeding activity, they are not directly comparable. The KDA included both diversity of breeding species and abundance i.e. the number of species and the number of individuals involved. The 2018 hotspots are based entirely on diversity, i.e. just the number of species showing breeding activity.

As described above, individuals of less detectable species may have been missed due to timing constraints and some scarce species may not have been recorded at all. These limitations are likely to have affected the baseline survey as well as the 2018 survey. Therefore, the emphasis of the analysis focused on the more detectable species and those with the highest conservation status. The adoption of this approach going forward, means comparisons between years are likely to be valid.

Conservation status

In the same way as the report on the baseline survey, bird species recorded were categorised by their Conservation Status. These were as described in Birds of Conservation Concern 4 (Eaton et al., 2013).

The conservation status of some species has changed since the baseline survey which predated the current Birds of Conservation Concern report.

Birds on the Red and Amber lists, i.e. those of the highest conservation status, are given greatest consideration in the analysis of the 2018 survey results.

Nomenclature

The English vernacular names and scientific bird names used in this report follow that of the British Ornithologists' Union (2012) and are the same as those used in the baseline survey report.

4.4.4.3 Results

Overview

Breeding evidence was recorded for 55 species within the road corridor. A number of other species were seen but were considered migrants, or were species where no evidence of breeding was noted.

A total of 14 species were recorded that are on the Red List of Birds of Conservation Concern. Of these, 9 species showed evidence of breeding.

A further 18 species were recorded that are on the Amber List of Birds of Conservation Concern. Of these, 10 species showed evidence of breeding. A full list of species recorded is given in Table 19, including whether they showed evidence of breeding, and their conservation status.

The most commonly recorded species were Great Tit, Blue Tit, Chaffinch and Wren, and all showed evidence of breeding throughout the road corridor.

'Hotspots' for breeding birds were identified at 10 locations. These were (from south to north):

- Adjacent to the Business park roundabout, north of Postwick junction;
- At the eastern side of the Middle Road overbridge;
- Between the road and Green Lane, Rackheath;
- The wooded areas at the eastern side of the Rackheath Hall overbridge;

- The wooded and rough grassland area to the west of the Newman Road overbridge;
- At the Springs County Wildlife Site, west of Rackheath;
- Between the road and Beeston Hall;
- Between the road and the settlement of Thorpe Marriott;
- To the north of the road at its eastern junction with the Fakenham road; and,
- To the south of the road at its eastern junction with the Fakenham road.

The Hotspot locations are shown on Figures 22 and 23, coloured by the number of species showing evidence of breeding.

Species of conservation concern

Nine Red-listed species showed evidence of breeding, outlined on the table below

Table 16: Breeding bird species of conservation concern

Species		Notes
	Grasshopper Warbler	A Grasshopper Warbler was heard singing in reedbed and scrub on two separate visits at the Springs County Wildlife Site but was otherwise not recorded during the survey (Figure 24).
Grey Partridge	A single pair of Grey Partridge were observed once in grassland immediately adjacent to the road north east of the airport (Figure 25).	
	House Sparrow	House Sparrow colonies were noted in four locations (Figure 24 and Figure 25).
Linnet		Linnets were heard singing at 13 locations
	Marsh Tit	Marsh Tits were recorded at the Springs County Wildlife Site, where a minimum of 4 territories were identified (Figure 24).
Skylark	Skylarks were heard singing along the full road corridor. Care was taken to distinguish territories of this species and only those territories that were wholly or largely within the road corridor are plotted in Figures 26 and 27, a minimum total of 25 territories.	
	Starling	Starlings were heard singing at the woods either side of the Rackheath Hall overbridge and at Green Lane, Rackheath (Figure 24). Singing male Starlings were also heard at three locations on the northern section of the road at Thorpe Marriott, at Quaker Farm, and at Beeston Park (Figure 25).
Yellowhammer	A minimum of nine Yellowhammer territories were identified, where singing was heard on more than one survey visit. All territories were based in hedges in the more open farmland. The areas where these were identified were near Plumstead and Postwick (Figure 24), at the far west end of the road, and near to the airport (Figure 25).	

Source: Mott MacDonald

A Grey Wagtail was seen in what could be considered suitable breeding habitat at the Springs County Wildlife Site in early May (Figure 24), although it was not seen subsequently. Song Thrushes were heard singing in a minimum of 10 locations.

Red-listed species recorded but not considered breeding were Herring Gull, Lapwing, Yellow Wagtail and Redwing. The first two were only observed flying high overhead during the survey. A male Yellow Wagtail was seen in flight in early May but was considered a passage migrant, whilst the Redwing was considered a lingering wintering bird (the species does not breed in the county).

Other observations

Other breeding species of note included a small colony of Sand Martins near to the Marriott's Way Trail north of the NDR. A pair of Little Ringed Plovers were observed near Plumstead Road on one visit, but on the second visit only one bird was seen.

Several of the drainage lagoons held water throughout the survey period. The lagoons next to the roundabout with the Wroxham Road regularly held groups of 30+ Mallard, 20+ Greylag Geese and large numbers of gulls. A feral Ruddy Shelduck was also seen on a lagoon holding water, along with feral Egyptian Geese, near to the airport, but there was no evidence of breeding.

Table 17: Species list of birds recorded in 2018, noting evidence of breeding where applicable, and the conservation status of each species.

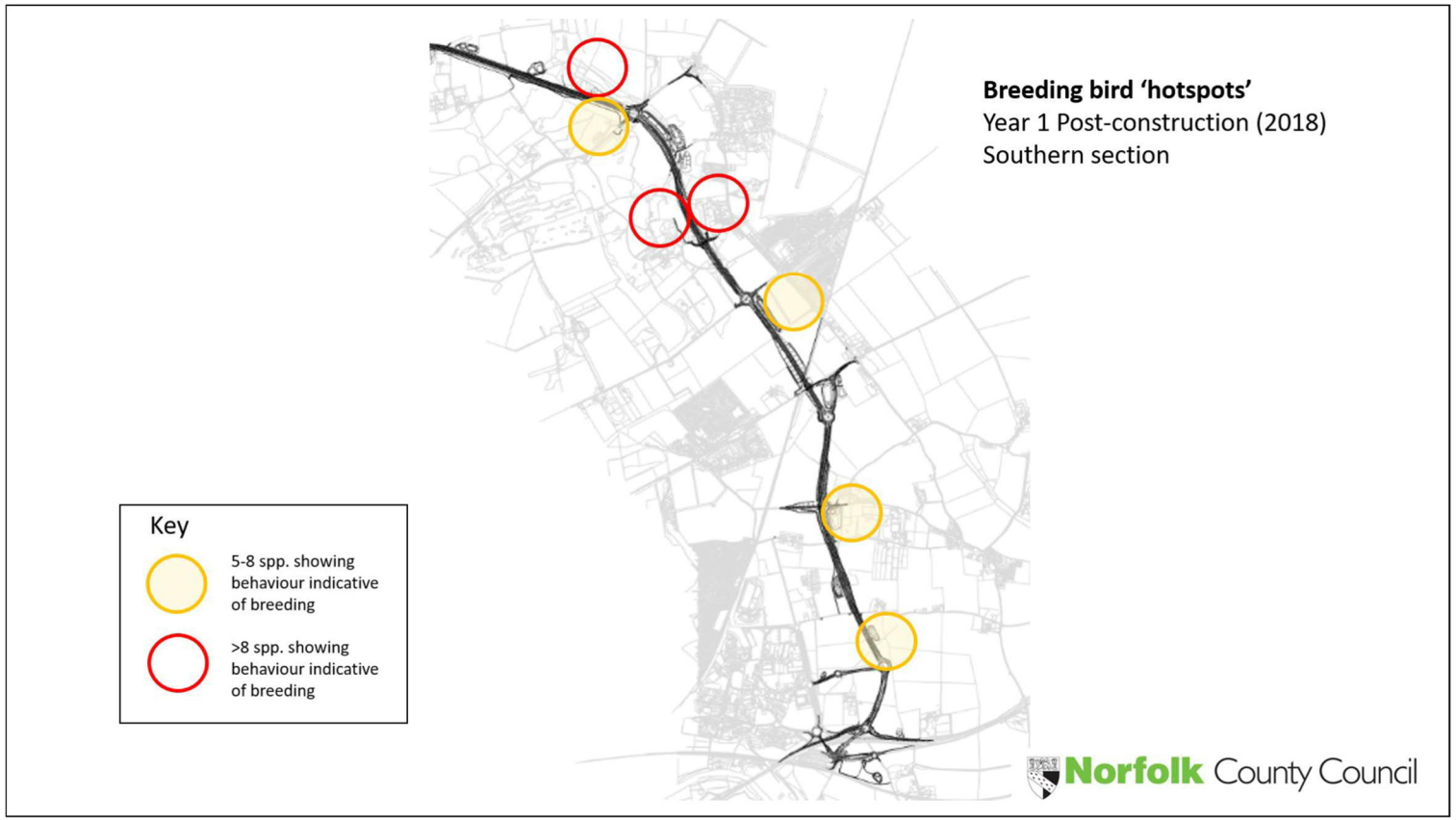
English name	Scientific name	Native or non-native	Evidence of breeding in 2018 (Y/N)	Birds of conservation concern
Blackbird	*Turdus merula*	N	Y	Green
Blackcap	*Sylvia atricapilla*	N	Y	Green
Black-headed Gull	*Chroicocephalus ridibundus*	N	N	Amber
Blue Tit	*Cyanistes caeruleus*	N	Y	Green
Bullfinch	*Pyrrhula pyrrhula*	N	Y	Amber
Buzzard	*Buteo buteo*	N	Y	Green
Carrion Crow	*Corvus corone*	N	Y	Green
Chaffinch	*Fringilla coelebs*	N	Y	Green
Chiffchaff	*Phylloscopus collybita*	N	Y	Green
Coal Tit	*Periparus ater*	N	Y	Green
Collared Dove	*Streptopelia decaocto*	N	Y	Green
Cormorant	*Phalacrocorax carbo*	N	N	Green
Dunnock	*Prunella modularis*	N	Y	Green
Egyptian Goose	*Alopochen aegyptiaca*	NN (feral)	N	Unlisted
Feral pigeon	*Columba livia domestica*	N (feral)	Y	Unlisted
Garden Warbler	*Sylvia borin*	N	Y	Green
Goldcrest	*Regulus regulus*	N	Y	Green
Goldfinch	*Carduelis carduelis*	N	Y	Green
Grasshopper Warbler	*Locustella naevia*	N	Y	Red
GS Woodpecker	*Dendrocopos major*	N	Y	Green
Great Tit	*Parus major*	N	Y	Green
Green Woodpecker	*Picus viridis*	N	Y	Green
Greenfinch	*Chloris chloris*	N	Y	Green
Grey Heron	*Ardea cinerea*	N	N	Green
Grey Partridge	*Perdix perdix*	N	Y	Red
Grey-lag Goose	*Anser anser*	N (feral)	N	Amber
Grey Wagtail	*Motacilla cinerea*	N	Y	Red
Herring Gull	*Larus argentatus*	N	N	Red

English name	Scientific name	Native or non-native	Evidence of breeding in 2018 (Y/N)	Birds of conservation concern
House Martin	*Delichon urbicum*	N	Y	Amber
House Sparrow	*Passer domesticus*	N	Y	Red
Jackdaw	*Corvus monedula*	N	Y	Green
Jay	*Garrulus glandarius*	N	Y	Green
Kestrel	*Falco tinnunculus*	N	N	Amber
Lapwing	*Vanellus vanellus*	N	N	Red
Lesser BB Gull	*Larus fuscus*	N	N	Amber
Lesser Whitethroat	*Sylvia curruca*	N	Y	Green
Linnet	*Linaria cannabina*	N	Y	Red
Little Egret	*Egretta garzetta*	N	N	Green
Little Owl	*Athene noctua*	NN	Y	Green
Little Ringed Plover	*Charadrius dubius*	N	Y	Green
Long-tailed Tit	*Aegithalos caudatus*	N	Y	Green
Magpie	*Pica pica*	N	Y	Green
Mallard	*Anas platyrhynchos*	N	N	Amber
Marsh Tit	*Poecile palustris*	N	Y	Red
Meadow Pipit	*Anthus pratensis*	N	Y	Amber
Mistle Thrush	*Turdus viscivorus*	N	Y	Amber
Moorhen	*Gallinula chloropus*	N	N	Green
Mute Swan	*Cygnus olor*	N	N	Green
Nuthatch	*Sitta europaea*	N	Y	Green
Oystercatcher	*Haematopus ostralegus*	N	N	Amber
Pheasant	*Phasianus colchicus*	NN	Y	Unlisted
Pied Wagtail	*Motacilla alba*	N	Y	Green
Red-legged Partridge	*Alectoris rufa*	NN	Y	Unlisted
Redwing	*Turdus iliacus*	N	N	Red
Reed Bunting	*Emberiza schoeniclus*	N	Y	Amber
Reed Warbler	*Acrocephalus scirpaceus*	N	Y	Green
Robin	*Erithacus rubecula*	N	Y	Green
Rook	*Corvus frugilegus*	N	N	Green
Ruddy Shelduck	*Tadorna ferruginea*	NN	N	Unlisted
Sand Martin	*Riparia riparia*	N	Y	Amber
Sedge Warbler	*Acrocephalus schoenobaenus*	N	Y	Green
Skylark	*Alauda arvensis*	N	Y	Red
Song Thrush	*Turdus philomelos*	N	Y	Red
Sparrowhawk	*Accipiter nisus*	N	N	Green
Starling	*Sturnus vulgaris*	N	Y	Red
Stock Dove	*Columba oenas*	N	N	Amber
Swallow	*Hirundo rustica*	N	Y	Amber
Swift	*Apus apus*	N	Y	Amber
Tawny Owl	*Strix aluco*	N	Y	Green

English name	Scientific name	Native or non-native	Evidence of breeding in 2018 (Y/N)	Birds of conservation concern
Treecreeper	*Certhia familiaris*	N	Y	Green
Tufted Duck	*Aythya fuligula*	N	N	Amber
Whitethroat	*Sylvia communis*	N	Y	Amber
Willow Warbler	*Phylloscopus trochilus*	N	Y	Amber
Wren	*Troglodytes troglodytes*	N	Y	Green
Yellow Wagtail	*Motacilla flava*	N	N	Red
Yellowhammer	*Emberiza citronella*	N	Y	Red

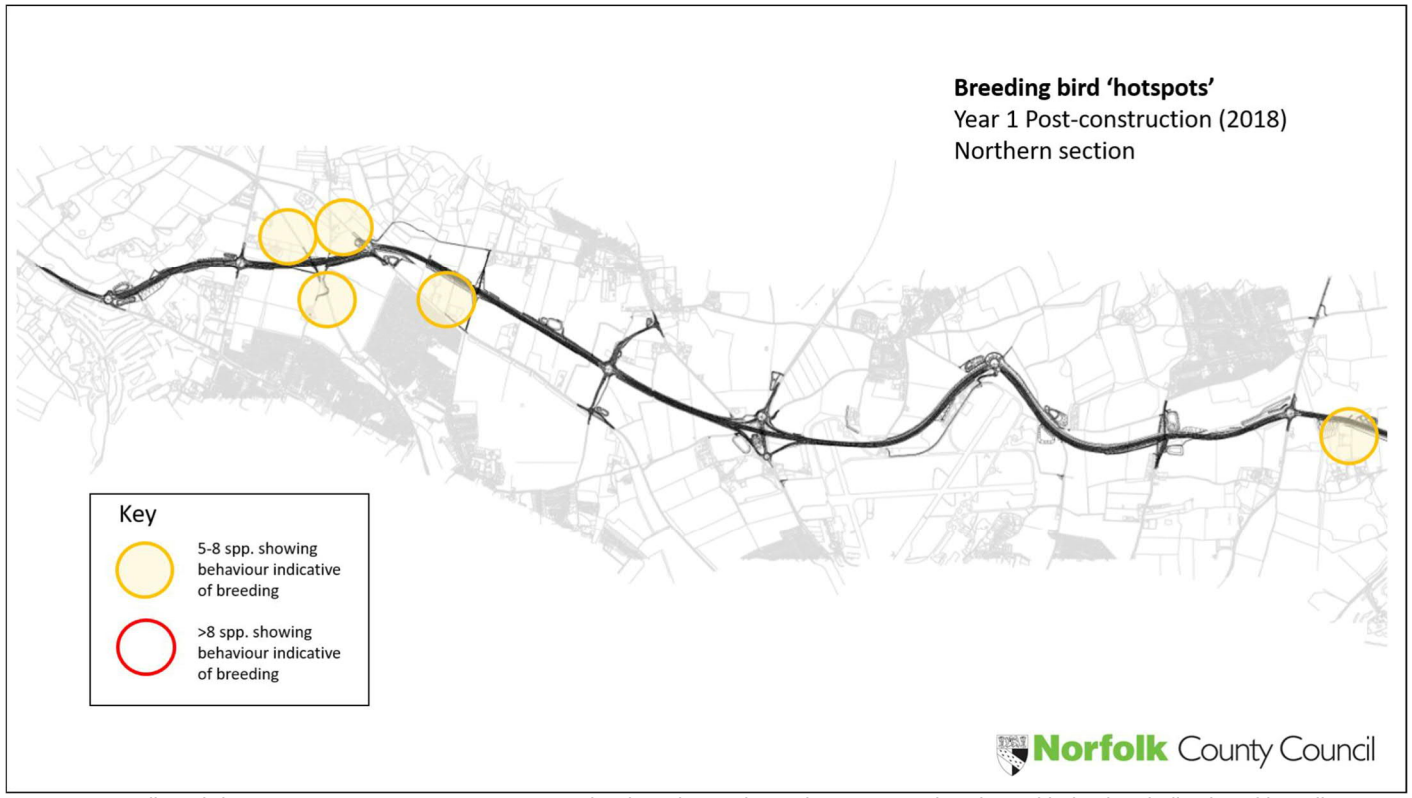
Source: Breeding Bird Survey: NDR – Year 1 Post-Construction (2018)

Figure 22: Locations of 'hotspots' of breeding birds in 2018; NDR Southern Section.



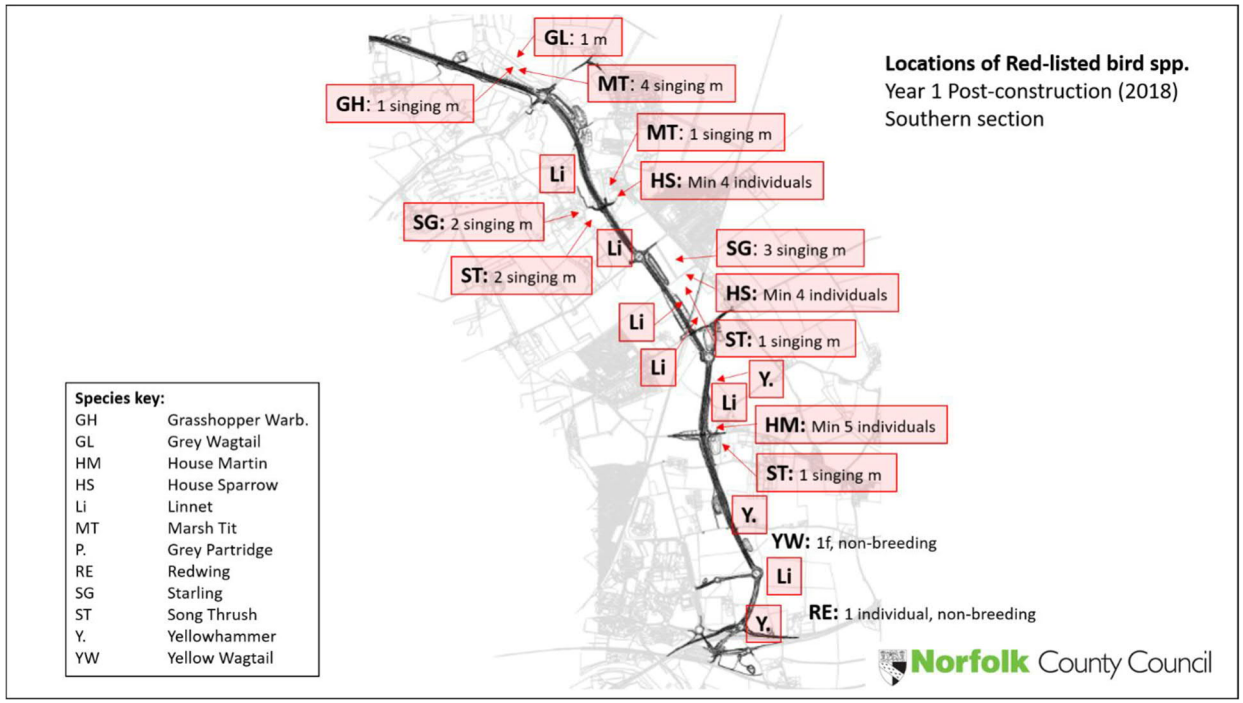
Source: Breeding Bird Survey: NDR – Year 1 Post-Construction (2018) Locations where 5-8 species showed behaviour indicative of breeding are marked by a yellow circle. Locations where >8 species showed behaviour indicative of breeding are marked with a red circle. The extent of the NDR scheme is shown in black.

Figure 23: Location of breeding bird 'hotspots' in 2018; NDR Northern section.



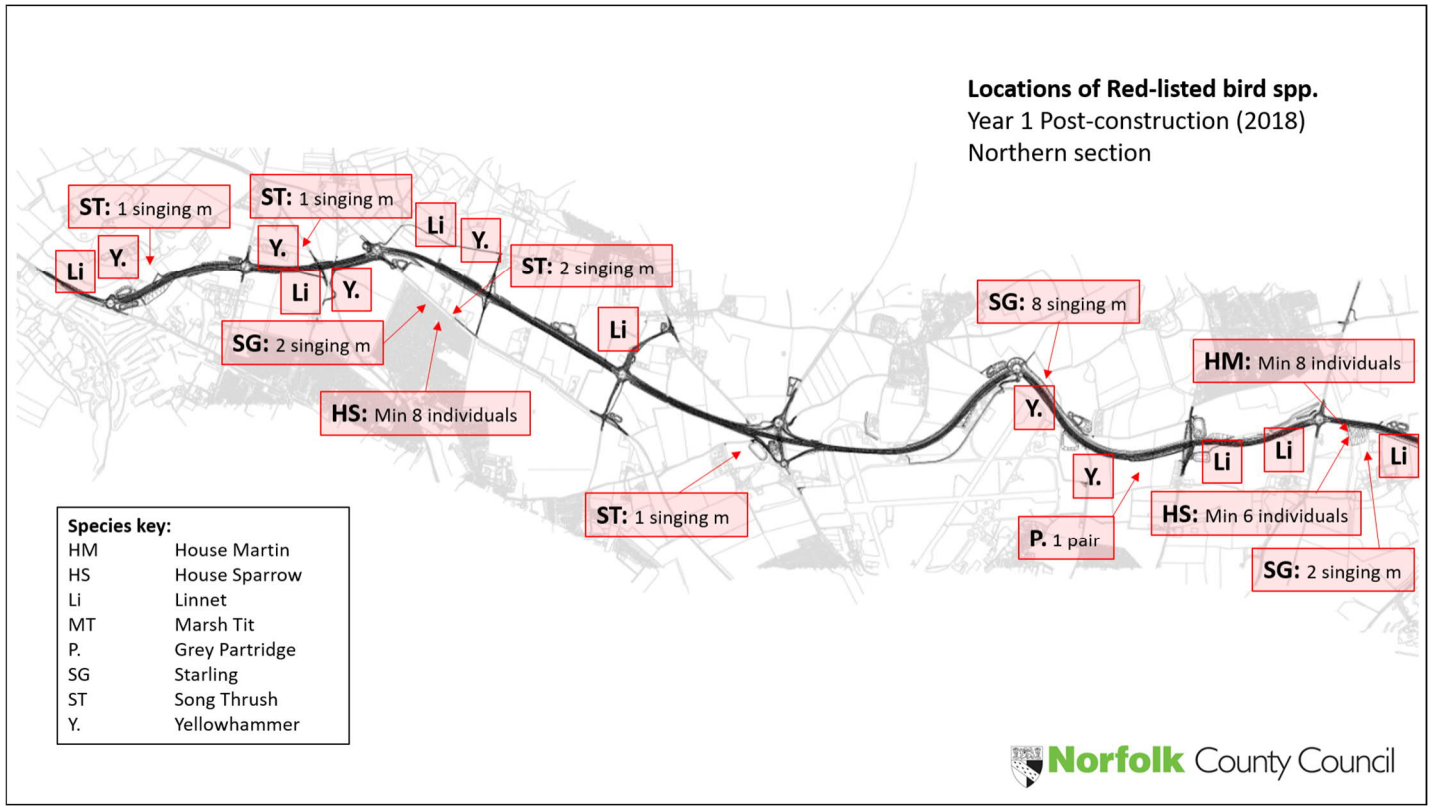
Source: Breeding Bird Survey: NDR – Year 1 Post-Construction (2018) Locations where 5-8 species showed behaviour indicative of breeding are marked by a yellow circle. Locations where >8 species showed behaviour indicative of breeding are marked with a red circle. The extent of the NDR scheme is shown in black.

Figure 24: Locations of 'Red-listed' bird species showing behaviour indicative of breeding in 2018; NDR Southern Section.



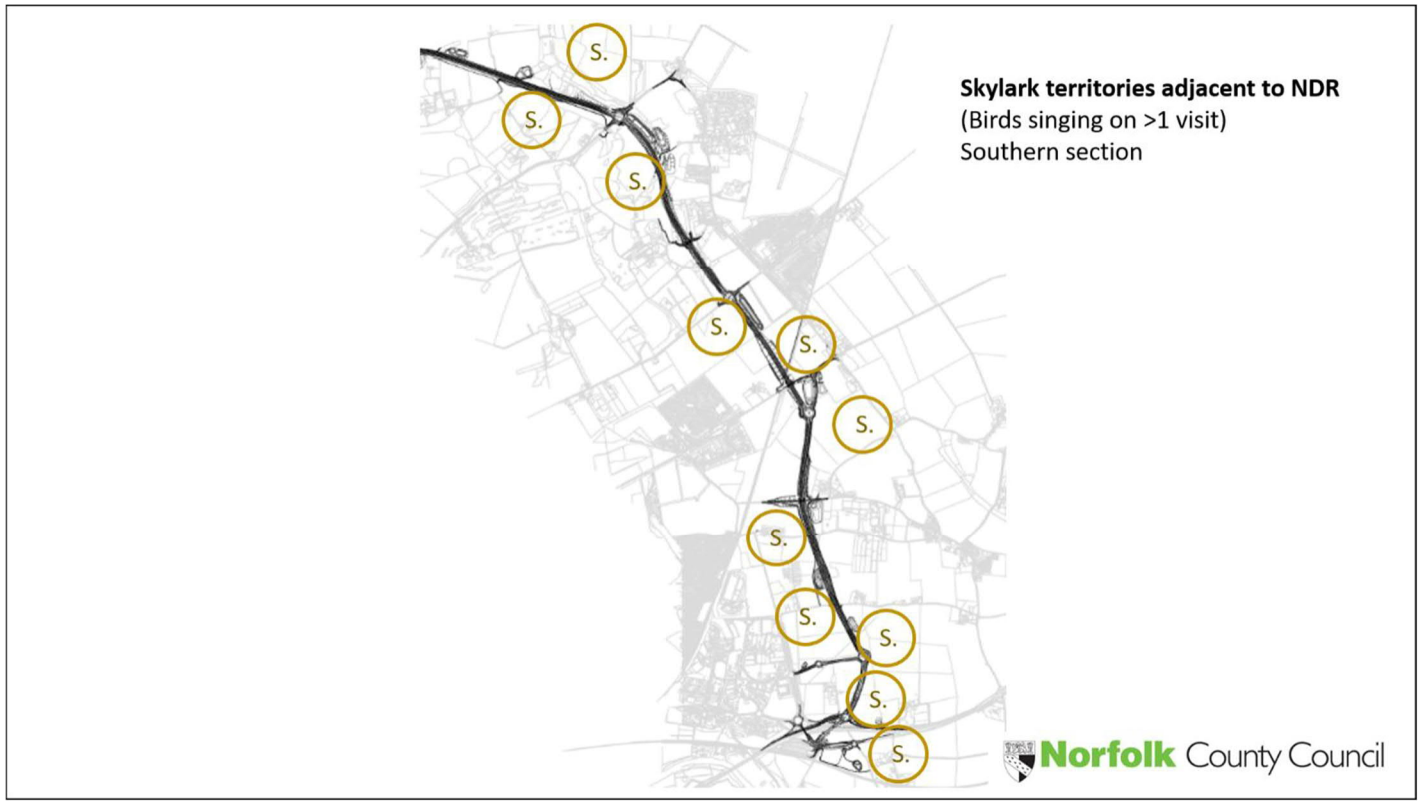
Source: Breeding Bird Survey: NDR – Year 1 Post-Construction (2018) For Starling and Song Thrush, the number of singing males is shown. For House Sparrow and House Martin, the minimum number of birds present on any single visit is recorded. For Linnet and Yellowhammer, the location is shown where birds were observed holding territory on >1 occasion. The locations where a single Redwing and a single Yellow Wagtail were observed are also shown, although it is not considered these individuals were breeding. Note: Skylark records are omitted from this Figure as they are shown in Figure 5. The extent of the NDR scheme is shown in black.

Figure 25: Locations of 'Red-listed' bird species showing behaviour indicative of breeding in 2018; NDR Northern Section.



Source: Breeding Bird Survey: NDR – Year 1 Post-Construction (2018) For Starling and Song Thrush, the number of singing males is shown. For House Sparrow and House Martin, the minimum number of birds present on any single visit is recorded. For Linnet and Yellowhammer, the location is shown where birds were observed holding territory on >1 occasion. Note: Skylark records are omitted from this Figure as they are shown in Figure 5. The extent of the NDR scheme is shown in black.

Figure 26: Location of Skylark Territories in 2018; NDR Southern Section.



Source: Breeding Bird Survey: NDR – Year 1 Post-Construction (2018) Locations are marked where singing males were heard on more than one occasion. Skylarks are a 'red-listed' species. The extent of the NDR scheme is shown in black.

Figure 27: Location of Skylark Territories in 2018; NDR Southern Section.

Source: Breeding Bird Survey: NDR – Year 1 Post-Construction (2018) Locations are marked where singing males were heard on more than one occasion. Skylarks are a 'red-listed' species. The extent of the NDR scheme is shown in black.

Comparison with baseline survey: Red-list species

The results of the 2018 breeding bird survey are broadly similar to the baseline survey. Breeding evidence was identified for a total of 55 species compared to 61 species in the baseline survey. The species for which evidence of breeding was found in the baseline survey but not the 2018 survey were:

- Kestrel
- Mute Swan
- Stock Dove
- Tufted Duck
- Coot
- Spotted Flycatcher
- Cuckoo

Neither the Cuckoo nor the Spotted Flycatcher were observed in 2018. The baseline survey recorded two Cuckoos (although breeding was only considered 'possible') and a single confirmed breeding of Spotted Flycatcher. The other species were recorded in 2018 but no evidence of breeding was identified.

The 2018 survey recorded two species showing evidence of breeding that were not recorded in the baseline survey, the Grasshopper Warbler and the Grey Partridge.

A comparison of the Red-listed species between the two surveys is shown in Table 20. Six species showed an increase in breeding numbers, one markedly so, whilst 5 species showed a decrease. For two species, Song Thrush and Yellowhammer, the decrease was large. The difference in Skylark numbers probably reflects the way they were recorded.

Table 18: Comparison of breeding Red-listed species between the 2018 and the baseline surveys

Red-list species	2018 survey	Baseline survey	Change
Cuckoo	Nor recorded	Max 2 birds recorded	Decrease
Grasshopper Warbler	1 singing male	Not recorded	Increase
Grey Partridge	1 pair	Not breeding	Increase
House Sparrow	4 colonies	3 singing males	Probable increase
Linnet	13 singing males	10 singing males	Increase
Marsh Tit	4 singing males	2 singing males	Increase
Skylark	25 territories	156 singing males	Decrease
Song Thrush	10 singing males	22 singing males	Marked decrease
Spotted Flycatcher	Not recorded	1 pair	Decrease
Starling	17 singing males	4 singing males	Marked increase
Yellowhammer	9 singing males	34 singing males	Marked decrease

Source: Breeding Bird Survey: NDR – Year 1 Post-Construction (2018)

Comparison with baseline survey: Breeding hotspots

A comparison of Hotspots for breeding birds before and after the construction of the road showed a similar pattern. Although some pre-construction hotspots were lost directly to the road, notably an area north of Beeston Park and one north of Thorpe Marriott, there was still relatively high numbers of breeding species in the nearby areas post-construction.

However, the way in which hotspots were identified was different between the two surveys. It is possible that the 2018 hotspots, whilst still the areas with the greatest breeding evidence, may have supported fewer individuals than the hotspots in the baseline survey. A clear example is at the western end of the road, where the area adjacent to the Marriott's Way to the south of the road qualified in 2018 as a hotspot with 6 species showing evidence of breeding. However, abundance levels were low, with only 8 pairs of birds involved. This area would not have shown as a hotspot in the analysis of the baseline survey.

Discussion of differences pre and post-construction

For bird species in the UK there are identified long-term trends for population change (British Trust for Ornithology, 2018b). In addition to the background population trends, there is frequently between-year variation in breeding numbers. This is due largely to weather conditions at critical times in the birds' lifecycles affecting adult survival, fledging rates, dispersal etc (Woodward et al., 2018). Given the above, the results of the 2018 survey must be seen in context; any observed changes in the abundance or density of breeding birds could just be as a result of weather or long-term environmental change, as much as they could be attributable to the road construction.

The 2018 breeding bird survey commenced almost immediately construction had finished. Some earth-moving and other activities associated with construction continued for a period of several weeks after this. Furthermore, the landscaping planting was incomplete and the specimens that were planted were very small and young. Unsurprisingly, the majority of the birds recorded were using habitats that were present before the road was constructed, in areas peripheral to the construction zone. Few birds were utilizing the recently planted and landscaped areas of the road itself.

The Red-listed species that are considered in this report are all, with perhaps the exception of Grasshopper Warbler, readily detectable species. It is considered reasonable to assume that they would have been equally detectable in both the baseline and the 2018 surveys. Therefore, and with the caveats described above in mind, the differences in abundance of the Red-listed species pre and post-construction is considered below.

Species showing apparent increases

Grasshopper Warbler and Grey Partridge showed evidence of breeding in 2018, although only as a single singing male and a pair in suitable habitat respectively. These species occur at low densities in much of Norfolk, and it may only be a matter of chance that they were present in the ZOI in 2018 but not in the baseline survey.

The numbers of singing Starlings increased between the two surveys. At Quaker Farm alone, there were more singing males (8) than on the whole corridor in the baseline survey (4). It may be this site has become more attractive for Starlings in the period between the surveys, although it is also possible that the particular location concerned was not visited for the baseline survey. Similarly, it is also possible that the location of the singing Starlings at Beeston Park may have been outside the ZOI for the baseline survey.

The increases in numbers of singing males of House Sparrows, Linnets and Marsh Tits are small and, without evidence to the contrary, are simply likely to reflect natural variation in breeding numbers between years.

Species showing apparent declines

Cuckoo and Spotted Flycatchers were recorded in the baseline survey as a single male and a single pair respectively. Both species are in decline nationally and, in a Norfolk context they

have declined markedly in the last 5 years. It is possible they have been lost from the general area north of Norwich, although this is not necessarily directly attributable to the road.

The decrease in singing Yellowhammer may be due to the direct loss of hedgerows as a result of road construction, or an indirect effect of a reduction in field size. However, their apparent decrease might also be - in part - an artefact of recording. Isolated cross-field hedgerows may not have received the same level of survey effort in 2018 as previously. The NDR has provided some 26kn of new hedgerow which in time should provide additional habitat for hedgerow nesting species.

There was an apparent decrease in the number of singing Song Thrushes between the surveys. This species is generally vocal and hard to miss in the Spring, so the decrease in numbers is likely to be real. It may be this species has declined or moved out of the area as a result of the road construction (disturbance would have continued over more than two years), or perhaps an increase in traffic noise or other disturbance once the road was operational has meant birds have moved. However, the decrease could also reflect a regional or national pattern of reduced numbers of Song Thrush in the survey year.

It is considered probable that the way in which singing Skylarks were recorded was different between the surveys. In the 2018 survey, attention was paid to identify territories by interpreting data derived from all visits, rather than just recording birds singing. Also, the detectability of Skylarks is greater than for many species and in 2018, only birds heard calling from over (i.e. within) the road corridor were included in the analysis. Birds heard from within the survey corridor but utilising land outside the corridor were excluded from the analysis. The road certainly removed some suitable Skylark habitat, but the difference in data collection and analysis between the surveys, probably means an accurate comparison of Skylark territories before and after construction is not possible.

4.4.4.4 Conclusion

The 2018 survey results are a snapshot in time of the breeding birds in the corridor of the NDR. In terms of the species of highest conservation concern, there was a strong similarity in the number and abundance of breeding Red-listed species present pre and post construction. Whilst broad patterns may be observable in the data, long-term trends and the natural between-year variation means it is difficult to attribute any observed changes to any factor, either environmental or as a result of the construction of the road.

The survey commenced almost immediately the road opened and while some construction activities continued. The landscaping was also very immature. The breeding bird surveys will be repeated in the years 2019, 2020, 2021 and 2022 in accordance with the DCO, and the breeding bird situation will be monitored as the setting of the road matures.

4.4.5 NDR Ecological Post-Construction Monitoring – Barn Owl boxes

4.4.5.1 Introduction

Pre-construction barn owl survey

The pre-construction field work in 2013 was undertaken to identify potential and confirmed nest, roost and rest sites and resource utilisation distribution within the ZOI using a protocol based on Project Barn Owl which was carried out by the BTO during the mid-nineties (Toms et al, 2001, cited in Mott MacDonald, 2013). The ZOI is defined by Chartered Institute of Ecology and Environmental Management (CIEEM) as the areas/resources that may be affected by the biophysical changes caused by activities associated with a project.

A single surveyor during the winter visited all areas within 250m of the proposed route and noted any sites that appeared suitable for a barn owl to roost or nest in. Barn Owl nest site records were included in the analysis, but the specific geographical location details were not provided. Presence/absence and breeding status data was obtained from local recorders and record centres. In addition, incidental Barn Owl records were obtained from Mott MacDonald ecology surveyors who were undertaking other surveys for the NDR scheme and records from the pre-construction breeding bird surveys.

Based on Barn Owl habitat preference, the habitat quality along the proposed route was categorised according to Mott MacDonald (2004) (as cited in Mott MacDonald 2013) to assess its value for Owls.

Kernel density estimation in Quantum GIS (QGIS) 1.8.0 (Quantum GIS Development Team, 2013, as cited in Mott MacDonald 2013) was used to generate a utilisation distribution (UD) illustrating the intensity of resource use by Barn Owls.

A total of 256 potential sites were found along the proposed route. Six occupied breeding sites and three roost or rest sites identified within the ZOI.

Based on the records collected in the study it was found likely that the home ranges of at least six breeding pairs overlapped with the ZOI, which was considered likely to equate to at least 1% of the county population. The proposed route was found to contain habitat that ranges from negligible to high quality and would be suitable for habitat enhancement.

It is considered that there is a potential for barn owls to be killed if crossing roads where vehicle speeds exceed 40 miles an hour (Shawyer and Dixon, 1999). There is a high proportion of young birds among road casualties, and it is therefore considered that inexperienced barn owls are disproportionally affected by road schemes. The standard approach to compensation is therefore to provide new nesting opportunities away from the road to ensure that the local population of barn owls can be maintained at similar levels to pre-construction, albeit that territories will be located in slightly different places.

The Barn Owl survey report (Mott MacDonald, 2013) recommends that where practicable nest boxes would be provided in a series parallel to the proposed route at 2km intervals, located no closer than 1.5km from the proposed road (Shawyer, 2011). This is equivalent to approximately 10 boxes given that the proposed route is 20km long.

Post construction barn owl box checks

Barn Owl boxes were installed as a compensation measure in-line with the recommendations of the Barn Owl survey report (Mott MacDonald, 2013) along the NDR. In accordance with the ES and Requirement 7 of the DCO the nest boxes require monitoring to determine the success of this compensation measure post-construction.

Aims

To monitor the success of barn owl boxes as a compensation measure post construction of the NDR by carrying out barn owl nest box checks to identify occupancy.

Relevant legislation

Barn Owls are included in Schedule 1 of the Wildlife & Countryside Act 1981 which affords them protection against disturbance whilst nesting in addition to the basic level of protection afforded to most wild birds. Specifically, under Part 1, Section 1 (5) it is an offence punishable with imprisonment for a period of up to 6 months to intentionally or recklessly:

- Disturb a Barn Owl while it is building a nest or is in, on or near a nest containing eggs or young.
- Disturb a Barn Owl's dependent young.

4.4.5.2 Methodology

Field methodology

The Barn Owl nest box visits were undertaken on the 1st August 2018 during dry and sunny weather. The field methodology involved a licenced surveyor checking the eight Barn Owl nest boxes for evidence of Barn Owls in a single day.

The Barn Own boxes had been positioned on mature trees in the following locations:

- A single Barn Owl box (approximately 1.37km north of the NDR) was installed at Woodland View School.
- Two Barn Owl boxes (approximately 2.34km north of the NDR) were installed at Taverham Mill.
- Two Barn Owl boxes (approximately 5.59km north of the NDR) were installed at Loke Farm.
- Two Barn Owl boxes were installed (approximately 4.72km north of the NDR) at Bluebell Burial Park
- One Barn Owl box (approximately 9.46km north of the NDR) was installed at upper Barn Farm, Reepham.

Barn Owl occupation was characterised in accordance with best practice guidance (Shawyer, August 2011) as follows:

- Active Roost Site (ARS) is defined as a place at which breeding does not occur, but where the bird is seen or heard regularly and/or there is evidence in the last 12 months of presence.
- Occupied Breeding Site (OBS) is defined a place where breeding was taking place or where it had done so in the recent past.

Personnel

The Barn Owl nesting checks were undertaken by Danny Thomas, a surveyor with over 20 years' post graduate experience of ecological services. Danny holds a licence for Schedule 1 birds and he also holds a bird ringing licence through the British Trust for Ornithology.

4.4.5.3 Results

Five of the eight Barn Owl boxes were inspected for evidence of Barn Owl activity. One of the five Barn Owl boxes inspected was considered an ARS. There was no evidence of barn owl activity at the other four inspected boxes.

Woodland View School

It was not possible to inspect the Barn Owl box at Woodland View School due to access issues.

Taverham Mill

The Barn Owl box located furthest south (Figure B28 in NDR OYA Report Appendix B) had been detached from the tree (possibly due to strong winds or the box not being secured correctly) and this box was therefore not inspected. Evidence of stock dove and wood pigeon in the form of feathers was found in the box located furthest north (Appendix A, Photograph 1).

Three additional boxes had been supplied for installation at this location but were not yet installed. No evidence of Barn Owl activity was recorded.

Loke Farm

The box located furthest west on the site (Figure B29 in NDR OYA Report Appendix B) was in use by an adult stock dove which was seen flying from the box. No evidence of nesting was found in the box furthest east (Figure B30 in NDR OYA Report Appendix B). Evidence of Barn Owl activity was identified in the box in the form a single pellet and therefore this nest box is considered an Active Roost Site (ARS). An individual Barn Owl has likely used the box on at least a single occasion for roosting.

Bluebell Burial Park

Stock dove chicks were found in the two barn owl boxes at Bluebell Burial Park (Figures B32 and B33 in NDR OYA Report Appendix B). No evidence of Barn Owl activity was recorded.

Upper Barn Farm, Reepham

The Barn Owl box at Upper Barn Farm (Figure B34 in NDR OYA Report Appendix B) was not accessible. It should be noted no evidence of Barn Owl use was visible from an external inspection of the box and the location of the Barn Owl box in the garden of Upper Barn Farm was not considered ideal to encourage uptake by Barn Owls. This box is also located a vast distance of approximately 9.45km from the NDR.

4.4.5.4 Conclusion

Of the five Barn Owl boxes inspected a single box at Loke Farm was considered an ARS. There was no evidence of Barn Owl activity at the other four inspected boxes. It was not possible to inspect three of the boxes. At this point, it is not possible to determine the success of the Barn Owl nest boxes as a compensation measure.

The Barn Owl survey report (Mott MacDonald, 2013) stated nest boxes should be provided in a series parallel to the proposed route at 2km intervals and these should be placed no closer than 1.5km from the proposed road (Shawyer, 2011). This is equivalent to approximately 10 boxes given that the proposed route is 20km long. However, due to the difficulty in finding suitable locations and willing landowners, only 8 boxes have been erected along the route at 2km intervals.

Several of the Barn Owl boxes were installed further than 5km from the road. For example, the box at Upper Farm Barn was located a vast distance of approximately 9.45km from the NDR. Given that a typical winter barn owl home range is approximately 5000m radius and during the breeding season this is considered to be between 1km and 1.5km from a nest site (Shawyer, 1990 in Shawyer 2011 as cited in Mott MacDonald, 2013) the boxes may not be located near enough to the home ranges of Barn Owls territories affected by the NDR, but it is recognised that some provision is better than nothing.

A further three Barn Owl boxes could be erected in suitable locations along the route, and any boxes that have been damaged should be repaired.

4.4.6 NDR Ecological Post-Construction Monitoring – Aquatic invertebrate and Desmoulin's whorl snails

4.4.6.1 Introduction

Abrehart Ecology was commissioned by NCC to assess the diversity of aquatic invertebrate species and presence/absence of Desmoulin's whorl snails (Vertigo moulinsiana) following development works undertaken as part of the NDR. The survey acts to highlight/monitor the abundance of species of conservation interest that may have been impacted by pollutants and run-off during construction works.

The Springs Lake CWS is located approximately 1km north-west of Rackheath in Norfolk and is bordered to the south by the A1270 (the Norwich NDR). The sample sites were located around the lake, within tributary streams, and throughout surrounding terrestrial habitats.

The aim of the survey detailed in this report was to monitor aquatic invertebrate and mollusc diversity following development works (measured against baseline surveys). This can then be used to inform mitigation, future monitoring, and assist the effective management of the site. The main survey objectives were to provide information on:

- Species richness (of macro-invertebrates);
- Species abundance (of macro-invertebrates); and
- The continued presence and extent of any species of conservation interest, such as Vertigo moulinsiana.

Figure 28: Location of survey area

Source: Aquatic invertebrate and Vertigo moulinsiana report Northern Distributor Road: Year 1 Post-construction Survey 2018

4.4.6.2 Methodology

Sampling points were distributed around The Springs CWS, as close as possible to sample locations used in the baseline surveys conducted by Mott MacDonald. Sample collection was undertaken by a pair of surveyors, including an experienced on-site surveyor (Toby Abrehart) and two team members responsible for recording botany, habitat characteristics, and water body features (David White and Charlotte Keightly of NCC). All of the sampling was undertaken in November 2018.

Aquatic invertebrate sampling

Six sweep samples were collected using ten-second sweeps of a net with 0.5mm mesh. Sweeps were repeated three times in different sections of the ditch profile, i.e. floating vegetation (where present), the benthic layer and the submerged edge of the nearside bank. Once collected each sample was placed into a 5-litre bucket and preserved in 99.9% ethanol for long-term storage.

Dredge samples were taken using a trawling method. A trawl net was lowered to the river channel substrate then towed slowly through the upper layers of the sediment, for approximately 10-20m, behind a slow-moving boat. Only sections of the lake that were deeper than 1m were

trawled. At the end of the trawl, the net was raised to the water surface wherein any excess sediment was removed, and molluscs were emptied into a white plastic survey tray. Specimens (alive and dead) were identified in the field (by an experienced surveyor) and then returned to the lake.

For identification, all invertebrates were separated from the retained sediment, detritus and vegetation under 40 - 80x stereo, binocular microscopes. All specimens were then separated into major taxonomic groups, preserved in fresh 99.9% ethanol, and referred to an appropriate taxonomist for identification.

Where possible, all specimens were identified to species level. Exceptions to this are groups that require specialist, time-consuming preparatory techniques such as head capsule dissection for chironomid larvae and prolonged clearing procedures for oligochaetes species. Such procedures are beyond the remit of this study.

Mollusc sampling

Non-destructive sampling techniques were used at each selected sample point. A white plastic tray was held near the base of the vegetation and the vegetation was bent over the tray and shaken vigorously. The samples were analysed quantitatively in the field. Specimens of Vertigo moulinsiana were recorded as adults or juveniles. Those with a developed lip and apertural teeth were counted as adults and others as juveniles.

Assessment of habitat characteristics

At each sample location ground moisture and vegetation structure were recorded. Ground moisture levels were recorded using a scale of 1-5, using the following criteria (suitable ground moisture levels for Vertigo moulinsiana are between 3-5):

1. Dry: no visible moisture on ground surface;
2. Damp: ground visibly damp, but water does not rise under pressure;
3. Wet: water rises under light pressure;
4. Very wet: pools of standing water, generally less than 5cm deep; and,
5. Site under water: entire sampling location is in standing or flowing water over 5cm deep.

The average height (in metres) of the main vegetation components within the sample (before beating) was measured using a 2m ruler. The measurement was used in the condition assessment and provided valuable information for assessments. The dominant plant species were recorded and other plant species within the sample were noted.

Thatch depth (measure in centimetres) and percentage canopy cover were also noted. Thatch is a loose, organic layer of dead and living shoots, stems, and roots which is essential for a number of mollusc species.

SAFIS analysis

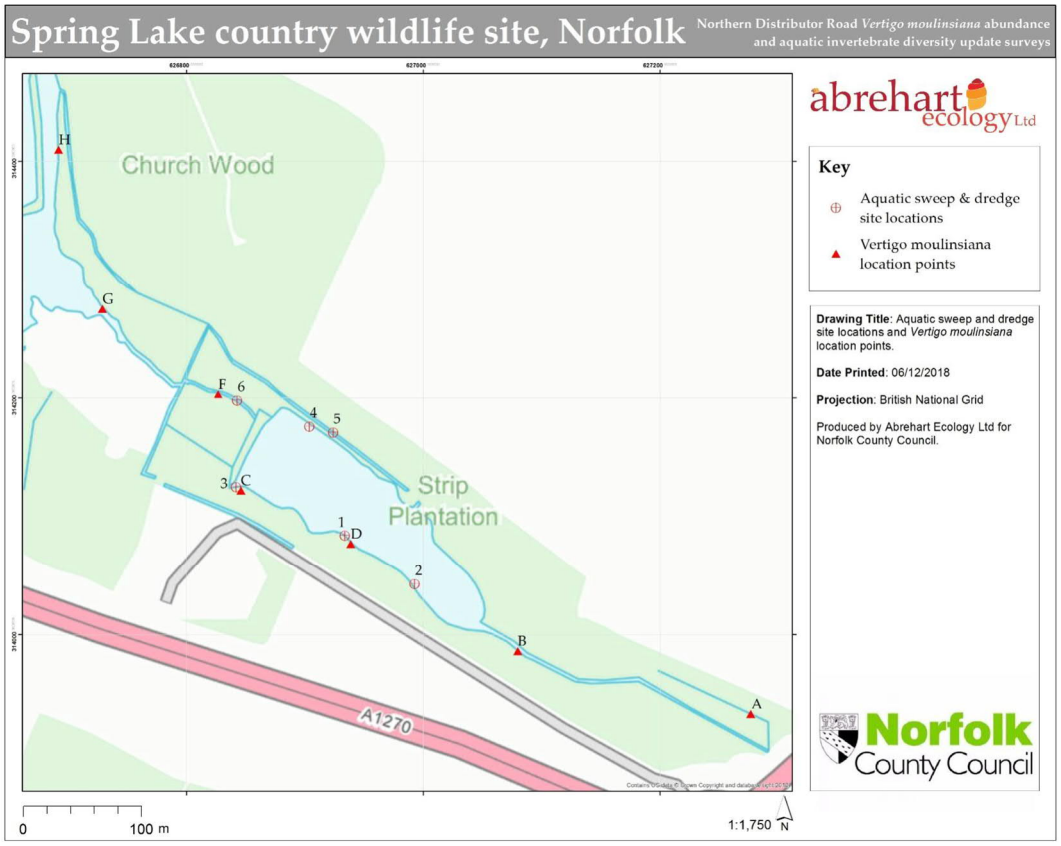
Data collected during the surveys were processed using SAFIS analysis (Site Analysis for Freshwater Invertebrate Surveys v.30.0). This was used to give an indication of the current conservation value of the The Springs, to assess water quality, and to highlight any species of conservation interest already present.

Limitations

Species within the orders Hirundinea (leeches) and Tricladida (flatworms) can be affected by preservation in ethanol (damage to eyes and genital pores – often key features of identification).

During future monitoring surveys, samples should be preserved using preservatives such as Bonuin's or Fleming's fixative, as recommended by Elliott & Mann (1998) among others.

Figure 29: Location of sampling points along the NDR



Source: Aquatic invertebrate and Vertigo moulinsiana report Northern Distributor Road: Year 1 Post-construction Survey 2018

4.4.6.3 Results

Aquatic Macro-invertebrates

Aquatic invertebrate sweep samples were collected at 6 survey points in total around the lake at The Springs CWS and associated streams (Figure 2). Dredge samples were undertaken at four of these locations (Sample Sites 1-4). The water depth was 1m deep around the lake margin, with the water depth increasing towards the middle of the lake. The water column was dominated with Ceratophyllum demersum around the entire site. Making getting to the muds more difficult to access. The margins of the lake were firm with gravels with a deeper layer of sediment the further out in to the lake. The bank of the lake was steep sided with numerous fishing platforms scattered around the site. The stream channel started narrow in the east of the site with a 1m wide channel and a 50cm drop into the limited water. This stream connected to the outflow from the lake. Here the stream increased in size and became wider and shallower. Sediment settled out in the stream bottom creating a deep sediment layer with limited water depth. In the wood there was a large amount of leaf litter in the stream. This stream then proceeded to the west and entered another smaller lake.

No Annex II, Species of Principle Importance in England under Section 41of the NERC Act 2006, or Red Data Book species were recorded during the survey. Seven species listed as 'Local' by SAFIS were identified, these are listed in Table 1 below and described in Section 3.3.

Two invasive species, the amphipod Crangonyx pseudogracilis and the mollusc Potamopyrgus antipodarum were found to be widespread throughout the survey area.

In total, at least 84 taxa of aquatic invertebrates were recorded during the update/monitoring surveys; of which, 68 were identified to species. The overall species richness of aquatic invertebrates varied from a minimum of 22 taxa to a maximum of 34 taxa in a sample. Areas of high overall species richness were predominantly found at the western end of the survey area, corresponding with a generally improved water quality. Full species lists for each sampling point are provided in the appendices.

Table 19: Notable species found during OYA surveys

Local
Bithynia leachii
Erythroma najas
Ilyocoris cimicoides
Noterus clavicornis
Notonecta maculata
Notonecta viridis
Plea minutissima

Source: Aquatic invertebrate and Vertigo moulinsiana report Northern Distributor Road: Year 1 Post-construction Survey 2018

Desmoulin's Whorl Snail – *Vertigo Moulinsiana*

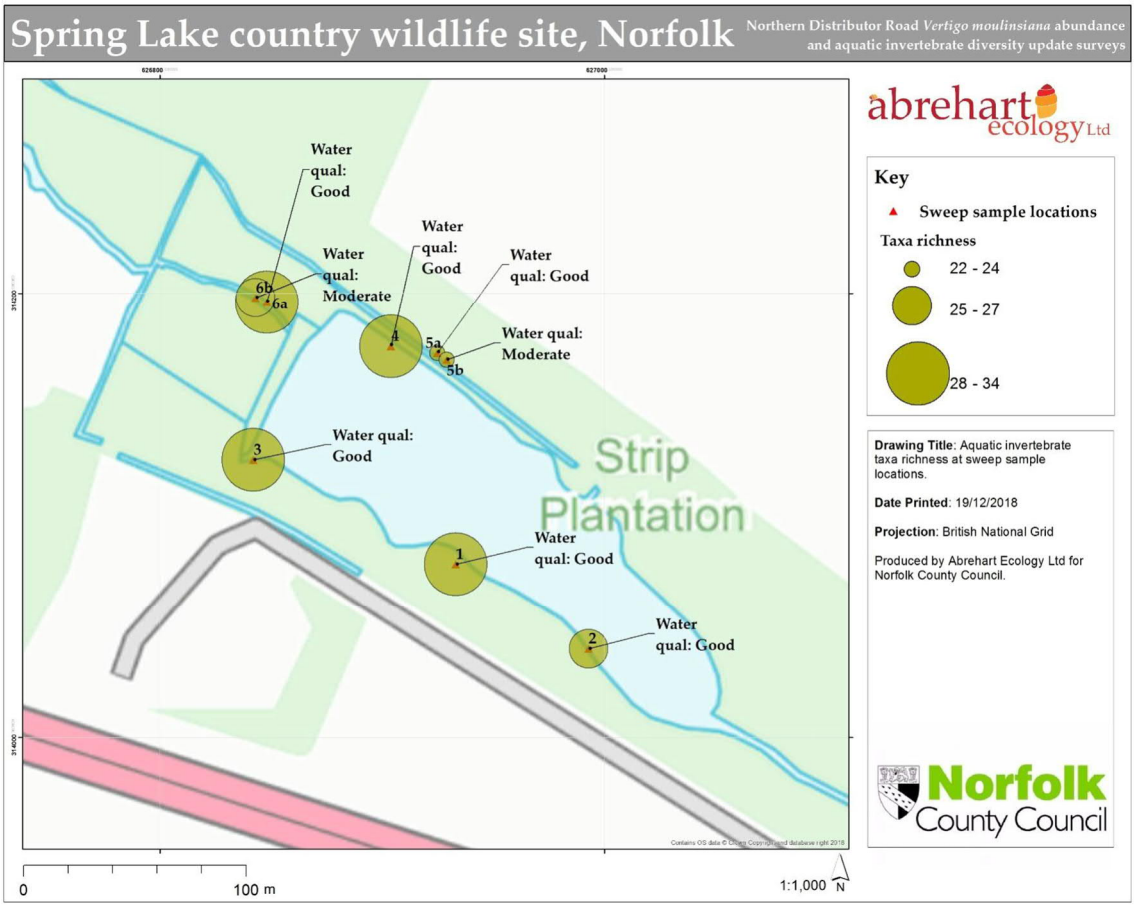
Mollusc diversity was assessed according to both species richness (the number of different mollusc species present at a sample point) and the number of species of conservation interest present. Full species lists are presented in Appendix B.

Ten mollusc species were found in total across the site. Species richness varied across the site from zero to five species in a single sample, with an average of 2.03 mollusc species per sample. The highest levels of mollusc species richness were generally observed in the south-eastern portion of the site. The lowest levels of mollusc species richness (0 or 1 species per sample) were observed at the western and southern sections of the survey area (points C1 and F1 had no animals recorded).

There was no clear relationship between mollusc species richness and any habitat variables, despite considerable variation moisture levels and shading across the site.

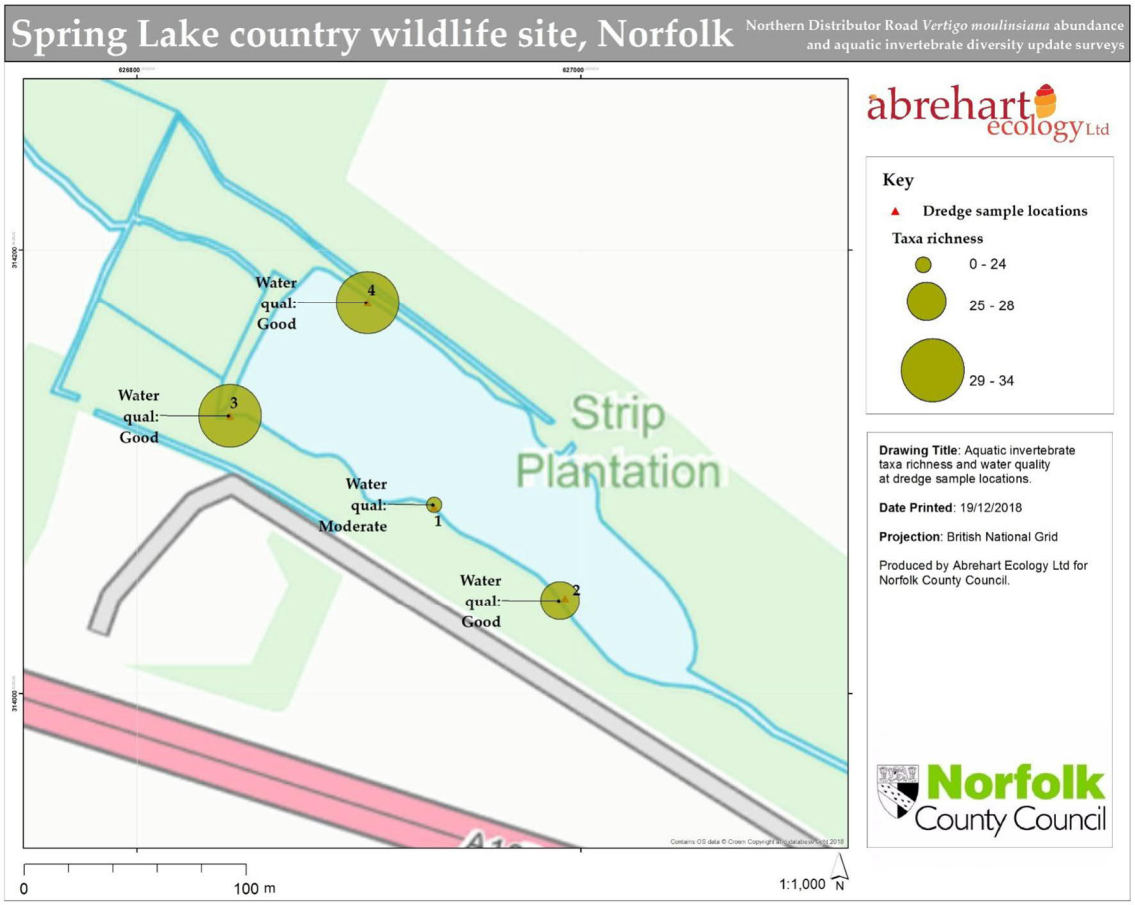
No Red Data Book-listed mollusc species were found during this survey.

Figure 30: Species richness and water quality of aquatic invertebrates in sweep samples across the survey area



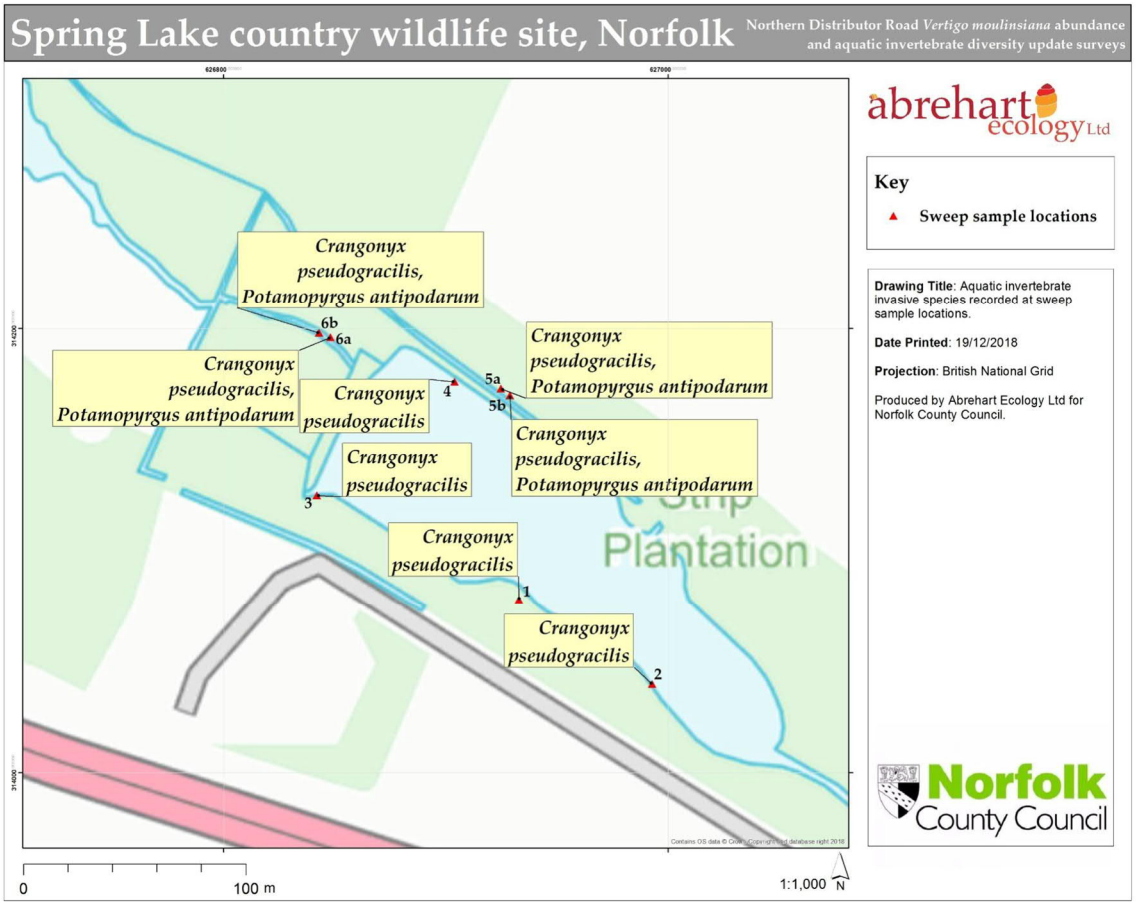
Source: Aquatic invertebrate and Vertigo moulinsiana report Northern Distributor Road: Year 1 Post-construction Survey 2018

Figure 31: Species richness and water quality of aquatic invertebrates in sweep samples across the survey area



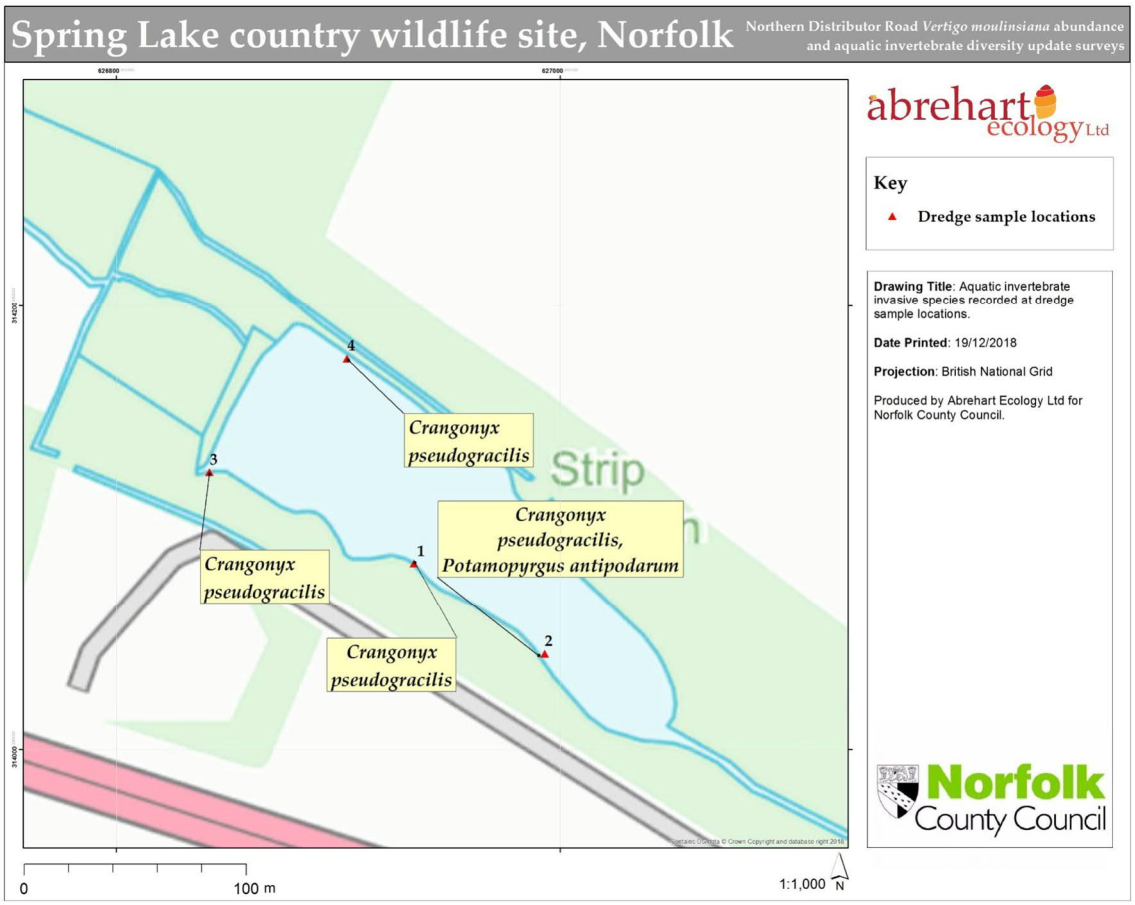
Source: Aquatic invertebrate and Vertigo moulinsiana report Northern Distributor Road: Year 1 Post-construction Survey 2018

Figure 32: Distribution of invasive aquatic invertebrate species within sweep samples



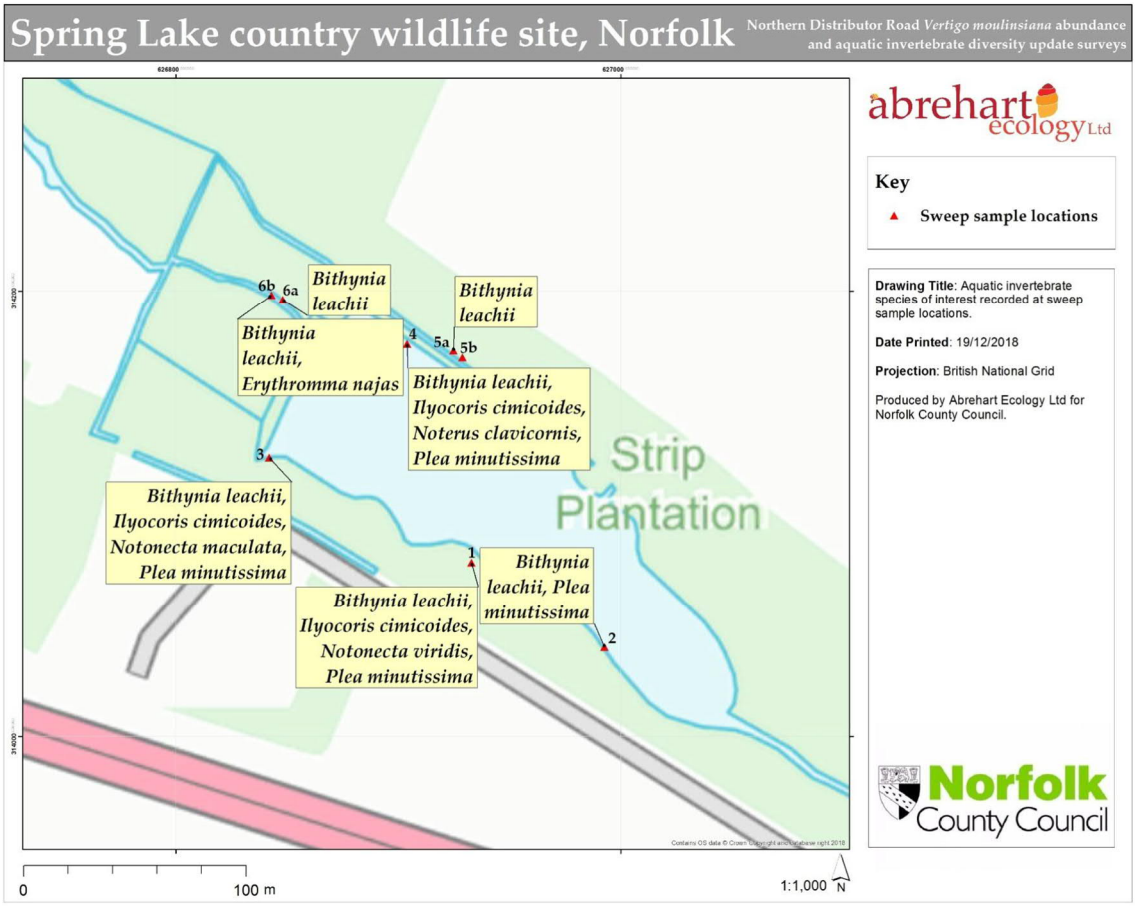
Source: Aquatic invertebrate and Vertigo moulinsiana report Northern Distributor Road: Year 1 Post-construction Survey 2018

Figure 33: Distribution of invasive aquatic invertebrate species within dredge samples



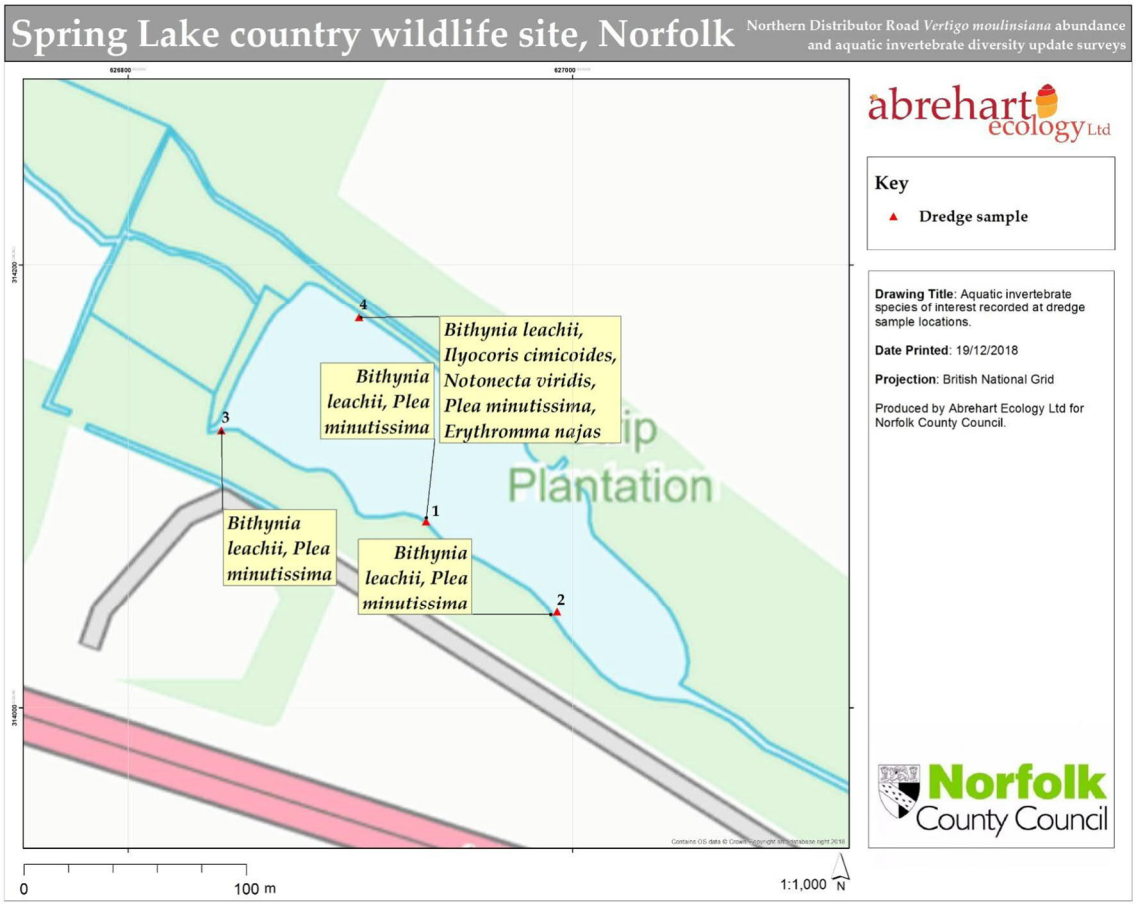
Source: Aquatic invertebrate and Vertigo moulinsiana report Northern Distributor Road: Year 1 Post-construction Survey 2018

Figure 34: Distribution of 'Local' aquatic invertebrate species within sweep samples.



Source: Aquatic invertebrate and Vertigo moulinsiana report Northern Distributor Road: Year 1 Post-construction Survey 2018

Figure 35: Distribution of 'Local' aquatic invertebrate species within dredge samples.



Source: Aquatic invertebrate and Vertigo moulinsiana report Northern Distributor Road: Year 1 Post-construction Survey 2018

Macro invertebrates – Sample site 1

- Both a sweep and dredge sample were taken. The sweep sample contained at least 34 taxa of aquatic invertebrates within the sample; of which 29 were identified to species. Animals from the orders Mollusca, Hemiptera, and Amphipoda dominated the sample, which included 115 *Plea minutissima* (pygmy backswimmer), 200 *Bithynia leachii* (Leach's bithynia), 150 *Bithynia tentaculata* (common bithynia), and 135 *Crangonyx pseudogracilis* (northern river crangonyctid).
- No species of interest were recorded within the sample; however, the 'local' species *Bithynia leachii, Ilyocris cimicoides* (great saucer bug), *Notonecta viridis* (a water boatman), and *Plea minutissima* were recorded – including very good numbers of *B.leachii* and *P.minutissima* as detailed above. The amphipod *Crangonyx pseudogracilis* is a non-native species, originating from North America.
- The dredge sample contained at least 24 taxa of aquatic invertebrates; of which 21 were identified to species. Amphipoda and Mollusca were again well represented and dominated the sample. Lower numbers of animals representative of the orders Bivalvia, Coleoptera, Diptera, Ephemeroptera, Hemiptera, Odonata, Rhynchobdellida and Trichoptera were also identified.

- The 'Local' species *Bithynia leachii* and *Plea minutissima* were recorded, along with the invasive *Crangonyx pseudogracilis*.

Macro invertebrates – Sample site 2

- Sweep Sample: At least 27 taxa of aquatic invertebrates were recorded, with 24 of these identified to species. *Bithynia tentaculata, Vqlvata piscinalis, and Crangonyx pseudogracilis* were the most abundant species within the sample. Lower numbers representative of Amphipoda, Diptera, Mollusca, Bivalvia, Megaloptera, and Odonata were also recorded.
- Two 'local' species: *Bithynia leachii* and *Plea minutissima* were identified within the sample.
- Dredge Sample: At least 29 taxa of aquatic invertebrates were recorded, with 25 of these identified to species. *Asellus aquaticus* (water hoglouse), *Bithynia tentaculata* and *Crangonyx pseudogracilis*) were the most abundant species within the sample (44, 165 and 224 respectively). Lower numbers representative of Amphipoda, Diptera, Mollusca, Bivalvia, Hemiptera, Megaloptera, Rhynchobdellida, and Odonata were also recorded.
- The 'Local' species *Bithynia leachii* and *Plea minutissima* were identified within the sample. A further invasive species, *Potamopyrgus antipodarum* (Jenkins' spire snail), was also identified.

Macro invertebrates – Sample site 3

- Sweep Sample: At least 34 taxa recorded; of which 26 were identified to species. Although taxa richness was high, no one species dominated the sample and lower numbers of animals were found – the specimen count for this sample was 284.
- Four 'local' species were identified: *Bithynia leachii, Ilyocris cimicoides, Notonecta maculata* (spotted backswimmer), and *Plea minutissima*. The invasive amphipod *Crangonyx pseudogracilis* was again recorded.
- Dredge Sample: At least 31 taxa were recorded, with 26 of these identified to species. Again, specimen count was lower at this sample site, with 299 animals recorded. However, this sample was dominated by species from the orders Amphipoda (including the invasive *Crangonyx pseudogracilis*), Bivalvia, and Mollusca.
- No species of interest were identified within the sample; however, the "Local" species *Bithynia leachii* and *Plea minutissima* were recorded.

Macro invertebrates – Sample site 4

- Sweep Sample: Sample Site 4 had at least 32 taxa of aquatic invertebrate were recorded, with 25 identified to species. The most common orders of aquatic invertebrate recorded were Amphipoda, Mollusca (particularly *Bithynia tentaculuata* and *Anisus vortex*), and Hemiptera.
- The 'local' species *Bithynia leachii, Ilyocris cimicoides, Noterus clavicornis* (larger noterus), and *Plea minutissima* were recorded within this sample. Again, the invasive species *Crangonyx pseudogracilis* was identified.
- Dredge Sample: At least 34 taxa of aquatic invertebrates were recorded, with 30 identified to species. Again, the sample was dominated by species from the orders Mollusca and Amphipoda – with particularly high numbers of *Bithynia tentaculata, Crangonyx pseudogracilis, Bithynia leachii*, and *Gyraulus albus* (white ramshorn).
- Although no species of interest were recorded, this sample did contain the highest number of 'Local' species (five). These were *Bithynia leachii, Erythromma najas* (red-eyed damselfly), *Ilyocris cimicoides, Notonecta viridis*, and *Plea minutissima.*

Macro invertebrates – Sample site 5

- Sweep A: At least 24 taxa of aquatic invertebrates were present within the sample, with 20 of these identified to species. Four species dominated the sample and accounted for much of

the total specimen count; these were *Asellus aquaticus* (175), *Pisidium henslowanum* (Henslow's pea mussel) (107), *Pisidium sp.* (501), and *Potamopyrgus antipodarum* (466).

- Only one 'local' species, *Bithynia leachii*, was recorded within the sample. *Crangonyx pseudogracilis* was again found at this location.
- Sweep B: This had the lowest taxa/species richness of the six sample sites; in total 22 taxa of aquatic invertebrates were recorded, with 15 of these identified to species. As well as reduced species diversity, Sweep B also had a much lower specimen count than Sweep A – 380 animals compared to 1357. Five species dominated the total specimen count, these were *Chironomidae sp.* (non-biting midges), *Asellus aquaticus, Pisidium sp*., *Potamopyrgus anitipodarum*, and *Ptychoptera sp*. (craneflies).
- There were no species of interest or 'local' species within this sample.

Macro invertebrates – Sample site 6

- Sweep A: At least 32 taxa of aquatic invertebrates were present within the sample, with 27 of these identified to species. The orders Mollusca, Bilvalvia, and Amphipoda dominated the sample – which had the second highest total specimen count (1544) – with four species particularly abundant: these were *Asellus aquaticus, Bithynia tentaculata, Pisidium sp*., and *Sphaerium corneum* (European fingernail clam).
- Only one 'local' species, *Bithynia leachii*, was recorded within the sample. *Crangonyx pseudogracilis* and *Potamopyrgus antipodarum* were again found at this location.
- Sweep B: This had the greatest specimen count of the sample sites, with 2132 animals recorded. A large proportion of these animals were comprised of species representative of the orders Mollusca, Bivalvia, and Amphipoda. The most numerous species within the sample were *Asellus aquaticus* (537), *Bithynia tentaculata* (224), *Pisidium sp*. (743), and *Sphaerium corneum* (185).
- The invasive species *P.antipodarum* (79 individuals) and *C.pseudogracilis* (91) were also abundant within the sample. No species of interest were recorded; however, the 'local' species *Bithynia leachii* and *Erythromma najas* were identified.

Vertigo moulinsiana – Sample site A

- This was the most species diverse sample site, with all samples supporting at least three species and up to five species recorded in a single sample (A4). *Succinea putris* (amber snail), *Deroceras reticulatum* (grey garden slug), and *Galba truncatula* (dwarf pond snail) were recorded in all five sub-samples. This was the only location in which *Vitrina pellucida* (pellucid glass snail) was recorded. This sample area had moderate levels of shading (50%), a moisture level of 1-3, and a thin thatch layer (1cm). The greatest species diversity coincided with the highest moisture level (moisture level of 3 at sample point A4).
- No species of interest were recorded.

Vertigo moulinsiana – Sample site B

- Species diversity was lower here; however, animals were recorded at all sub-sample points. The most abundant species within these samples was *Succinea putris*, of which there were 23 individuals in subsample B2. Shading was greater here (90%), the moisture level was consistently dry (always 1), and a thin thatch (1cm).
- No species of interest were recorded.

Vertigo moulinsiana – Sample site C

- Species diversity was variable at Sample Site C, with zero to three species recorded. The habitat ranged from 100% shaded sub-samples with dry, thin thatch (moisture level 1 and thatch of 1cm), to substantially wetter samples (moisture level 3) with similar high shading.

This was the only sample site that supported *Bithynia tentaculata* (common bithynia), a species typically associated with freshwater habitats.

- No species of interest were recorded.

Vertigo moulinsiana – Sample site D

- Sample Site D had consistently low numbers of species recorded within sub-samples – either one or two species found. The species recorded here were *Cepaea nemoralis* (brown-lipped snail), *Cepaea hortensis* (white-lipped snail), and *Deroceras reticulatum*. *C.nemoralis* was not recorded at any other sample site. This sample site had moderate shading (60%) but was uniformly dry across its extent – never more than a moisture level 1.
- No species of interest were recorded.

Vertigo moulinsiana – Sample site F

- Sample Site F had a range of species diversity recorded across the sub-sample survey area, ranging from zero to three species within a sample. All sample points had heavy shading (90%), a moisture level of 1 or 2, and a thin thatch (1cm). Sample Site F was the only area in which *Bathyomphalus contortus* (twisted ram's-horn) and *Oxychilus cellarius* (cellar snail) were recorded.
- No species of interest were recorded.

Vertigo moulinsiana – Sample site G

- This sample site had the most consistent species diversity across its subsample sites – with two species recorded at each. In total, four species were recorded at this site, with *Succinea putris* recorded at all four locations and often dominated the sample – with up to 13 individuals recorded in a single sample. Sample Site G had the lowest shading of all the sample locations (30%), was one of the wettest (moisture levels either 2 or 4), and had the thickest thatch layer (2cm at G3-5).
- No species of interest were recorded.

Vertigo moulinsiana – Sample site H

- This sample location had the fewest sub-samples taken (two) and was the wettest sample area (both sites had a moisture level of 4). Only two species were recorded here, *Succinea putris* – which was recorded in both samples – and *Zonitoides nitidus* (shiny glass snail) – which was only found in H1.
- No species of interest were recorded.

SAFIS analysis – Aquatic invertebrates

Full results from SAFIS are presented in Appendix A.

Water quality across the site was classed as Moderate or Good (Figures 3 & 4). The sample points considered to have Good water quality were located towards the central-eastern end of the survey area and generally coincide with the highest taxa richness (of aquatic invertebrates).

None of the sample sites supported species of conservation interest (according to SAFIS criteria this is defined as a species listed as Notable or above); however, eleven of the twelve sample sites supported 'Local' species.

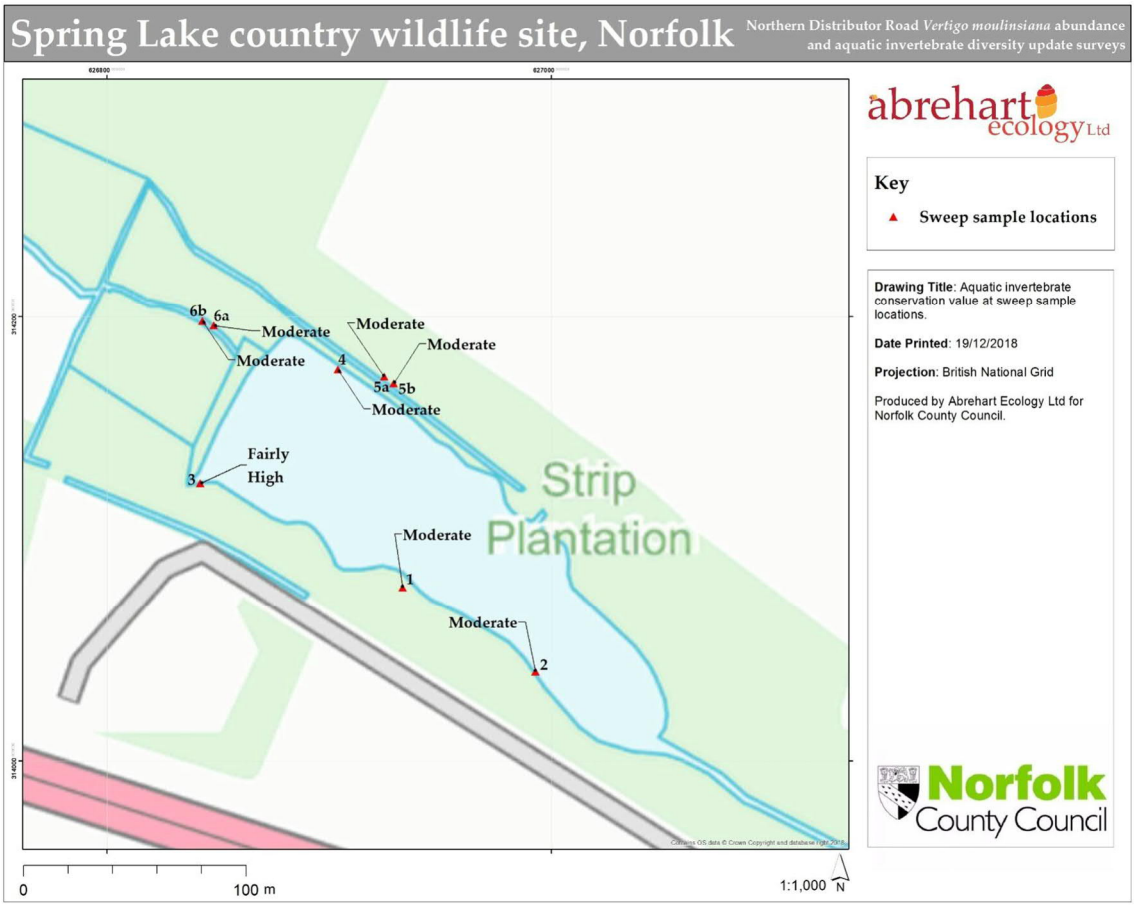
According to the CCI value produced by SAFIS, sample sites surveyed are of Moderate or Fairly High conservation importance (Figure 6), with the Fairly High sites coinciding with the presence of more locally important species. This assessment considers both the overall taxon richness at a sample site, and the presence of conservation priority species (for example rare species or species with limited distributions).

Rare and notable species

The six samples collected from The Springs lake held seven species considered locally important. The habitat requirements, and local and national status for each are briefly detailed below:

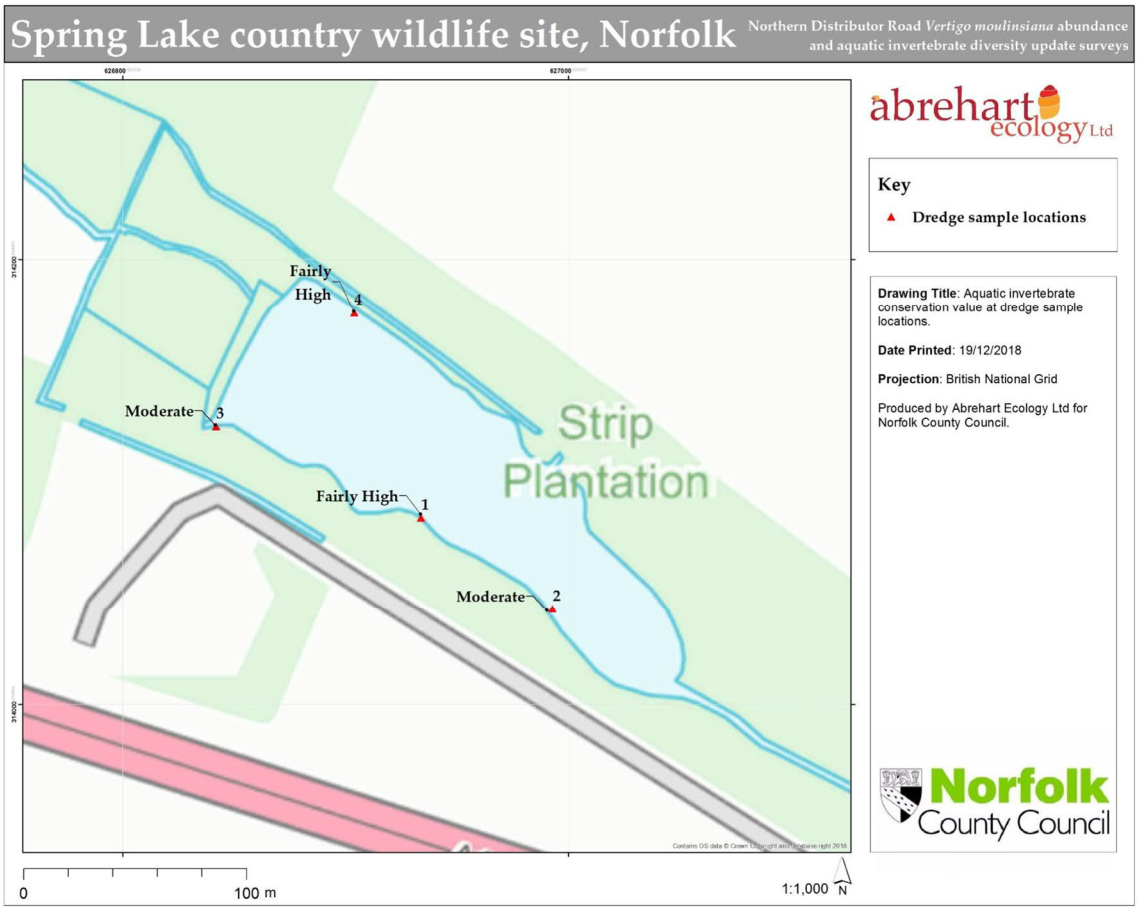
- *Bithynia leachii* (Sheppard, 1823) - Found in slow-moving waters, but generally restricted to calcareous lowland with a high diversity of species (often found alongside *Bithynia tentaculata*). Water bodies supporting *B.leachii* are usually less than 3m deep. It is often found in marshland dykes, canals, and canalised rivers – it is rarely found in ponds and lakes. Although frequent over its English range, it is showing evidence of local decline.
- *Erythromma najas* (Hansemann, 1823) - Associated with floating leaves – predominantly water-lilies, amphibious bistort, and pondweeds (which are important for egg laying) – in large ponds, lakes, flooded mineral workings, canals, large drains, and slow-flowing rivers. It is restricted to southern and central England and the Welsh border area, with smaller populations in Devon and south Wales. It may be at risk from over-clearance of ditch vegetation, which would remove important emergent/floating vegetation.
- *Ilyocoris cimicoides* (Linnaeus, 1758) - Found in still, often muddy-bottomed water, living on or near the bottom, often amongst dense vegetation. Despite having fully formed wings, *I. cimicoides* is not able to fly and disperses by 'nocturnal walking'. They are primarily distributed in central, southern, and eastern England, with further records on the England-Wales border and south-west England. There is no conservation status associated with this species.
- *Noterus clavicornis* (De Geer, 1774) - Predominantly found in well-vegetated eutrophic ponds and ditches. Although flight musculature of examined animals has been found to be reduced, the changing distribution of this species indicates that some individuals can fly. It is widely distributed throughout England and Wales, with further records in southern Scotland. They are often found amongst submerged and decaying vegetation and spend most of the time crawling on aquatic vegetation.
- *Notonecta maculata* (Fabricius, 1794) - A species which is fairly common in the south of England and Wales, but rare or absent to the north. It is found in still water and is particularly associated with barren pools or artificial water bodies with hard substrate – including cattle troughs - or little vegetation (it can be found in other habitats, but in much lower numbers).
- *Notonecta viridis* (Delcourt, 1909) - Inland records are predominantly from non-organic, silt-bottomed waters. Although thought to associate with brackish waters, many records are away from this habitat. They are primarily distributed in central, southern, south-western, and eastern England, with further records in north and south Wales and northern England. It is often found alongside *Notonecta glauca*.
- *Plea minutissima* (Leach, 1817) - A small predator that lives amongst weeds in rich lakes, ponds, and ditches – predominantly where water is clear and there is little organic matter in suspension. It is mostly found in lowland England, with some records in Wales. There is no conservation status associated with this species

Figure 36: Overall conservation value of invertebrate communities based on SAFIS analysis



Source: Aquatic invertebrate and Vertigo moulinsiana report Northern Distributor Road: Year 1 Post-construction Survey 2018

Figure 37: Overall conservation value of invertebrate communities based on SAFIS analysis.



Source: Aquatic invertebrate and Vertigo moulinsiana report Northern Distributor Road: Year 1 Post-construction Survey 2018

4.4.6.4 Conclusion

The surveys detailed in this report assessed the diversity and conservation value of aquatic invertebrate communities at six locations and the presence/absence of *Vertigo moulinsiana* at The Springs Lake CWS, near Norwich.

- Species composition was generally similar to the baseline surveys conducted in 2008 (and subsequent re-surveys in 2013); however, a greater number of taxa recorded across the sample locations.
- The results indicate that the area is of moderate conservation value for aquatic invertebrates, reflected in the absence of species of interest – seven 'local' species were found - and supported by the results of SAFIS analysis.
- As with the 2013 survey, the boundary ditch (Sample Point 5) had the lowest number of taxa recorded. This ditch remained heavily shaded and silted.
- *Vertigo moulinsiana* were found to be absent from the survey area. Previous surveys of the site (Mott MacDonald, 2013) found good numbers of the snail in 2008; however, the population had reduced significantly at the time of re-survey in 2013, prior to construction start in 2016. Habitats within the site were now considered sub-optimal/unsuitable to support

the snail and habitat manipulation/management would likely be required should the snail be re-introduced.

- Several invertebrates recorded in samples were not identified to species level, due to these groups requiring either specific preservation techniques or identification skills which are beyond the remit of this study. Consequently, disparity exists between the SAFIS species richness results and taxon richness actually recorded. This is caused by the spreadsheet used for the analysis (which requires a certain level of identification) and has been taken into account in this assessment.

4.5 Indicator 3: Road drainage and water quality

Due to the importance of both fluvial and groundwater in providing both habitat and drinking water, a regime of water quality monitoring was carried out during the construction phase to ensure that the construction resulted in no adverse effects.

The original Monitoring and Evaluation Plan highlighted the need for specific indicators to be monitored, these being: -

- The drainage performance of all lagoons should be monitored to ensure that they are performing as expected;
- The effectiveness of the hydrobrake and erosion protection measures at the discharge points from Lagoons 17, 18 and 18A and all culverts conveying overland flow beneath the Scheme will be regularly monitored by NCC to ensure their effectiveness; and
- Monitoring of the effective functioning of the drainage features improved or reinstated, particularly those upstream of the scheme to address sediment input into the River Wensum, will be carried out in conjunction with the ongoing maintenance. This will be in line with the requirements of the Habitats Regulations Assessment Addendum and the Mitigation Measures Management Plan therein.

4.5.1 Lagoons

4.5.1.1 Environment Agency Discharge of Requirements

During the construction of the NDR it was found that the permeability of the soils at certain lagoon locations was poorer than expected. This meant that the lagoons were not draining down as fast as expected, thereby not meeting the discharge rates agreed with the Environment Agency through the Discharge of Requirements process. The soils were found to be less permeable than expected in a number of locations along the route, but especially in the eastern section from Rackheath south east towards the Postwick junction.

The result of the poorer permeability means that a number of lagoons now have standing water in them that covers the bottom of those lagoons for an extended period of time, especially in the wetter times of year. This does not cause operational problems for the County Council as the lagoons have adequate capacity to cater for this standing water, but the County Council has held a number of meetings with the Environment Agency to investigate this matter to see if the issues could be resolved practicably. Following additional site investigation by the County Council it is understood that the Environment Agency is now accepting of the lagoons in their current state, and as such there is no further action required of the County Council in relation to the Discharge of requirements process.

4.5.1.2 Norwich International Airport operational issues

During construction it was noted that standing water in Lagoons 5, 6, 8 and 14 was attracting seagulls to land and swim within these lagoons. As these lagoons are within the immediate operational envelope of Norwich International Airport it was recognised that an engineering solution was required to reduce the attractiveness of these lagoons to seagulls.

The envisaged solution is to reduce the water level on Lagoon 5 via placement of additional discharge boreholes, and install additional aquatic planting in Lagoons 5, 6, 8 and 14 to reduce the area of water available, and reduce the attractiveness of these lagoons to seagulls. This remedial work is due to be carried out in the Autumn of 2019.

Recognising the importance to reduce the risk of bird strikes on aircraft operating out of the airport, the County Council has been paying for additional bird scaring teams at the airport.

4.5.2 Monitoring of Hydrobrakes and Culverts

During construction of the Bat Culvert c. 400m west of Gazebo Farm, it was noticed that the excavation for the foundation of the culvert had breached the localised groundwater level in this area. A hydrological risk assessment was prepared by Mott MacDonald to consider the risk of the construction on this exposed groundwater, and the potential effect of this downstream upon The Springs watercourse and fishing area. The hydrological risk assessment was presented to the Environment Agency, giving detail of the actions the site team would take when carrying out the remainder of the works. This was accepted by the Environment Agency, who's only request was that the water quality testing regime at The Springs be extended from the envisaged end of construction until the end of 2018. This monitoring regime was duly extended.

The effectiveness of the hydrobrake and erosion protection measures at the discharge points from Lagoons 17, 18 and 18A, and all culverts conveying overland flow beneath the NDR, have been periodically monitored by the Construction supervisors. No issues have been raised and no remedial works are envisaged.

4.5.3 Monitoring of Drainage features

Monitoring of the effective functioning of the drainage features improved or reinstated, particularly those upstream of the scheme to address sediment input into the River Wensum, has been carried out in conjunction with the ongoing maintenance.

It has been noted that the drainage swales along the majority of the route are performing particularly well.

The scheme to address sediment input into the River Wensum at Lenwade was successfully implemented during the construction phase and accepted by the statutory environmental bodies.

4.5.4 Future Monitoring

There is no requirement in the approved Monitoring and Evaluation Plan to monitor water quality and drainage past the first year of opening, and so future M+EP reports will not review these items.

5 Traffic

This chapter presents the indicators which relate to traffic levels that will be influenced by the scheme, including the reduction of traffic and congestion and improvements in transport connectivity.

5.1 Key points

Key findings from this chapter are presented in the summary box below.

- The NDR scheme is shown to be achieving the following desirable objectives in terms of reducing traffic levels and congestion:
  - Reducing orbital rat running in the northern suburbs of Norwich.
  - Reducing orbital rat running on rural roads outside the built-up area of Norwich.
  - Reducing traffic flows on the roads just outside the Norwich Outer Ring Road.
  - Reducing traffic flows on the Norwich Outer Ring Road.
  - Traffic flows have decreased over the railway level crossing.
- The NDR scheme has caused some traffic increases near the western end of the scheme, as anticipated, but these are the subject of DCO Requirements 27 and 29 and being dealt with separately.

5.2 Introduction

This section documents the evaluation of the two traffic indicators:

- Indicator 4: Reduce traffic levels and congestion.
- Indicator 5: Improved transport connectivity.

5.3 Indicator 4: Reduce traffic levels and congestion

The results for Indicator 4 are presented in terms of two-way traffic flows for a 24-hour period. This is known as Annual Average Daily Traffic (AADT) and was collected with Automatic Traffic Counters (ATC) placed across the road at the specified location for at least one week.

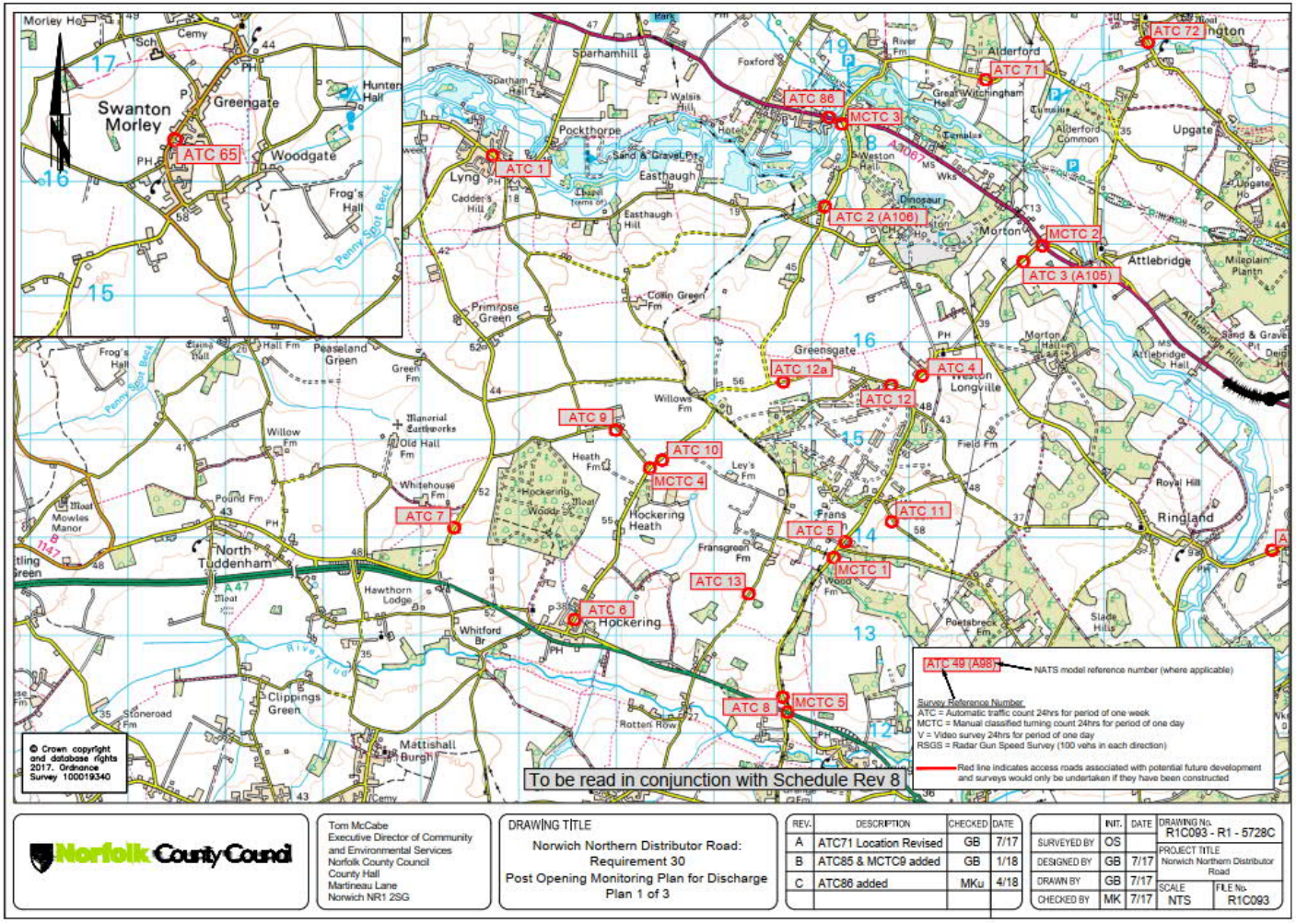
For the majority of the sites, data was collected in October/November 2015 and in October/November 2018. The beginning of the data collection in October/November 2015 predates the construction for the NDR scheme and the concluding of the data collection in October/November 2018 is approximately six months after the scheme opened.

The results for Indicator 4 are divided into four tables in accordance with the distinctions between the sites used to collect the data:

- Table 20 – Sites already committed to undertake monitoring.
- Table 21– Sites Required to Monitor Level Crossings.
- Table 22 – Sites Required to Produce Monitoring and Evaluation Plan.
- Table 23 – Additional Sites Agreed following Consultation in October/November 2016.

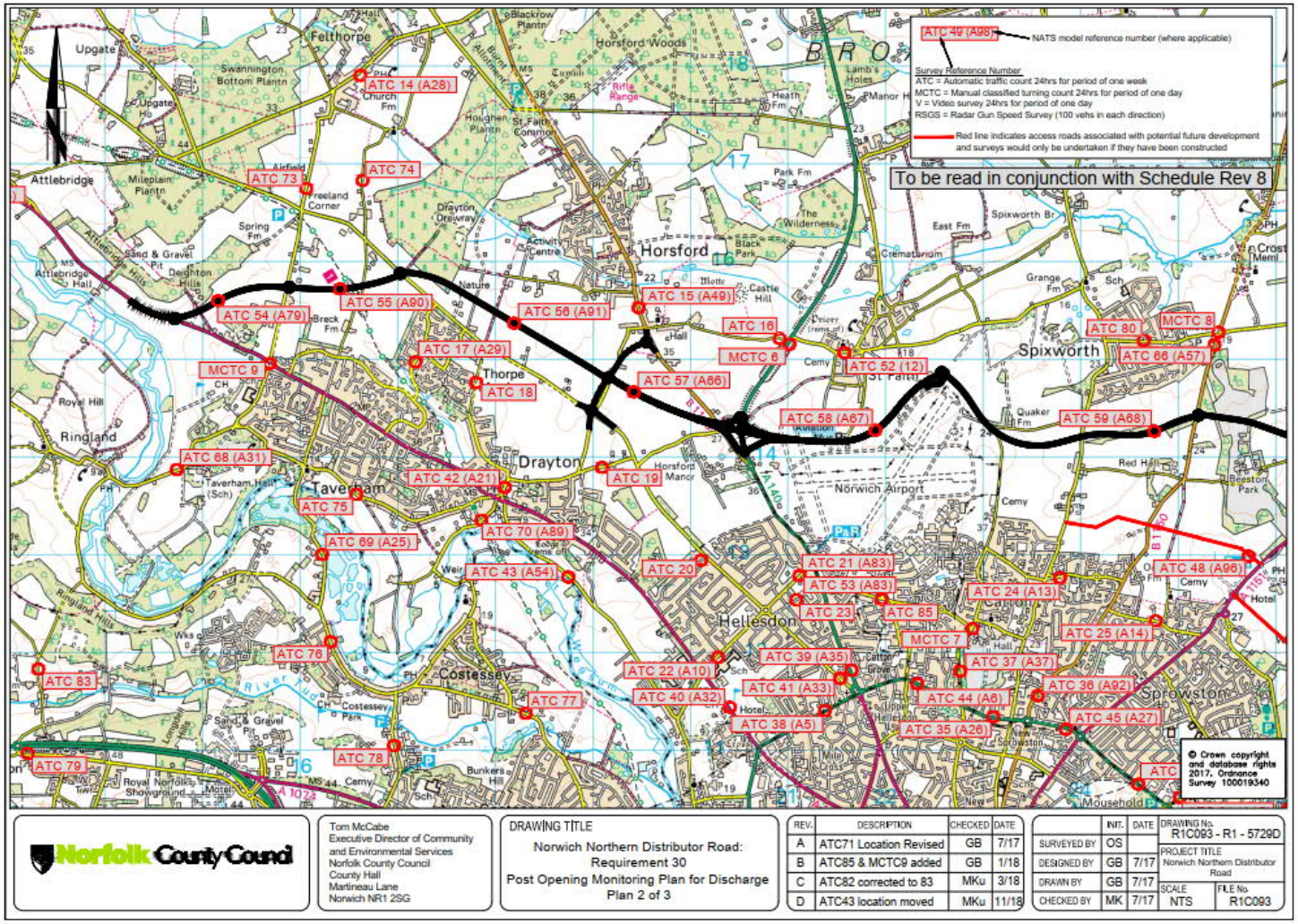
The locations of the sites used to collect the data for Indicator 4 are shown in Figure 38, Figure 39 and Figure 40.

Figure 38: Norwich NDR: Requirement 30 Post Opening Monitoring Plan for Discharge Plan 1 of 3



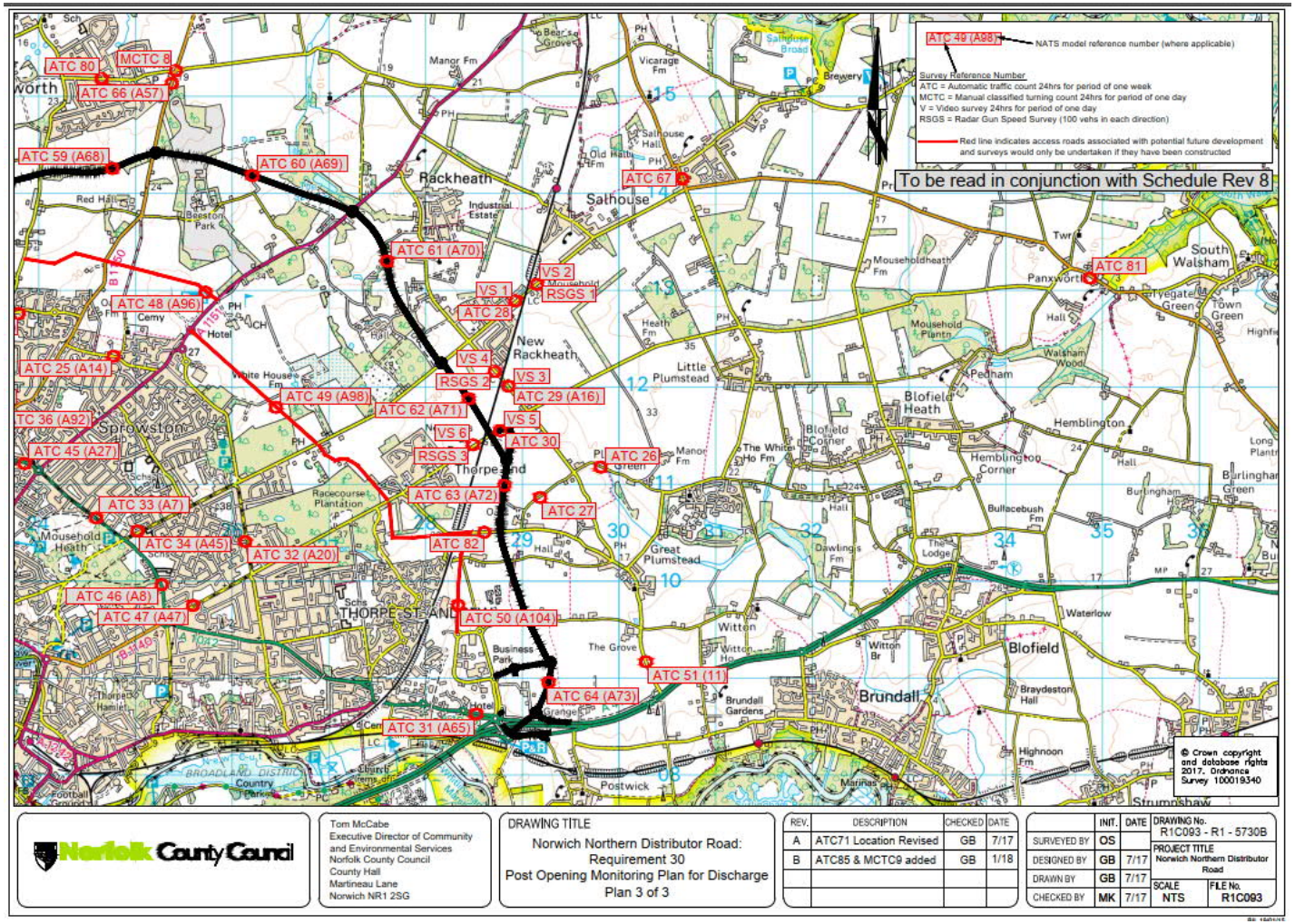
Source: NCC

Figure 39: Norwich NDR: Requirement 30 Post Opening Monitoring Plan for Discharge Plan 2 of 3



Source: NCC

Figure 40: Norwich NDR: Requirement 30 Post Opening Monitoring Plan for Discharge Plan 3 of 3



Source: NCC

5.3.1 Sites already committed to undertake monitoring

The results for Table 20 are set out below in terms of two-way traffic flows for a 24-hour daily period. This AADT was collected with ATCs placed across the road at the specified location for at least one week.

For the majority of the sites, data was collected in October/November 2015 and in October/November 2018. This is before the NDR was built and after it had been opened for about 6 months. The final column in the table shows percentage change between 2015 and 2018, that is the change brought about by the implementation of the NDR.

Table 20 presents the data for the sites already committed to undertake monitoring.

Table 20: Sites already committed to undertake monitoring

	ATC two-way AADT	Oct/Nov 2015 Pre-construction	Oct/Nov 2018 Post-opening	% change 2015 to 2018
1	C198 The Common Lyng	1,727	1,847	6.9%
2	C173 Weston Hall Road	3,628	4,170	14.9%
3	C167 Marl Hill Road	2,813	3,042	8.1%
4	C167 Woodforde Close	2,614	2,949	12.8%
5	C167 Paddys Lane	2,299	2,433	5.8%
6	C173 The Street Hockering	1,626	1,569	-3.5%
7	C198 Lyng Road	1,765	2,327	31.8%
8	C167 Wood Lane	4,677	4,978	6.4%
9	C493 Stone Road	648	940	45.1%
10	C173 Heath Road	1,789	1,968	10%
11	U57214 Breck Lane	125	106	-15.2%
12	C464 Rectory Road	388	421	8.5%
12a	C173/30 Rectory Road	296	295	-0.3%
13	U35074 Sandy Lane	206	272	32%
14	C245/52 The Street	5,487	4,559	-16.9%
15	B1149/12 Holt Road	12,982	12,520	-3.6%
16	C253/12 Church Street	2,883	2,373	-17.7%
17	51205/10 Pendlesham Rise	4,290	4,392	2.4%
18	57172/22 School Road	2,124	2,278	7.3%
19	57141/22 Hall Lane	4,435	2,104	-52.6%
20	57388/10 Drayton Wood Rd	2,431	2,490	2.4%
21	C259/36 Middletons Lane	10,498	9,299	-11.4%
22	C259/12 Middleton's Lane	10,111	9,742	-3.6%
23	57370/10 Meadow Way	1,486	1,335	-10.2%
24	C252/3 Fifers Lane	6,271	5,492	-12.4%
25	C255/10 Barker's Lane	8,637	6,066	-29.8%
26	59283/10 Broad Lane	1,163	982	-15.6%
27	59284/10 Toad Lane	143	104	-27.3%
65	C888 Greengate		4,238	
66	B1150 North Walsham Rd		14,013	
67	B1140 Mill Road		5,765	
68	C172 Ringland Road		3,899	
69	C461 Taverham Lane		6,389	

	ATC two-way AADT	Oct/Nov 2015 Pre-construction	Oct/Nov 2018 Post-opening	% change 2015 to 2018
70	C162 Costessey Lane		3,698	

Source: The Norfolk County Council (Norwich Northern Distributor Road (A1067 to A47 (T))) Order: Requirement 30: Traffic Monitoring Generally First Year Traffic Monitoring

An objective of the NDR was to reduce urban rat running in the northern suburbs and this is evidenced by the traffic reductions at the following sites:

- Site 21, Middletons Lane (-11.4%).
- Site 22, Middletons Lane (-3.6%).
- Site 24, Fifers Lane (-12.4%).
- Site 25, Barkers Lane (-29.8%).

Another objective of the NDR was to reduce rural rat running around Norwich and this is evidenced by the traffic reductions at the following sites:

- Site 14, The Street, Felthorpe (-16.9%).
- Site 16, Church Street, between Horsford and Horsham St Faiths (-17.7%).

At Site 23, Meadow Way in Hellesdon there was a fear that existing rat running between Reepham Road and the A140 Cromer Road would be exacerbated with the NDR. The results show that traffic levels reduced by 10.2% at that location.

Table 20 also included Manual Classified Turning Counts (MCTC) at 8 junctions. These were carried out on a single day in September 2018. No equivalent counts are available from before the NDR opened so no comparison is possible at this time.

5.3.2 Sites required to monitor level crossings

The results for Table 21 are set out below in terms of two-way traffic flows for a 24 hour daily period. This is known as AADT and was collected with ATC placed across the road at the specified location for at least one week.

The data was collected in October/November 2015 and in October/November 2018. This is before the NDR was built and after it had been opened for about 6 months. The final column in the table shows percentage change between 2015 and 2018, that is the change brought about by the implementation of the NDR.

Table 21 presents the data for the sites required to monitor level crossings.

Table 21: Sites Required to Monitor Level Crossings

	ATC two-way AADT	Oct/Nov 2015 Pre-construction	Oct/Nov 2018 Post-opening	% change 2015 to 2018
28	C283/44 Salhouse Road	4,885	4,422	-9.5%
29	C258/32 Broad Lane	4,634	245	-94.7%
30	C874/50 Plumstead Road	7,335	5,491	-25.1%

Source: The Norfolk County Council (Norwich Northern Distributor Road (A1067 to A47 (T))) Order: Requirement 30: Traffic Monitoring Generally First Year Traffic Monitoring

5.3.3 Sites required to produce M&EP

The results for Table 22 are set out below in terms of two-way traffic flows for a 24-hour daily period. This is known as AADT and was collected with ATC placed across the road at the specified location for at least one week.

For the majority of the sites, data was collected in October/November 2015 and in October/November 2018. The final column in the table shows percentage change between 2015 and 2018, that is the change brought about by the implementation of the NDR. Traffic counts have also been carried out on sections of the NDR itself but mainly in October/November 2018. Further counts are programmed to be carried out in future years.

Table 22 presents the data for the sites required to produce the M&EP.

Table 22: Sites Required to Produce Monitoring and Evaluation Plan

	ATC two-way AADT	Oct/Nov 2015 Pre-construction	Oct/Nov 2018 Post-opening	% change 2015 to 2018
31	A1042/181 Yarmouth Road	21,350	20,400	-4.4%
32	C256/32 Woodside Road	12,072	9,755	-19.2%
33	A1042/60 Mousehold Lane	26,257	22,323	-15%
34	C283/12 Salhouse Road	13,988	14,356	2.6%
35	A1042/28 Chartwell Road	28,859	22,819	-20.9%
36	B1150/38 Constitution Hall	15,307	13,622	-11%
37	C251/10 St Faiths Road	13,825	10,357	-25.1%
38	A140/130 Boundary Road	29,737	27,356	-8%
39	A140/2004 Cromer Road	19,433	17,821	-8.3%
40	A1067/1122 Drayton High Rd	17,891	16,289	-9%
41	C261/52 Reepham Road	8,666	8,258	-4.7%
42	C282/10 School Road	9,978	9,808	-1.7%
43	Low Road Hellesdon	3,596	2,672	-25.7%
44	A1042/18 Mile Cross Lane	23,429	20,651	-11.9%
45	A1042/40 Chartwell Road	30,059	24,473	-18.6%
46	A1042/80 Heartsease Lane	18,379	15,234	-17.1%
47	C874/12 Plumstead Road East	11,335	10,410	-8.2%
48	A1151 to B1151	New housing link not yet built		
49	A1151 to Salhouse Road	New housing link recently opened		
50	C874 to Broadland Bus. Park	New Housing link not yet built		
51	C258/10 Church Road	2,969	1,862	-37.3%
52	C253/25 Church Street	5,913	3,608	-39%
53	C259/36 Middletons Lane	10,498	9,299	-11.4%
54	NDR Fakenheam to Fir Covert Road		6,392	
55	NDR Fir Covert to Reepham Road		9,701	
56	NDR Reepham Road to Drayton Lane		10,045	
57	NDR Drayton Land to A140		18,674	
58	NDR A140 to Airport roundabout		17,690	
59	NDR Airport roundabout to North Walsham Road		17,385	
60	NDR North Walsham Road to Wroxham Road		21,659	

	ATC two-way AADT	Oct/Nov 2015 Pre-construction	Oct/Nov 2018 Post-opening	% change 2015 to 2018
61	NDR Wroxham Road to Salhouse Road		19,460	
62	NDR Salhouse Road to Plumstead Road		20,314	
63	NDR Plumstead Road to and Broadland roundabout		19,242	
64	A1270/30 Link Road		19,127	

Source: The Norfolk County Council (Norwich Northern Distributor Road (A1067 to A47 (T))) Order: Requirement 30: Traffic Monitoring Generally First Year Traffic Monitoring

An objective of the NDR was to reduce rural rat running around Norwich and this is evidenced by the traffic reductions at the following sites:

- Site 51, Church Road, south of Great Plumstead (-37.3%).
- Site 52, Church Street, Horsham St Faiths (-39.0%).

Another objective of the NDR was to reduce urban rat running in the northern suburbs and this is evidenced by the traffic reductions at the following sites:

- Site 32, Woodside Road (-19.2%).

5.3.4 Additional sites agreed following consultation in October/November 2016

The results for Table 23 are set out below in terms of two-way traffic flows for a 24-hour daily period. This is known as AADT and was collected with ATC placed across the road at the specified location for at least one week.

For the majority of the sites, data was collected in June 2018 after the road had been opened for about 3 months and in October/November 2018 after it had been opened for about 6 months. No data is available for October/November 2015, as the decision to monitor at these locations was made in 2016.

Table 23: Additional Sites Agreed following Consultation in Oct/Nov 2016

	ATC two-way AADT	Oct/Nov 2015 Pre-construction	Oct/Nov 2018 Post-opening
71	C270 Hall Road	N/A	724
72	C263 The Street	N/A	427
73	C262 Taverham Road	N/A	4,378
74	U57169 Brands Lane	N/A	258
75	C172 Taverham Road	N/A	2,821
76	C171 West End	N/A	6,864
77	C171 Town House Road	N/A	4,352
78	C162 Longwater Lane	N/A	10,056
79	C574 Dereham Road	N/A	2,326
80	C249 Crostwick Lane	N/A	3,149
81	B1140 South Walsham Road	N/A	3,962
82	C442 Middle Road	N/A	973
83	U78219 Ringland Road	N/A	3,768

Source: The Norfolk County Council (Norwich Northern Distributor Road (A1067 to A47 (T))) Order: Requirement 30: Traffic Monitoring Generally First Year Traffic Monitoring

No conclusions can be drawn from this monitoring with regard to pre and post NDR traffic levels. Future year monitoring will enable trends at these sites to be determined.

5.3.5 Conclusions

This monitoring of Indicator 4 has shown that the NDR has caused some traffic increases near the western end of the scheme, as anticipated, but these are the subject of DCO Requirements 27 and 29 and being dealt with separately.

Based on the extensive set of monitoring locations across the wider area, these results show that the NDR is achieving the following desirable objectives:

- Reducing orbital rat running in the northern suburbs of Norwich.
- Reducing orbital rat running on rural roads outside the built-up area of Norwich.
- Reducing traffic flows on the roads just outside the Norwich Outer Ring Road.
- Reducing traffic flows on the Norwich Outer Ring Road.
- Traffic flows have decreased over the railway level crossing.

5.4 Indicator 5: Improved transport connectivity

Currently awaiting information for this indicator.

6 Process and governance

Three further indicators (Indicators 8-10) intended to assess the process of delivering the NDR scheme have been monitored.

6.1 Key points

Key findings from this chapter are presented in the summary box below.

- Construction started on the NDR scheme on the 4th January 2016 and Phase 3 of the scheme was completed on the 17th April 2018. The opening of the route took place in line with the programme (Q1 2018).
- The final account has been settled with the Contractor, but land purchase negotiations are continuing, so the final cost of the scheme is not yet known.
- The cost of the scheme has exceeded the original budget making it necessary for NCC to seek approval for an increase in the budget. This was approved and the revised budget is £205m and currently the forecasted cost of the scheme is within this revised budget.
- During the consultation process the following key points were identified:
  - There was a consensus that there was some degree of delay for certain elements of the programme caused by issues including: funding uncertainty and judicial reviews early in scheme delivery; issues around the Rackheath Railway Bridge; adverse weather conditions during construction; and, uncertainty around the management of the DCO process. Stakeholders acknowledged that some of these were out of control of the project management team.
  - The scheme was delivered largely on time due to the phased opening of the NDR scheme. Some consultees stated that the successful delivery of the scheme is proof of the effectiveness of programme management and delivery, whilst others commented that quality assurance could have been better in certain areas.
  - In terms of the effectiveness of the risk management strategy and the risk mitigation approaches there were conflicting opinions given by the consultees. Some felt that the risk management strategy identified many of the risks early and the mitigation approaches implemented dealt with them appropriately. However, other consultees emphasised the overspend for the scheme as proof of the inability of the risk management strategy and the mitigation measures to deal with the high financial risks associated with infrastructure projects of this size.

6.2 Introduction

The NDR M&EP sets out three process and governance indicators that need to be monitored:

- Indicator 8: Project cost.
- Indicator 9: Project programme.
- Indicator 10: Consultations for Process Evaluation.

Although these indicators are considered as part of the Process Evaluation report, the M&EP also requires them to be included within this OYA report.

6.3 Indicator 8: Project cost

Table 24 presents the estimated base costs and quantified costs that were validated by DfT in 2011 for the NDR scheme through three different scenarios including:

- Total base cost.
- NDR to A140 excluding Postwick Hub.
- NDR to A11067 excluding Postwick Hub.

Table 24: Cost estimated for both NDR to the A140 and the NDR to the A1067

Cost Heading	As per BAFB (including any adjustments advised by DfT) (£ million)	Currently Estimated Cost (NDR to A140 excluding Postwick Hub) (£ million)	Currently Estimated Cost (NDR to A11067 excluding Postwick Hub) (£ million)
Base Cost Summary			
Construction Cost	73.7	81.331	115.458
Land Cost	9.0	11.274	17.230
Preparation Cost	4.4	10.340	14.362
Supervision	1.0	0.936	1.300
Base Cost Total	88.1	103.881	148.350
Quantified Cost Estimate			
Base costs (incl. Eligible Preparation Costs)	97.7	103.881	148.350
Quantified Risk Assessment	6.34	1.465	2.035
Inflation	7.1	0.544	0.762
Total	**111.14**	**105.890**	**151.147**

Source: Norwich Northern Distributor Road (NDR) Local Authority Major Schemes Outline Business Case

The final account has now been agreed with the Contractor. Ongoing land purchase negotiations means that the final scheme cost is not yet finalised.

The cost of the scheme has exceeded the original budget making it necessary for NCC to seek approval for an increase in the budget. This was approved and the revised budget is £205m and currently the forecasted cost of the scheme is within this revised budget.

6.4 Indicator 9: Project programme

The project programme for the NDR scheme originated with the contractor and was updated monthly before being submitted for approval by NCC under the terms of the contract. The contractor issued a progress report on the project programme for discussion at each Delivery Team and Contract Admin meeting.

The key milestones in the delivery of the NDR scheme are outlined in the table below.

Table 25: NDR scheme key milestones

Milestone	Completion date
Preliminary assessment of NDR Route options and Preferred Route Announcement	2005
Major Scheme Business Case (MSBC) submitted to DfT	July 2008
DfT requested further information to support MSBC and the information was provided	2009
NDR Contract Awarded (stage 1)	2009
NDR route between A47 and A140 formally granted Programme Entry	December 2009
NDR and Postwick Hub included in 'Development Pool' of schemes requiring new funding bid	June 2010
Best and Final Bid for NDR (A140 to A47) and Postwick Hub submitted to DfT	September 2011
Funding bid approved for DfT with reconfirmation of Programme Entry	December 2011
Start/Finish of DCO examination process	2nd June 2014 – 2nd December 2014
DCO granted by Secretary of State for Transport	2nd June 2015

Milestone	Completion date
A47 junction at Postwick Hub opened to traffic (separate process to the NDR)	December 2015
Construction started on NDR scheme	4th January 2016
NDR Phase 1 (A1067 Fakenham Road to A140 Cromer Road) opened to traffic	11th November 2017
NDR Phase 2 (A140 Cromer Road to A1151 Wroxham Road) opened to traffic	21st December 2017
NDR Phase 3 (A1151 Wroxham Road to Postwick Hub (A47)) opened to traffic	17th April 2018

Source: NCC

Although there were slippages and delays in the programme for certain elements of this scheme, as discussed in detail in the Process Evaluation report, the overall aim of opening the NDR in Q1 of 2018 was achieved.

6.5 Indicator 10: Consultations for Process Evaluation

As part of the Process Evaluation a consultation process was carried out across a number of weeks in December 2018 and January 2019. The consultations were conducted through a mixture of telephone interviews and face-to-face meetings.

Consultees were identified through discussions with the scheme's overall project manager. Consultees interviewed included[2]:

- Representatives of NCC who have been responsible for delivering the scheme.
- Representatives of Mott MacDonald who have supported project management and delivery including site supervision.
- NCC and district authority representatives who, whilst not involved in day to day delivery, have played a role in supporting delivery through their regular job functions (e.g. planning officers, environmental officers).
- A number of project board members overseeing delivery of the scheme.

Interviews were typically 45 minutes in duration and a pro-forma was produced to guide the consultations. The pro-forma can be found Appendix A of the Norwich NDR Process Evaluation.

In total, 17 consultations were undertaken with a full list of consultees (by organisation name) can be found in Appendix B of the Norwich NDR Process Evaluation.

6.5.1 Topics covered by the consultation exercise

Consultees were invited to discuss the following topics:

- The initial design and planning phases of the scheme.
- The key changes in the scheme which emerged from its delivery as opposed to its design.
- Views on how the scheme has been managed – with a focus on process and management structures.
- The degree of confidence the individual stakeholders have that the scheme will achieve its key outputs and anticipated wider impact based on how the scheme has been delivered.
- Participants were also asked to provide an assessment of good practice and key lessons learned. Evidence is crucial, particularly in cases where a specific insight or perspective is being offered.

The views reflected in the subsequent sections are those of the consultees and have not been fact checked or subjected to significant scrutiny. Detailed review of technical, engineering,

[22] The list is not necessarily mutually exclusive – for example Project Board members are also employees of individual organisations.

financial and design points raised during consultations are beyond the scope of this evaluation and, in any case, this exercise is about capturing the views and perceptions of those involved and that is how the report has been written. Where contradictions occur, this reflects the different perspectives of individuals that can commonly arise during delivery of a complex project involving stakeholders with a wide variety of backgrounds.

6.5.2 Scheme context consultation findings

Stakeholders were asked what external factors affected scheme design at planning and construction phases and which of these were positive or negative.

A number of external factors were identified by the consultees that affected scheme design at planning and construction phases. Mitigating environmental impacts was a key consideration that impacted scheme design as it became necessary to incorporate sufficient mitigation measures to reduce noise, light and air pollution, protect vulnerable and endangered species and maintain local habitats and green space.

Interactions with Network Rail and Norwich Airport were also suggested as external factors affecting scheme planning and construction due to the importance of these organisation as key stakeholders with a vested interest in the scheme. The route of the scheme encountered existing transport infrastructure owned by these key stakeholders thereby ensuring that their input was required at both planning and construction to ensure their own operations were not adversely impacted. The occurrence of unforeseen issues concerning utility infrastructure such as underground gas mains during construction was another external factor identified by some consultees.

The requirements of individual land owners were identified as an external factor affecting scheme design by some consultees. This included the requirement for providing access points to land as well as avoiding key areas.

Prior to the NDR, NCC had never undertaken an infrastructure scheme of this scale nor had they used the DCO process to deliver an infrastructure scheme. This initially contributed towards a variety of issues including excessive workloads, a shortage of required skills as well as a lack of general experience of the DCO process.

Political changes at a national level were noted by some consultees as impacting scheme design, especially following the formation of the Coalition Government in 2010. Changes in policy relating to the awarding of funding for infrastructure caused long delays in the early stages of the scheme.

Stakeholders were asked what barriers to delivery were encountered and how they were overcome.

During the consultation process several barriers to delivery were identified that impacted on the scheme during delivery. Early in the development of the scheme several consultees pointed to the barriers caused by a legal challenge to the scheme as well as uncertainty and removal of funding by central government. Consultees stated that these early barriers caused delays in the scheme programme and contributed towards a loss of knowledge as the delivery team was demobilised for a significant amount of time until the funding issue was resolved.

Another barrier to delivery acknowledged by the consultees were the longstanding issues surrounding the construction of Rackheath Railway Bridge. Consultees identified the delay in gaining approval for designs for the bridge from Network Rail as well as the limitation of only allowing construction during possession opportunities to ensure the minimal amount of disruption to regular rail services.

There was limited dialogue between land owners and the delivery team early in the development of the scheme, leading to issues and problems with the scheme held by land owners not being received until construction had begun. This in turn led to difficulties in altering the scheme given the delivery of the scheme through the DCO process.

While not perhaps a barrier, some consultees highlighted that the number of environmental considerations for the scheme caused delays due to a consistent need to ensure negative impacts on the local environment and ecosystem caused by the scheme were mitigated against wherever possible.

Other consultees discussed the barrier around the ongoing conflict between the scope and budgetary constraints placed on the scheme. This conflict led to a lengthy value engineering process to minimise where possible the additional funding required to deliver the scheme.

Stakeholders were asked if the scheme's external stakeholders changed (personnel and/or policy) at local, regional and national levels and how this affected implementation.

There was general consensus from all consultees that there were minimal personnel changes throughout the duration of the scheme once construction had begun within key positions at NCC and other district councils involved in the scheme.

There were also minimal changes in personnel within major stakeholders such as Network Rail and DfT once the scheme was underway. In terms of the contractor the only major change in personnel occurred when the preferred contractor Birse Civils Ltd, part of the Balfour Beatty group, changed its trading name to Balfour Beatty Civils Ltd. This led to a change in the team delivering the contract at Balfour Beatty.

It was also noted that significant changes occurred amongst land owners along the route of the scheme during the lifespan of the scheme. Several land owners changed agents during the delivery of the scheme which led to a loss of relationships and knowledge in certain circumstances, but the impact was considered minimal by consultees.

The occurrence of political elections on both national and local levels through the duration of scheme delivery led to changes in policy, especially in terms of funding allocation and personnel. Other political changes impacting the scheme include the creation of the New Anglia Local Enterprise Partnership (LEP) that would become a key stakeholder in the scheme.

Stakeholders were asked what views external stakeholders have on the way the scheme has been developed and constructed.

There was consensus amongst the consultees that there was consistent cross-political support for the scheme, apart from the Green Party. It was felt that the opposition from the Green Party to the scheme came from environmental concerns. It was also widely agreed that the public reaction to the scheme was largely positive throughout development and construction phases (although it should be noted this opinion was not based on any formal evidence or data). The only negative perspectives of the scheme mentioned by consultees related to the overspend on the cost of the scheme.

6.5.3 Scheme inputs consultation findings

Stakeholders were asked how the funding profile performed against forecast.

The performance of the funding profile of the scheme against forecasts was viewed by some consultees to be a failure given the significant overspend of the present total cost of the scheme compared with the initial cost estimate, but it is recognised that it was not anticipated there would be nine years between contract award and start of construction.

However, other consultees stated that the current total cost was within the agreed revised budget therefore illustrating how the funding profile was managed over time.

Stakeholders were asked whether there were any areas of cost savings or overspend.

A key area of cost saving on the scheme was the extensive process of value engineering that sought to reduce costs by limiting the cost of materials and scope of the project where possible. Other areas of cost saving identified included the outsourcing of tree landscaping to sub-contractors for a reduced fee below normal market rates. The completion of a Quantitative Schedule Risk Assessment (QRSA) exercise was also regarded as a cost saving measure by some consultees because had an assessment not been done the financial implications would have been far greater than they are currently.

Key areas of overspend in the view of the consultees included the issues and delays associated with the construction of the railway bridge at Rackheath in collaboration with Network Rail as well as utility diversions (some of which were unexpected) throughout the construction of the scheme. Some consultees also voiced concerns over the commercial approach from the contractor citing poor project controls as a reason for additional overspend. Consultees also outlined the total estimate of land acquisition estimates increasing after a review during the construction of the scheme which contributed towards the overall overspend on the scheme.

Stakeholders were asked how management and governance arrangements performed.

Overall, the majority of consultees felt that the governance structures and the management of strategic decision-making about scheme design and delivery were effective. Consultees pointed to the use of the Project Board and various monthly meetings attended by a diverse range of members from leadership teams as being efficient in communicating and making strategic decisions in the best interest of the scheme. Many consultees felt that positive lessons such as the need for increased use of the Project Board from the outset had been learnt from this experience that will be applied to future infrastructure projects.

Some consultees did however note that at the start of scheme delivery the Project Board was not used as much as it should have been, but its importance and use increased and developed over time.

Stakeholders were asked how decision-making about scheme design and delivery was managed.

The Project Board managed the strategic decision-making process for scheme design and delivery and many consultees felt that as the time progressed the performance of the Project Board improved regarding its ability to make effective strategic decisions. Many consultees felt that positive lessons had been learnt with regards to making strategic decisions that will be applied to future infrastructure projects. These positive lessons included the acknowledgement that better escalation of issues and concerns to the relevant decision-making body as well as the need to utilise the Project Board more often when making decisions.

Some consultees did suggest that the recording of strategic decisions could have been improved if there had been better documentation produced by the Project Board.

Stakeholders were asked how the procurement system performed.

In terms of the performance of the procurement system those consultees that felt they could offer an opinion felt that the system was not fit for purpose given the length of time between the signing of the contract in 2009 and the start of construction in January 2016.

Stakeholders were asked how external factors influenced scheme design,

Several external factors that influenced scheme design identified by the consultees included the financial issues of funding availability and periods of uncertainty as well as the process of value engineering undertaken to better match the desired scope of the scheme with the available budget. The value engineering process sought to better align the proposed outputs of the scheme with the cost with outcomes through several means including the use of more cost-effective materials.

Some consultees stated that the views of key stakeholders as well as the wider public expressed through numerous consultations also influenced scheme design. However, it was also suggested that given the limited dialogue with some local land owners during scheme design their views were not always taken into account.

Ongoing interactions with key stakeholders such as Norwich Airport, Network Rail and various utility companies also directly influenced scheme design as the proposed route of the scheme impacted on existing infrastructure therefore requiring mutual agreement on all elements of the scheme.

Stakeholders were asked whether there were any issues with suppliers.

When discussing suppliers for the scheme some consultees voiced their views on issues regarding the complicated relationship between NCC and the contractor. It was suggested that any issues in this relationship revolve around the combined handling of the commercial strategy for the delivery of the scheme.

Targets were set for the scheme to have a strong local supply chain for materials and labour force. There was a general consensus that local suppliers and labour were utilised where possible with the contractor reporting that they had successfully met their target of sourcing 50% of their labour force from the local area (Norfolk). However, it was not possible to use the local supply chain in all instances, especially for certain materials including those required for making tarmac, therefore requiring the accessing of national and even international supply chains.

Stakeholders were asked whether any skills capacity and shortage issues were identified which disrupted scheme delivery.

In terms of specific skills shortages experienced during scheme delivery there was a noted issue with recruiting gas pipe welders during the construction phase but this is linked to a nationwide skills shortage for this skillset, although overall there were no significant skills capacity issues.

Stakeholders were asked if there were any skills challenges identified in the scheme's management team.

Within the management team for the scheme it was suggested that there were some skills issues. Within NCC it was suggested that during the early stages of delivery there was a noted lack of commercial skills within the management team, especially during the design phase of the scheme. However, it was also noted that this lack of commercial skills was identified by NCC and effectively addressed by the time construction started thereby limiting the potentially negative impact of this skills gap.

Some consultees also stated that there was limited knowledge and skills relating to the DCO process within the NCC management team. This skills gap relating to the DCO process was acknowledged as being due to NCC never having delivered a scheme through this process before. It was recognised that very few major schemes had been delivered via a DCO process at this time, so there was also a national shortage of expertise in this area.

On the contractor side it was noted that there were limited personnel already based in Norfolk necessitating a recruitment drive in the area to source approximately 60% of the total staff that would deliver the scheme.

Stakeholders were asked how the quality and quantity of human resources were suited to the scheme's requirements.

There was a general consensus that the quality of human resources available were able to meet the requirements of the scheme.

However, some consultees suggested that the construction supervisor team from NCC could have been larger whilst other consultees also questioned the staffing situation at times from the contractor side, especially early on from a leadership perspective.

Stakeholders were asked if the local supply chain was able to satisfy requirements for materials.

There was a general consensus amongst the consultees that the local supply chain was successful in satisfying requirements for materials as far as it could. Some materials, particularly tarmac, had to be sourced nationally given the lack of these materials locally.

Stakeholders were asked if the cost estimates for materials matched the price paid for them.

The consultees who were involved in purchasing materials felt that there were no major deviations between the estimated cost of materials and the real prices paid. This suggests that the cost estimating process worked well in the early stages.

6.5.4 Risk management consultation findings

Stakeholders were asked if the logic maps need to be amended to reflect causal links.

The consultees made very few comments on the logic maps for the scheme aside from some very minor changes including the altering of the stated scheme completion date and the addition of the New Anglia LEP as a funding source for the scheme.

Stakeholders were asked if there was any delay/slippage in the programme and how this affected delivery and budget.

There was a consensus amongst the consultees that there were delays and slippages in the programme for certain elements of this scheme. Several key factors were offered as explanations for the delays and slippages in programme experienced. Early in the lifespan of the scheme issues with funding and judicial reviews were acknowledged as the cause of delays in the starting of construction.

During construction many consultees identified issues associated with the construction of the railway bridge at Rackheath and with numerous utility diversions as being the main contributors to delays and slippages of the programme during construction. Adverse weather conditions in the final months of construction were also acknowledged as a major contributor towards delays in opening the final phase of the scheme. Some consultees noted that delays and slippages in the programme for this scheme led to increases in cost that contributed towards the overall overspend of the scheme.

However, the scheme was delivered in phases with some opening well before the targeted delivery date thus helping to limit the overall impact of the delays and slippages in the programme for this scheme.

Stakeholders were asked if better planning and management could have avoided slippage and delays.

When asked about the potential for better project planning and management to limit or remove some of the delays and slippages in programme experienced there was a view amongst some consultees that it could have helped in some cases. It was felt by some that greater management and scrutiny of the contractor budgets by NCC could have saved both time and costs overall. Some consultees did note that this did occur during the latter stages of the project. Others felt that the contractor could have better managed the communication with Network Rail to limit delays around the construction of the railway bridge.

However, there were some factors that consultees agreed were beyond all control of planning and management. For example, it was noted that it would have been impossible to better plan or manage some factors such as adverse weather conditions and changes in funding policy by central government.

Stakeholders were asked whether the risk management strategy was effective.

The risk management strategy was considered by most consultees to have been effective at identifying potential risks using risk registers as well as identifying appropriate mitigation measures. Some consultees also stated the view that the risk management strategy worked well overall at dealing with risks as they appeared.

However, other consultees pointed to the risk management strategy being incapable of containing the financial risks of the scheme that have led to the overall overspend compared to the initial budget estimate for the scheme.

Stakeholders were asked if scheme quality assurance methods were effective.

There was some disagreement amongst the consultees over the quality assurance methods of the scheme. Some consultees pointed to the overall successful delivery of the scheme and the general positive feedback received from the public thus far on the completions of the scheme.

Other consultees were less positive and highlighted the ongoing issues still being dealt with post-construction such as the number of accidents at roundabouts and the drainage issues with the lagoons near Norwich Airport.

Stakeholders were asked if risk mitigation approaches worked.

In terms of the risk mitigation measures implemented for the scheme mixed views were expressed on their effectiveness. Most consultees felt that many of the risks were identified through the maintenance of risk registers and regular meetings and were managed well throughout the duration of scheme delivery. The excellent safety record during construction on the scheme was also highlighted as evidence of the effective risk mitigation approaches employed.

Others felt that the overspend on this scheme was a sign that the most important risk (increased capital expenditure requirements) was not managed effectively thus impacting the overall effectiveness of the risk mitigation measures adopted.

6.5.5 Scheme outputs consultation findings

Stakeholders were asked whether there were scheme changes between planning and construction phases.

Many consultees stated that the DCO did not allow for any changes to occur to the scheme design between planning and construction and any changes that were required had to be

approved by DfT. However, some non-material changes to the scheme were noted during the consultation that were more significant than those allowed for within the Limits of Deviation. This is something that experience nationally is learning to consider in more detail when setting limits of deviation. Many of these changes were made during construction and have been applied for approval retrospectively including numerous minor changes to earthworks.

Stakeholders were asked whether the scheme supported the delivery of development sites

In terms of determining the impact the scheme has had on supporting the delivery of development sites there was a general consensus that it would achieve this strategic objective based on the number of planning applications received by the local planning authorities in the vicinity of the scheme. Some consultees highlighted the presence of new development near Postwick Junction as well as planned residential development near Rackheath as proof of the scheme's ability to support the delivery of development. However, some consultees did suggest that it is too early at this stage to accurately determine the overall impact the completion of the scheme will have on supporting development in the surrounding area.

Stakeholders were asked how scheme implementation has been managed to deliver the associated environmental benefits proposed.

Consultees were in general agreement again that it is too early to accurately assess the effectiveness of the scheme in delivering the proposed environmental benefits. However, many consultees emphasised the extensive efforts made to mitigate negative environmental impacts of the scheme both during construction and operation.

Stakeholders were asked if any unintended outputs had been identified during delivery and how they could be measured.

Many consultees agreed that there were very few unintended outcomes or outputs identified since the delivery of the scheme. One of the few unintended outcomes mentioned was the number of road accidents occurring at the new roundabouts built along the scheme. The other unintended outcome identified during the consultation process was the inability of the newly constructed lagoons near Norwich Airport to drain within the planned seven days. This ongoing problem with the lagoons has led to the requirement of further mitigation efforts to alleviate the problem.

6.6 Results

Table 28 presents key conclusions identified during the Process Evaluation and lessons learned that could be considered for future design and delivery of highways schemes.

Table 26: Results of Process Evaluation

Scheme stage and transferable lessons
Scheme context
• Environmental concerns and the required mitigation processes are becoming increasingly influential on major transport infrastructure projects. • The DCO process has proved to be a difficult system through which to deliver a major infrastructure project according to many consultees involved because of the inability to make changes to the scheme once the DCO has been approved. • The availability of funding is an issue for major infrastructure schemes.
Scheme inputs
• Key areas of cost saving include the value engineering process and key areas of overspend include the construction of Rackheath Railway Bridge as a result of the conflict between the project programme and the timetable of possessions overseen by Network Rail.

Scheme stage and transferable lessons
• The lack of commercial skills and experience within NCC in the DCO process were considerable issues during the early phases of the delivery of the NDR scheme. However, the lack of commercial skills was addressed before construction began through strategic recruitment. A proven ability to manage large capital budgets for complex project delivery is a skillset that should not be underestimated in delivering schemes similar to the NDR. • The procurement system was considered not fit for purpose by many consultees given the length of time between the signing of the contract in 2009 and the start of construction in January 2016. • There are local skills and materials available for major infrastructure projects, and set targets were met, but the national skills base and sources of materials are still essential. About one-half of the onsite labour resource was from Norfolk residents.
Risk management
• Delays or slippages in the project programme were constant risks during the delivery of the NDR scheme. Some could have been avoided through better planning and management such as the construction of Rackheath Railway Bridge whilst others could not such as adverse weather conditions. • Risk registers are key to identifying potential risks and mitigation measures and the upkeep of these records is an important part of risk management. However, the keeping of risk registers does not always guarantee success in mitigating risks as shown by the consistent financial issues experienced during delivery of the NDR scheme. • The safety record on the NDR scheme was excellent with very few minor injuries and no major injuries recorded.
Scheme outputs
• A number of benefits are expected to be delivered as a result of the delivery of the NDR scheme including those linked with spatial development and the environment. Although it is too close to the delivery of the NDR scheme for these benefits to have been fully realised. • Some unintended outputs can be experienced as a consequence of the delivery of major infrastructure schemes like the NDR scheme such as the number of road accidents near the newly constructed roundabouts.

Source: Mott MacDonald

Based on this evidence and the stakeholder consultations undertaken, the following key conclusions can be drawn:

- The NDR scheme has been received positively by the public and key stakeholders since it has been completed and opened to traffic.
- The DCO process proved to be a difficult system through which to deliver a major infrastructure project according to many consultees involved given the inability to make any changes post submission and the lack of experience in completing the process.
- The NDR scheme was well managed on the whole but suffered from delays/slippages in the programme as well as financial issues resulting in overspend.
- The NDR scheme had an excellent safety record with very few minor injuries and no major injuries recorded.
- Confidence in scheme benefits realisation is high.

7 Conclusions and evaluation summary

To conclude this report, this section summarises how the scheme is meeting its objectives and assesses the scheme's impacts against those forecast.

7.1 Evaluation summary table

The table below presents the results of this evaluation exercise compared against the forecasts which were outlined in the NDR Baseline Report.

Table 27: Comparison of indicators - forecast and actual results

Indicator		Baseline position	Y1 position
Indicator 1: Landscape integration		During the baseline investigations representative views of the NDR scheme were prepared from nine specific locations along the proposed route. These photomontages are the baseline position for this indicator.	The comparison between the Y1 photomontages and Y1 photographs illustrate that across the majority of the key viewpoint locations, the Y1 photograph largely mirrors the Y1 photomontage. The one notable exception is photomontage location 1. Here the single carriageway has been retained, with a bund provided to the north, to allow continued access to the existing BT manholes. This means the photomontage, which shows that this area should have been seeded with a species-rich wildflower mix, does not wholly match the Y1 photograph.
Indicator 2: Biodiversity and Nature Conservation	Overall comment	For Indicator 2, it appears that the scheme has not had a significant adverse impact on the biodiversity of the area. Mitigation measures appear to have had a positive impact (for instance, the installation of bat boxes and barn owl boxes have resulted in these being used). However, with only one year's worth of post-construction data it is impossible to comment upon long-term trends – for example, the observed amount of GCN is high, but this could be due to factors such as the sustained cold period prior to the breeding season and the warm weather during the data collection period.	
	Bats	• A total of ten bat species were identified over the various survey seasons (common pipistrelle; soprano pipistrelle; nathusius' pipistrelle; brown long-eared; natterer's; daubenton's; noctule; serotine; leisler's; barbastelle).	• Across all 2019 bats surveys, nine species were recorded (common pipistrelle; soprano pipistrelle; nathusius' pipistrelle; brown long-eared; natterer's; daubenton's; noctule; serotine; barbastelle). • Excluding noctules, five species were observed using the bat crossings during the surveys. • While more bats are crossing the NDR at a safe height than those crossing at an unsafe height, there is still a large proportion of bats crossing unsafely, these are at risk of vehicle collision mortality. • Out of the four surveyed locations, Quaker Farm was the only area to have no uptake in any of the bat boxes. Nine out of the 23 boxes were either in use or showed evidence of use. • No dead bats were found during any of the bat vehicle collision surveys.
	Hibernating Bats	• Hibernating bats observed at four locations	• Hibernating bats observed at three locations (military buildings in Rackheath, had no bats or signs of bat activity present).
	Great Crested Newts	• 54 ponds surveyed • 10 ponds confirmed breeding grounds • Amphibian species found at 29 ponds	• 13 ponds surveyed (ponds were GCN had previously been identified in baseline). • The number of GCN recorded within each meta-population was higher in 2018 than in 2017 (except for Quaker Farm) and in previous years. • A large population (102 peak count) was identified within the ponds at Rackheath, with medium populations identified at Dog Lane (93 peak count) and Quaker Farm (27 peak count). The counts of GCN recorded in 2018 at Dog Lane and Quaker Farm are significantly higher than average.
	Breeding Bird Survey	• 61 species of breeding birds • 11 species are Red List Birds of Conservation Concern. • 14 species are Amber List Birds of Conservation Concern.	• 55 species of breeding birds. • 14 species were recorded that are on the Red List of Birds of Conservation Concern. Of these, 9 species showed evidence of breeding. • A further 18 species were recorded that are on the Amber List of Birds of Conservation Concern. Of these, 10 species showed evidence of breeding.

Indicator		Baseline position	Y1 position
			• Whilst broad patterns may be observable in the data, long-term trends and the natural between-year variation means it is difficult to attribute any observed changes to any factor, either environmental or as a result of the construction of the road.
	Barn Owl boxes	• Nest boxes should be provided in a series parallel to the proposed route at 2km intervals and these should be placed no closer than 1.5km from the proposed road. This is equivalent to approximately 10 boxes given that the route is 20km long. • 6 occupied breeding sites • 3 roost or rest sites • 1% of county population	• 8 boxes have been erected along the route at 2km intervals • 2 additional boxes have been erected on Anglian Water land at Taverham Mill • Several of the Barn Owl boxes were installed further than 5km from the road due to issues finding appropriate locations and willing landowners • 1 Active Roost Site (ARS) • It was not possible to inspect three of the boxes • Boxes damaged by Storm Doris (February 2017) have been replaced
	Aquatic Invertebrate and Desmoulin's whorl snails	• Variety of aquatic invertebrate species across sampling sites • Population of Vertigo found at 8 sampling sites around Spring Lakes and wet woodland	• The results indicate that the area is of moderate conservation value for aquatic invertebrates, reflected in the absence of species of interest – seven 'local' species were found - and supported by the results of SAFIS analysis. • Species composition was generally similar to the baseline surveys conducted in 2008 (and subsequent re-surveys in 2013); however, a greater number of taxa recorded across the sample locations. • Vertigo moulinsiana were found to be absent from the survey area, but it is recognised that there was a population decline prior to commencement of construction.
	Reseeding at Hoary Mullein	No baseline available	Awaiting information
Indicator 3: Road drainage and water quality		Groundwater quality: • Chromium was frequently found to exceed the drinking water standard. • Groundwater in the region has a current and predicted (2015) chemical quality status of 'poor (deteriorating)'. • Groundwater also has a 'poor' quantitative status due to concerns for groundwater dependent terrestrial ecosystems. • However regional modelling predicts good quantitative and chemical status by 2027. Surface water quality: • The status of the River Wensum nearest the Scheme at Attlebridge was stated to have been at 'poor' ecological potential and failing for biological and chemical elements (Waterbody ID GB105034055881). The target for the River Wensum is to show good ecological potential by 2027.	The project did not in itself set out to improve groundwater quality, but rather ensure no detrimental effect upon the groundwater regime within the environs of the project. The monitoring regime undertaken during the construction and post construction phases has shown no negative impact upon the water quality regime within the confines of the project. The sediment control measures placed in Lenwade adjacent to the River Wensum have already shown value in reducing the ingress of sediment into the River Wensum.

Indicator	Baseline position	Y1 position
	• Spixworth Beck (Waterbody ID GB105034050960) and the River Bure (Waterbody ID GB105034050930). Both were considered to have a 'moderate' ecological potential. The target for Spixworth Beck and the River Bure is to be rated as having good ecological potential by 2027. The tidal section of the River Yare (Waterbody ID GB105034051370), located to the south of the A47, was considered to have a 'moderate' status. The target for the River Yare is to achieve good ecological status by 2027.	
Indicator 4: Reduce traffic levels and congestion	Due to the volume of data having been collected during the baseline surveys of the identified monitoring sites already shown it is not possible to fully summarise the results.	The NDR has caused some traffic increases near the western end of the scheme, as anticipated, but these are the subject of DCO Requirements 27 and 29 and being dealt with separately. Based on the extensive set of monitoring locations across the wider area, these results show that the NDR is achieving the following desirable objectives: • Reducing orbital rat running in the northern suburbs of Norwich. • Reducing orbital rat running on rural roads outside the built-up area of Norwich. • Reducing traffic flows on the roads just outside the Norwich Outer Ring Road. • Reducing traffic flows on the Norwich Outer Ring Road. • Traffic flows have decreased over the railway level crossing.
Indicator 5: Improved transport connectivity	No baseline available	Awaiting information
Indicator 8: Project cost	• Proposed Scheme Cost (£m) as at DCO: £121.8 • Anticipated cost at construction: £151.250	Revised budget following approval for increased budget: £205m.
Indicator 9: Project programme	• NDR to open in Q1 of 2018.	Although there were slippages and delays in the programme for certain elements, as discussed in detail in the Process Evaluation report, the overall aim of opening the NDR in Q1 of 2018 was achieved.
Indicator 10: Consultations for Process Evaluations	N/A	Based on this evidence and the stakeholder consultations undertaken, the following key conclusions can be drawn: • The NDR scheme has been received positively by the public and key stakeholders since it has been completed and opened to traffic. • The DCO process proved to be a difficult system through which to deliver a major infrastructure project given the inability to make any material changes post submission and the lack of experience in completing the process. • The NDR scheme was well managed on the whole but suffered from delays/slippages in the programme as well as financial issues resulting in overspend. • The NDR scheme had an excellent safety record with very few minor injuries and no major injuries recorded. • Confidence in scheme benefits realisation is high.

Source: Mott MacDonald, NCC

7.2 Concluding remarks

The OYA report has established that many of the indicators used to demonstrate the effects of the NDR scheme are delivering as predicted or better than predicted. This shows that the NDR scheme is meeting its objectives in these areas. This is especially shown by Indicator 4 as the NDR scheme has shown to contribute towards reducing orbital rat running and reducing traffic flows in key areas of the road network. Some indicators (such as some elements of Indicator 2) are more long-term and it was not expected that they would reach their full potential in the first year.

Further assessment to track the progress of all indicators is necessary to establish how the scheme meets and maintains the targets set in the Baseline Report.

The Process Evaluation developed a nuanced and detailed picture of the design and delivery of the NDR. Using information from a variety of sources (including stakeholder consultations, Project Board reports and independent performance reviews), the following three findings emerged:

- The NDR scheme has been received positively by the public and key stakeholders since it has been completed and opened to traffic.
- The DCO process proved to be a difficult system through which to deliver a major infrastructure project according to many consultees involved given the inability to make any changes post submission and the lack of experience in completing the process.
- The NDR scheme was well managed on the whole but suffered from delays/slippages in the programme as well as financial issues resulting in overspend.
- The NDR scheme had an excellent safety record with very few minor injuries and no major injuries recorded.
- Confidence in scheme benefits realisation is high.

When comparing the full range of evidence assembled in this report it is a fair conclusion to say that the NDR – in terms of its process for delivery and wider impacts – is broadly positive one-year after construction completed and the road opened to traffic. The capital costs are higher than anticipated but the reasons for this are now understood and despite some delays at points in the construction process, the road was delivered on time. Traffic impacts are being observed to be in-line with expectations and the various wildlife species monitored and recorded along the route of the NDR appear to be adjusting to the road's presence and with the help of mitigation measures no significant detrimental effect has been observed.

Glossary

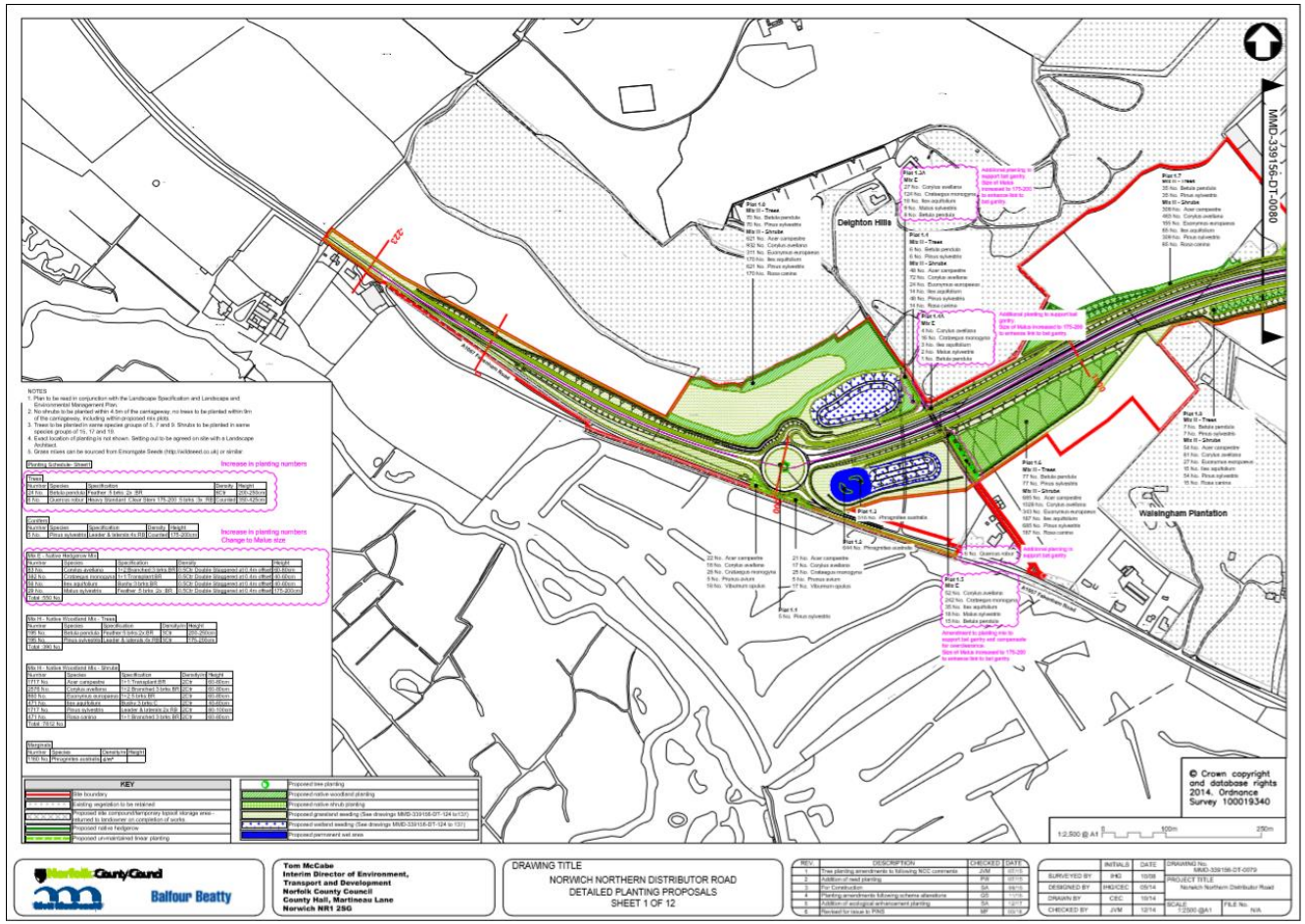
AADT	Annual Average Daily Traffic
ATC	Automatic Traffic Counters
BAFB	Best and Final Funding Bid
DCO	Development Consent Order
DfT	Department for Transport
ECI	Early Contractor Involvement
EPS	European Protected Species
GCN	Great Crested Newt
GNES	Greater Norwich Economic Strategy
JCS	Joint Core Strategy
M&EP	Monitoring and Evaluation Plan
NCC	Norwich County Council
NDR	Northern Distributor Road
NEC	New Engineering Contract
OYA	One Year After
PRF	Potential Roost Features
SPO	Spatial Planning Objective
SAFIS	Site Analysis for Freshwater Invertebrate Surveys
ZVI	Zone of Visual Influence

A. Landscaping

Appendix A: Indicator 1: Landscape Integration

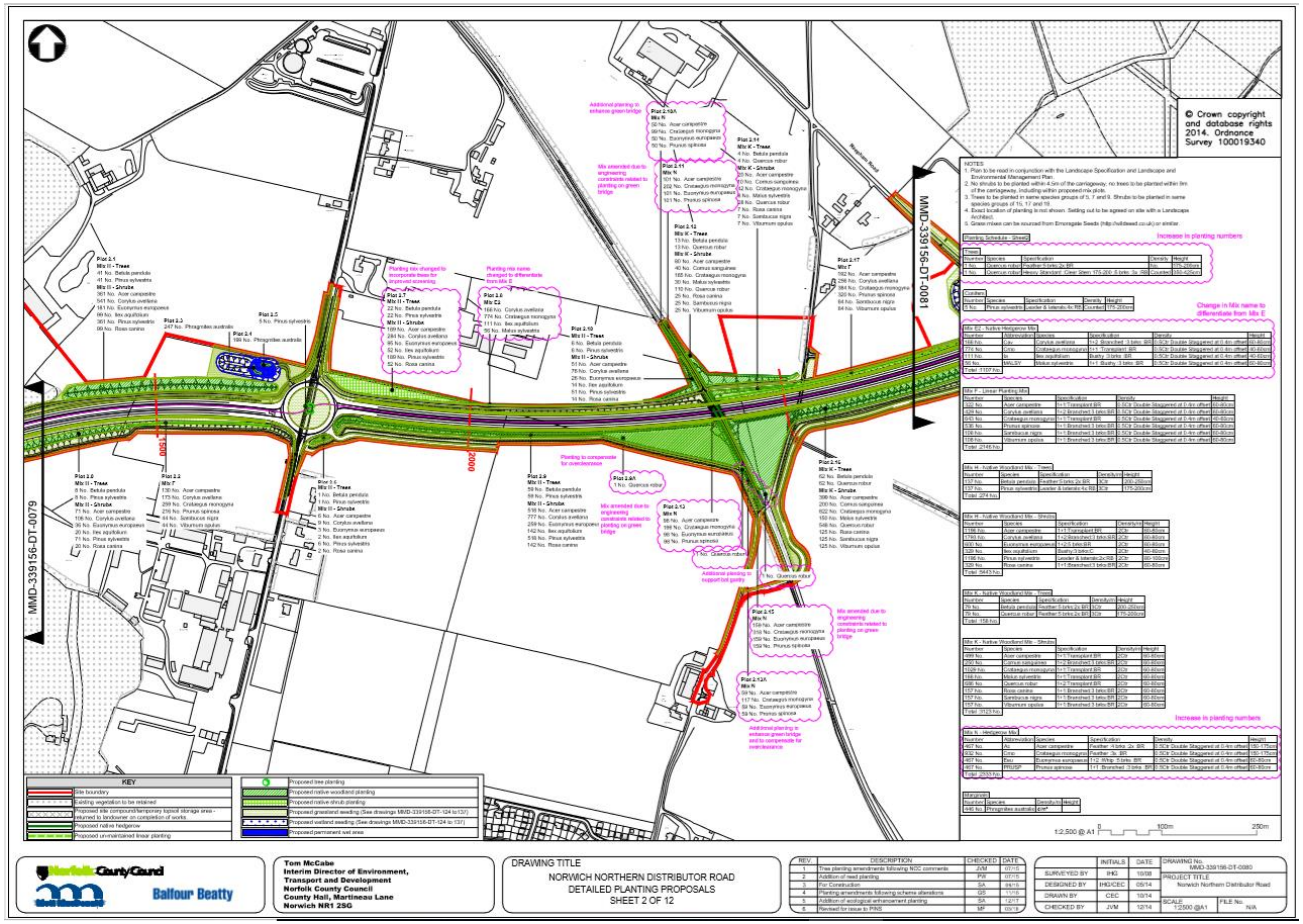
Appendix A contains the detailed planting proposals (as-built). Where plans differ from the original drawings in the Environmental Statement, the difference is highlighted with a revision cloud and details of the reason for the change noted on the drawings

Figure A1: Norwich NDR Detailed Planting Proposals 1



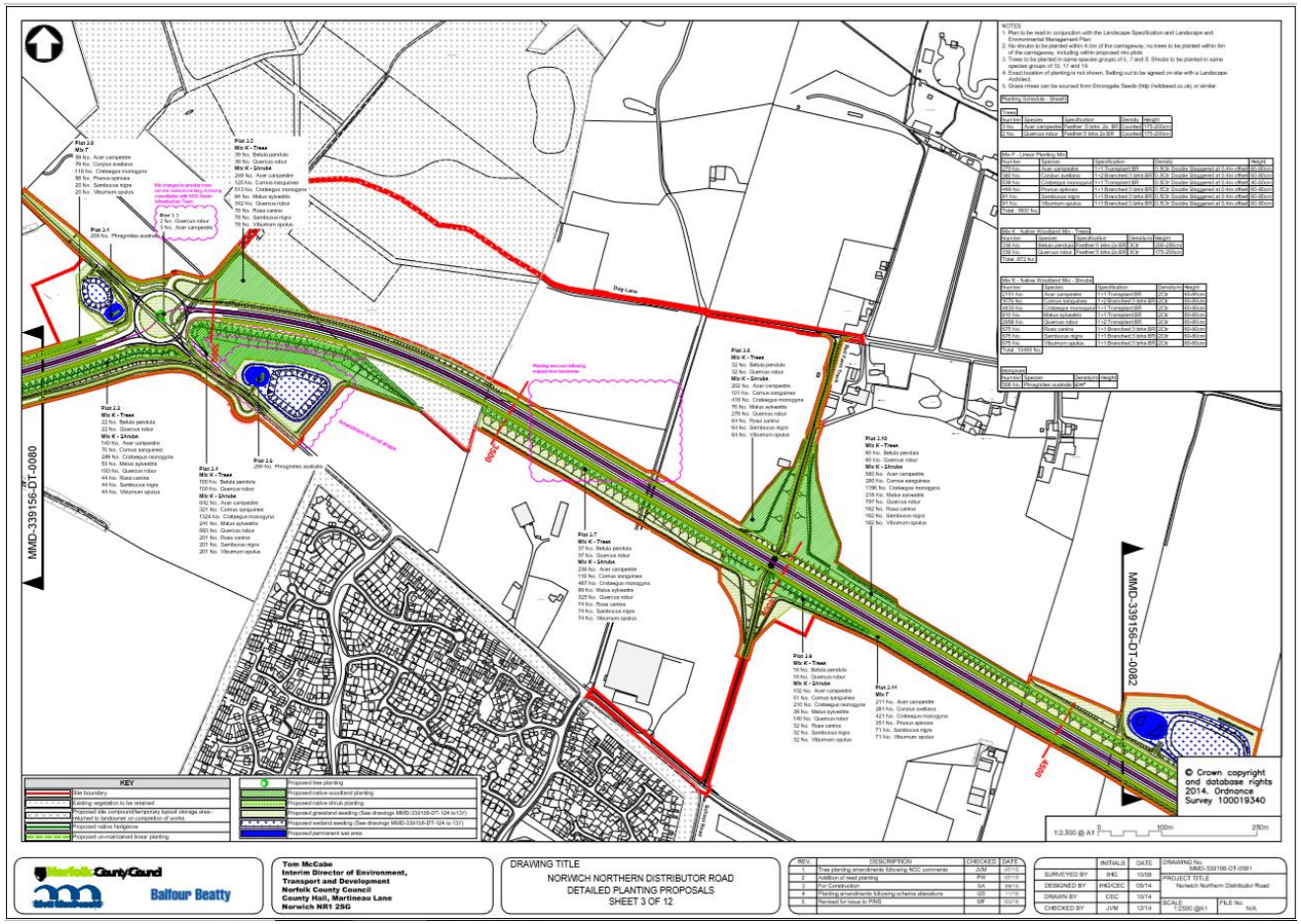
Source: Norwich Northern Distributor Road: Landscape Monitoring Report

Figure A2: Norwich NDR Detailed Planting Proposals 2



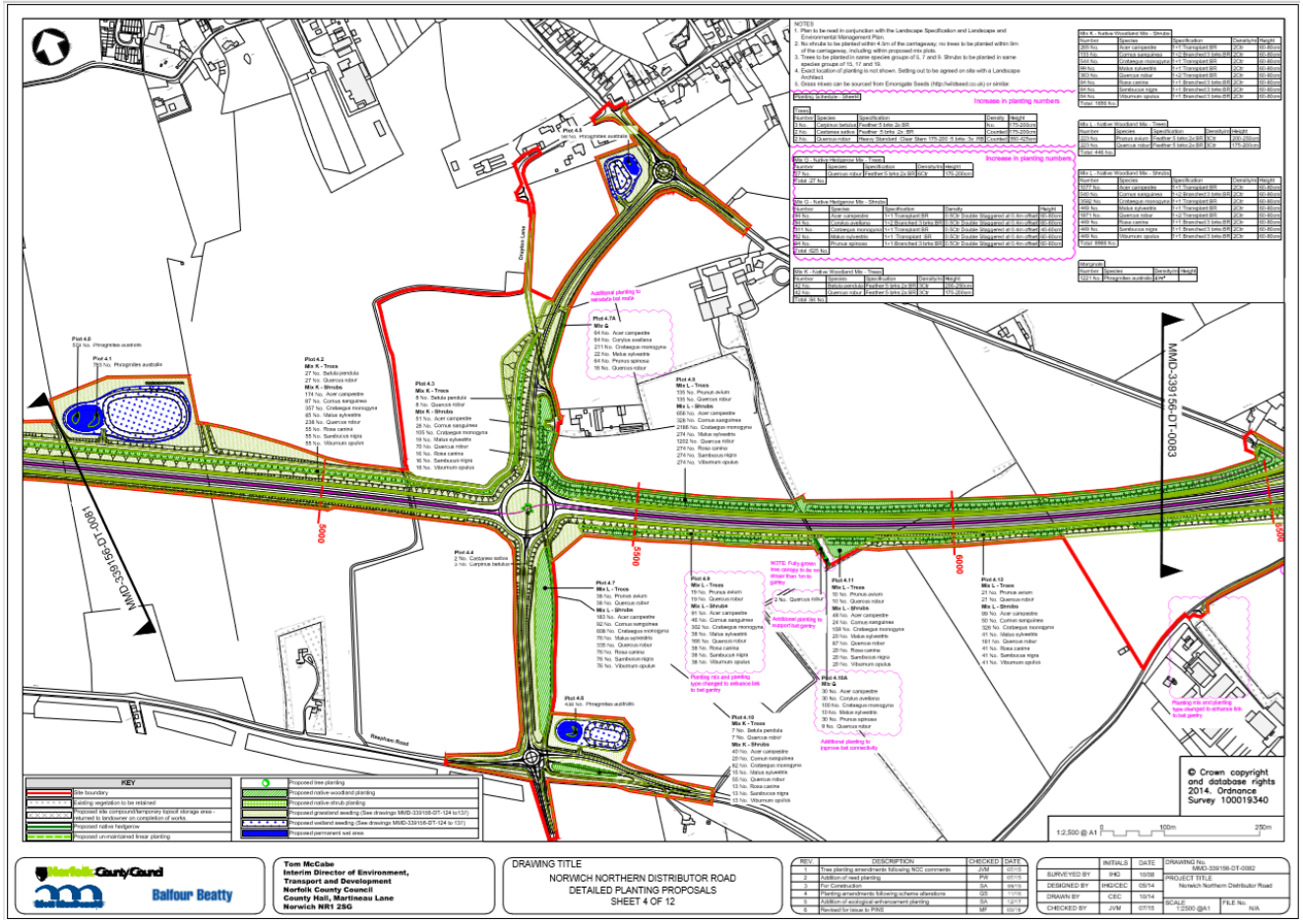
Source: Norwich Northern Distributor Road: Landscape Monitoring Report

Figure A3: Norwich NDR Detailed Planting Proposals 3



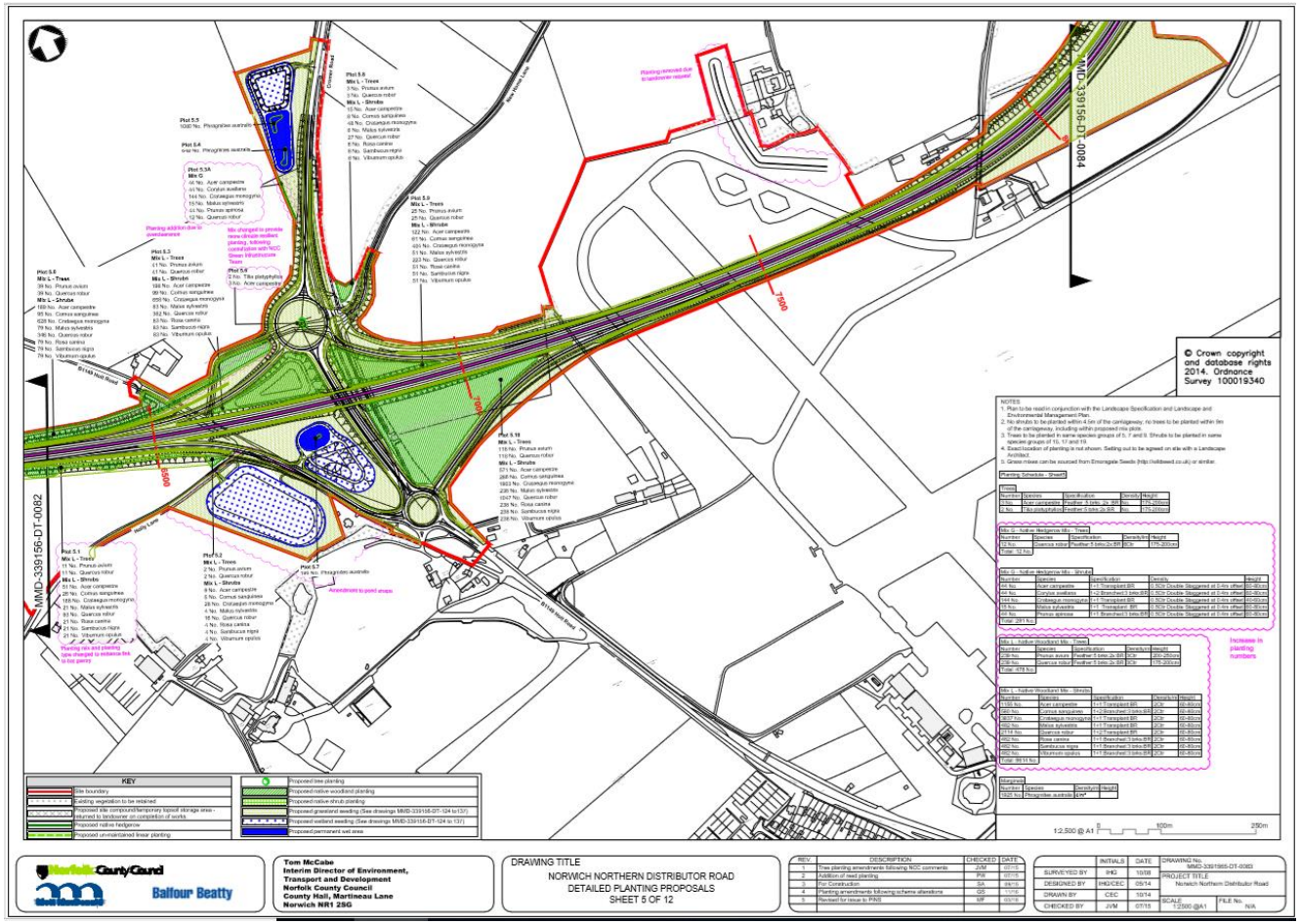
Source: Norwich Northern Distributor Road: Landscape Monitoring Report

Figure A4: Norwich NDR Detailed Planting Proposals 4



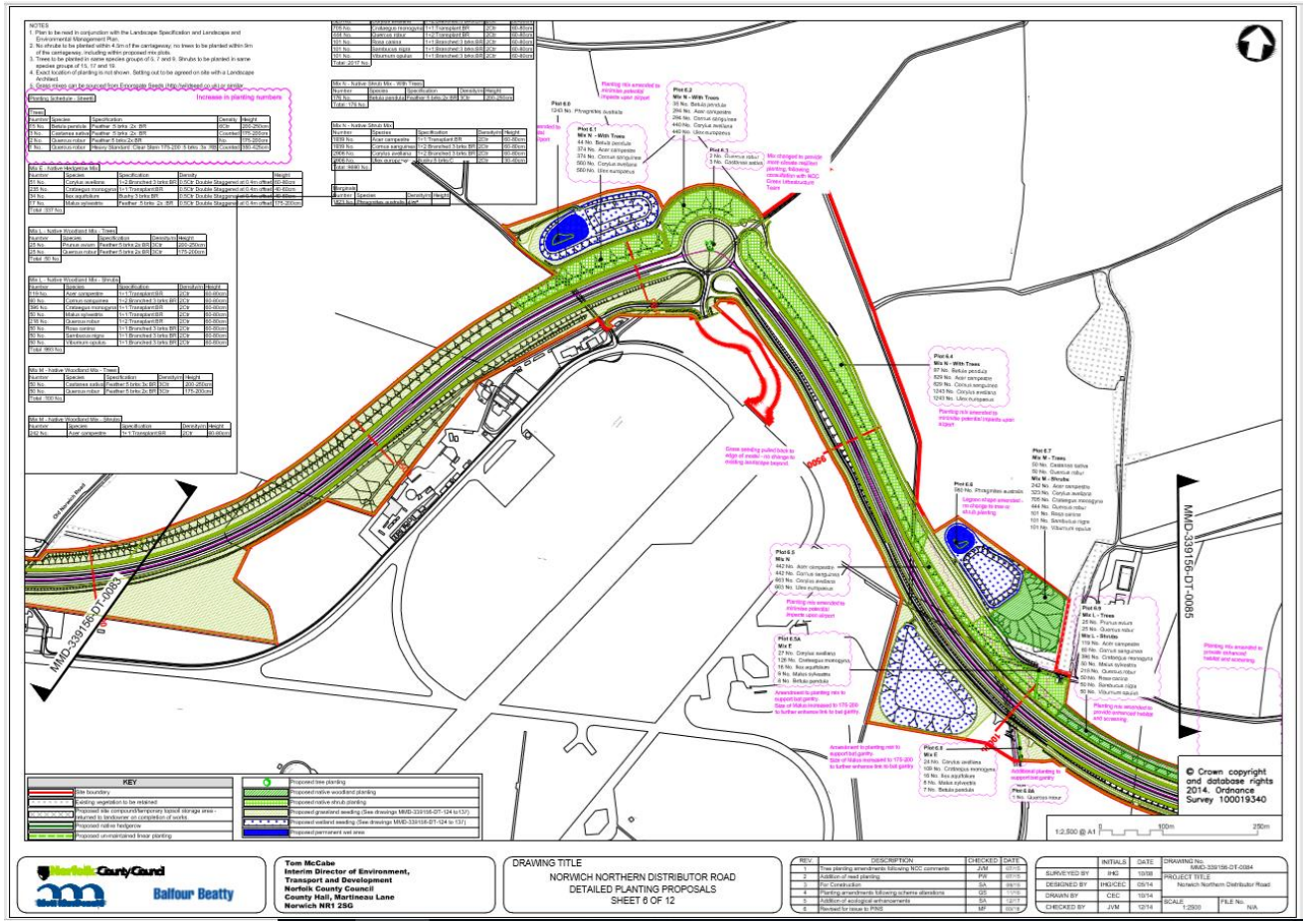
Source: Norwich Northern Distributor Road: Landscape Monitoring Report

Figure A5: Norwich NDR Detailed Planting Proposals 5



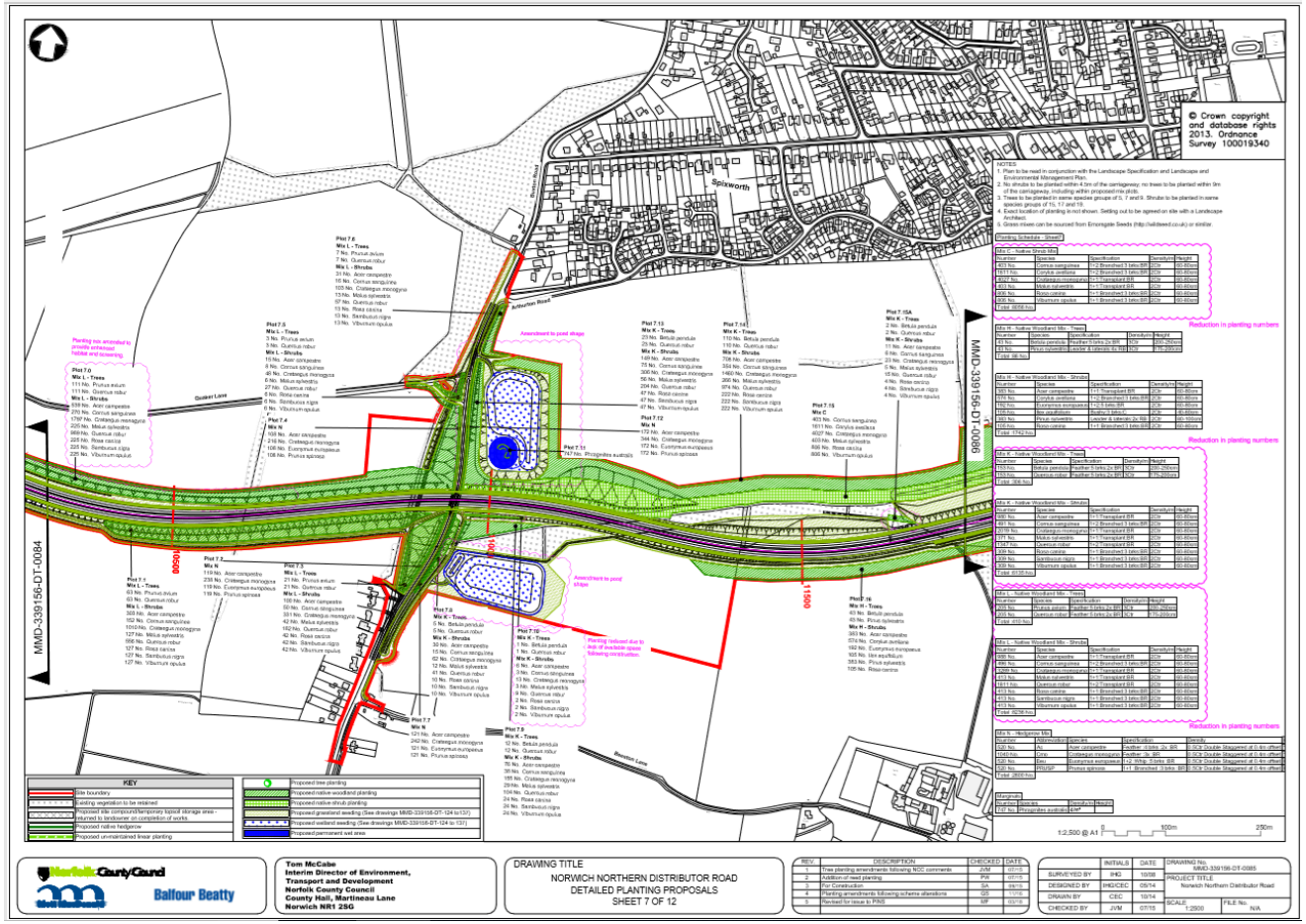
Source: Norwich Northern Distributor Road: Landscape Monitoring Report

Figure A6: Norwich NDR Detailed Planting Proposals 6



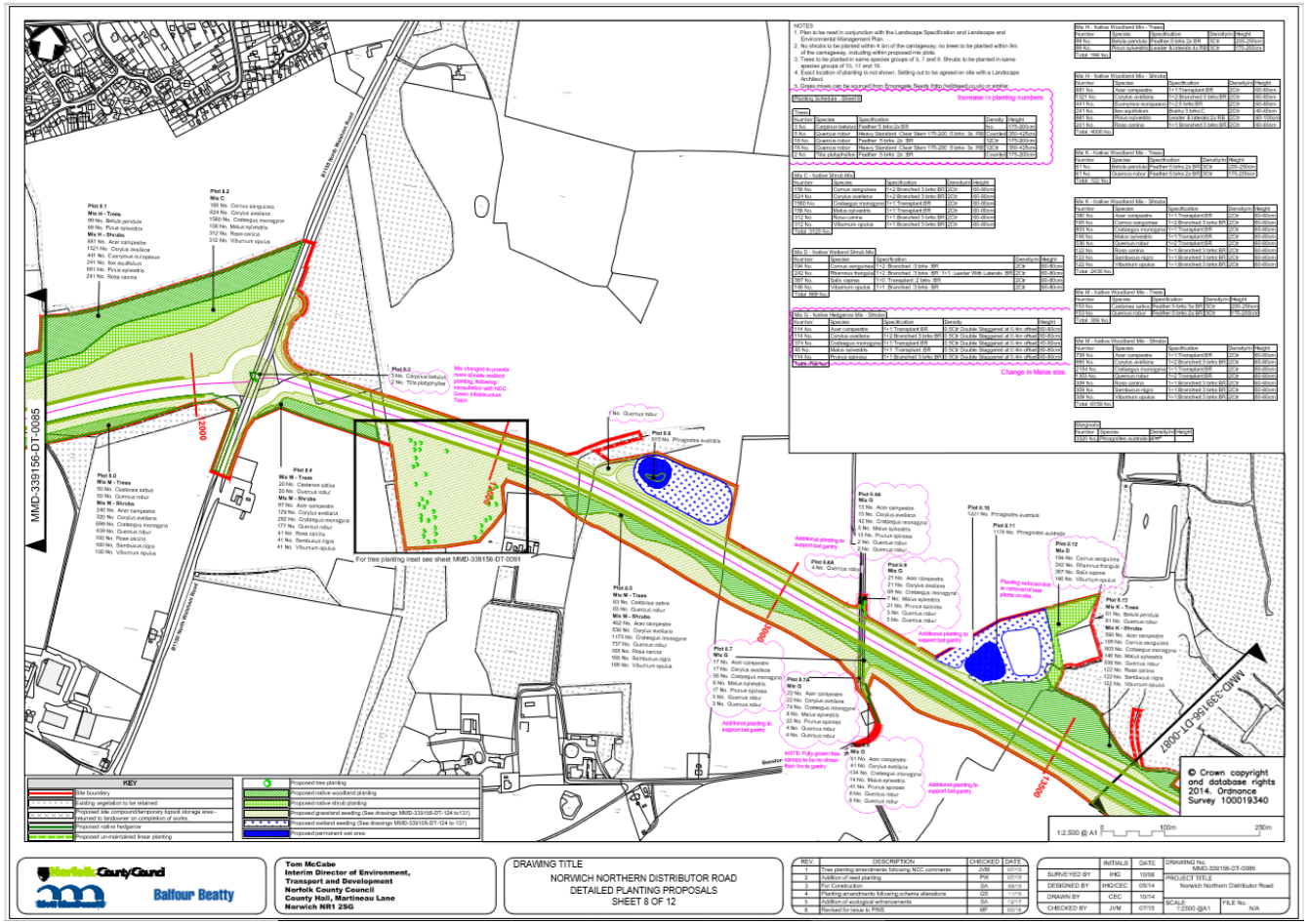
Source: Norwich Northern Distributor Road: Landscape Monitoring Report

Figure A7: Norwich NDR Detailed Planting Proposals 7



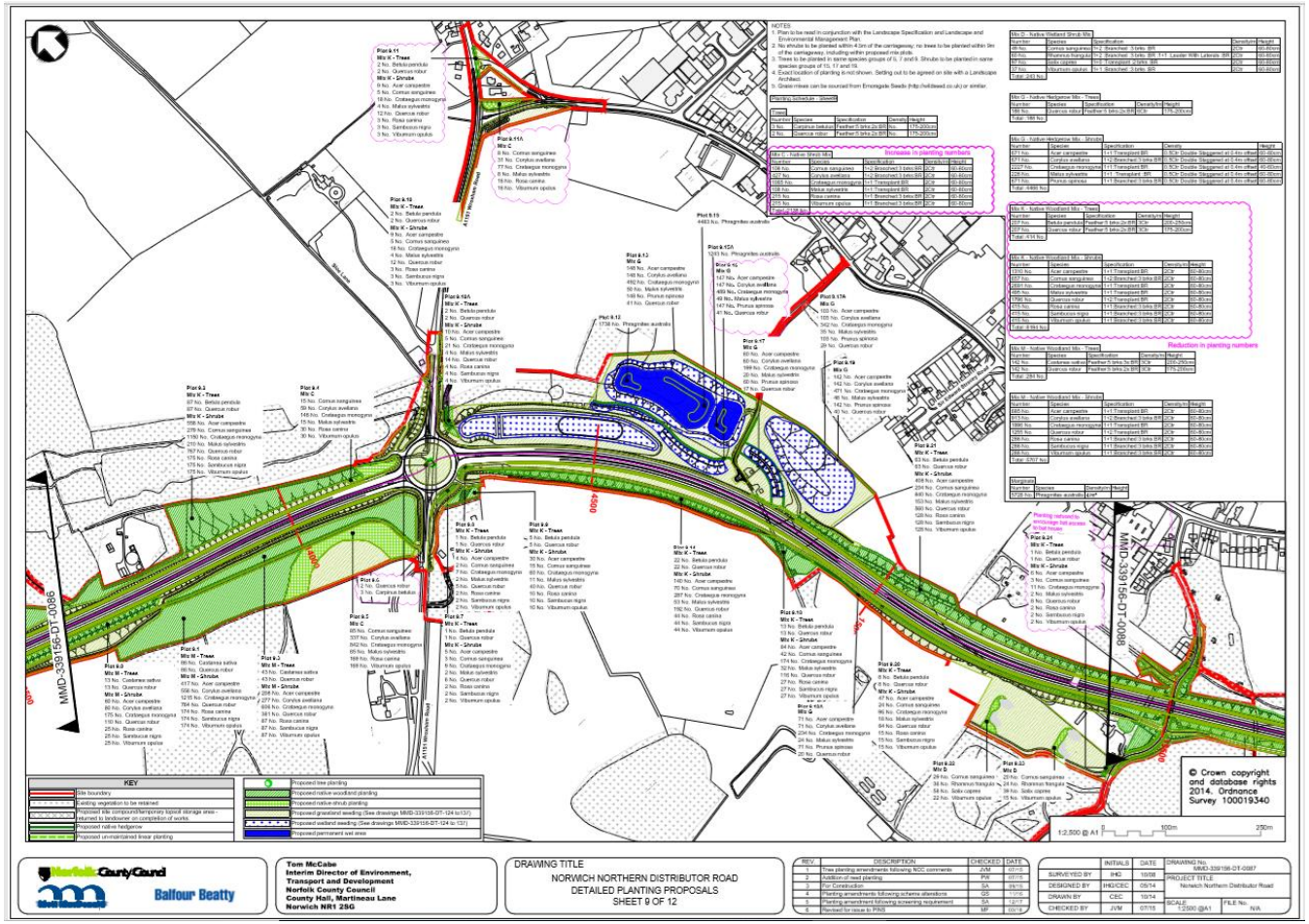
Source: Norwich Northern Distributor Road: Landscape Monitoring Report

Figure A8: Norwich NDR Detailed Planting Proposals 8



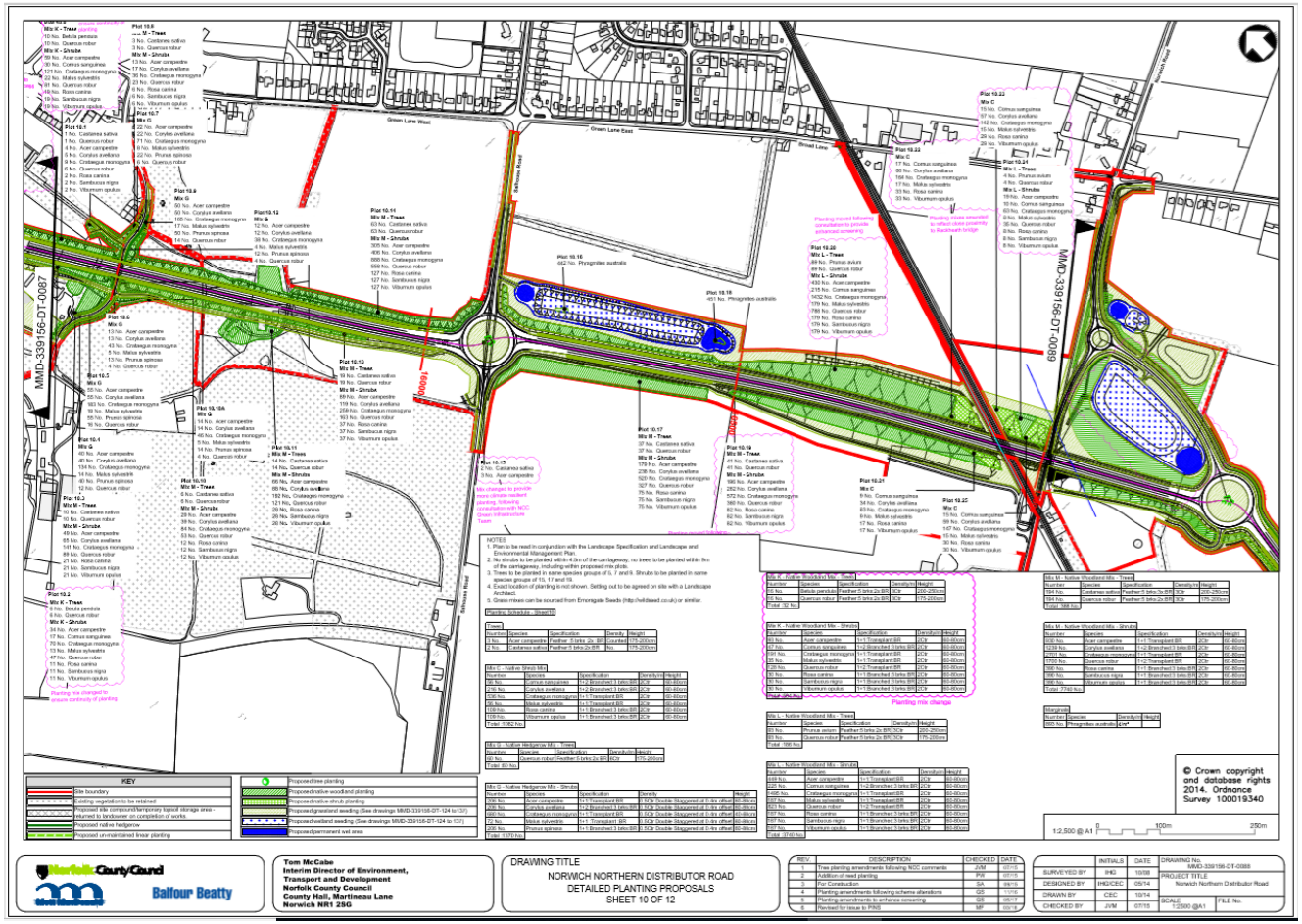
Source: Norwich Northern Distributor Road: Landscape Monitoring Report

Figure A9: Norwich NDR Detailed Planting Proposals 9



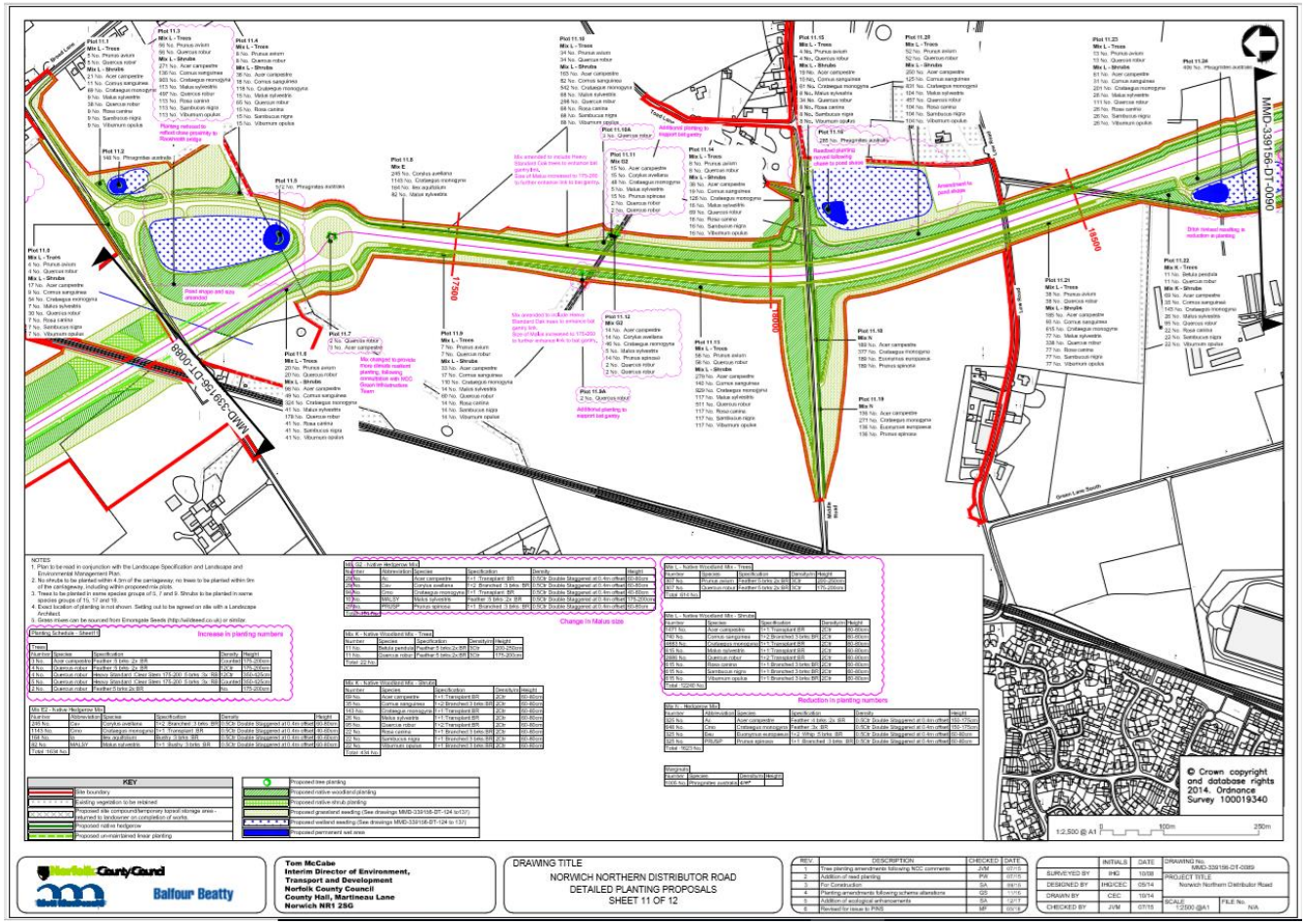
Source: Norwich Northern Distributor Road: Landscape Monitoring Report

Figure A10: Norwich NDR Detailed Planting Proposals 10



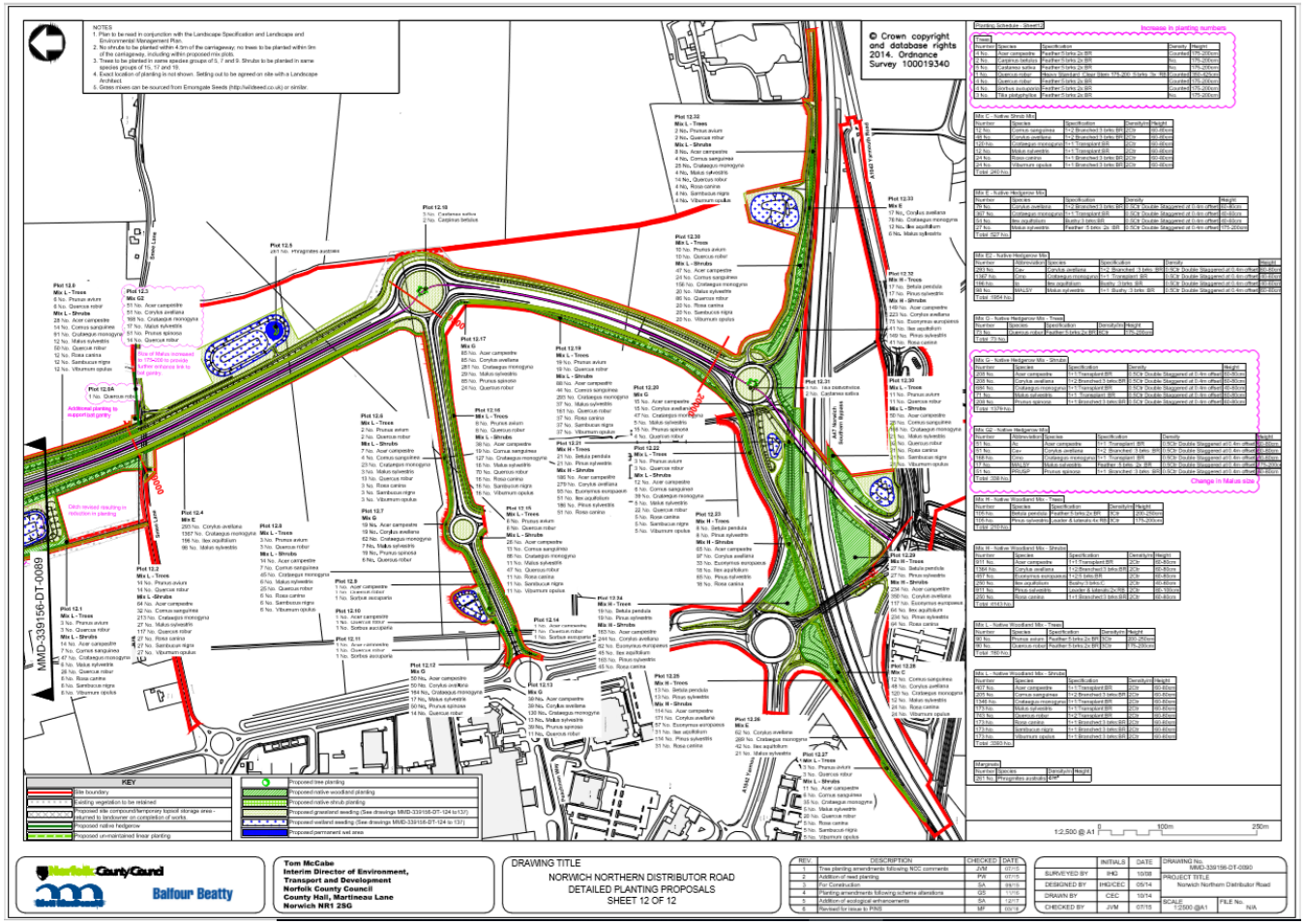
Source: Norwich Northern Distributor Road: Landscape Monitoring Report

Figure A11: Norwich NDR Detailed Planting Proposals 11



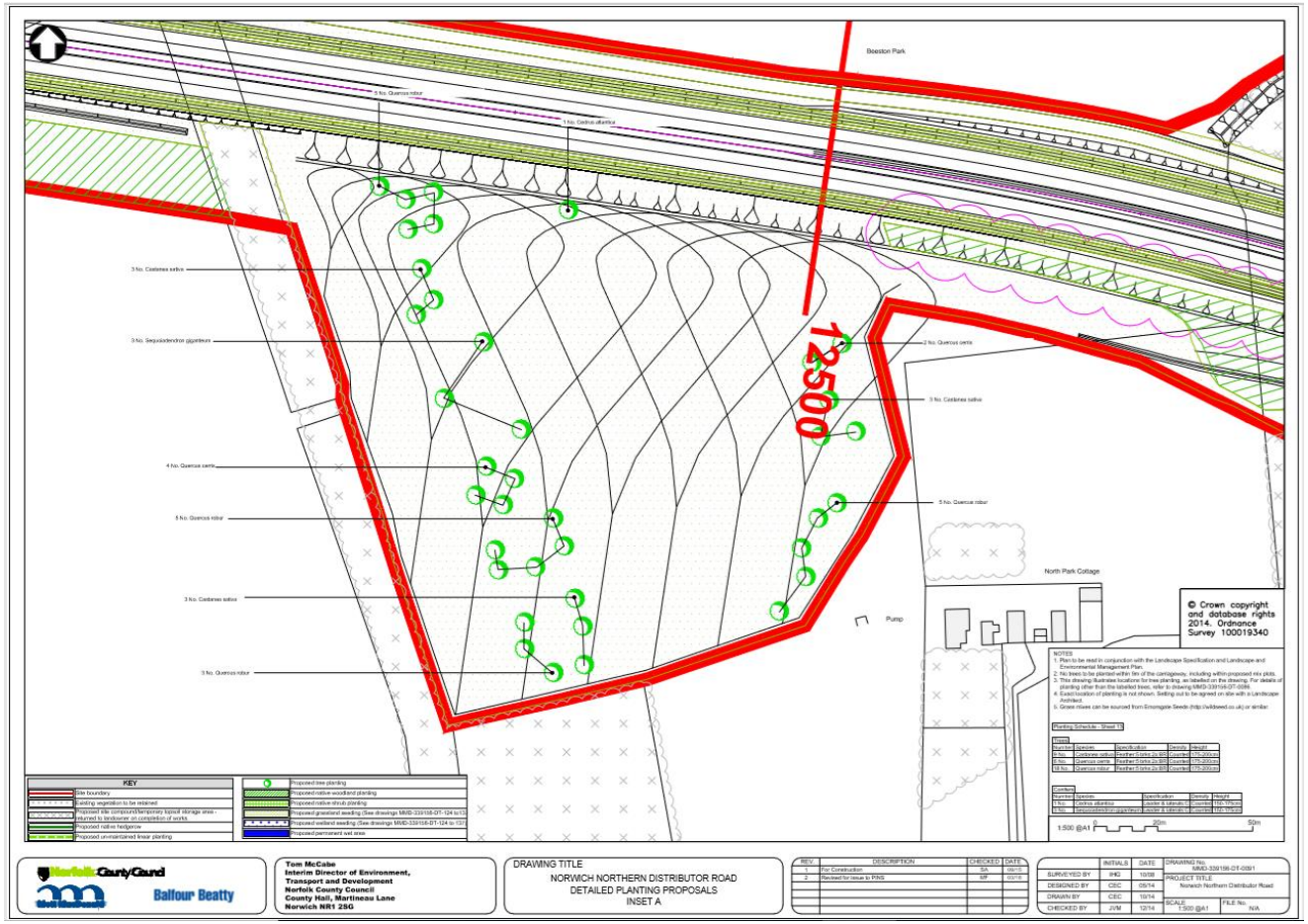
Source: Norwich Northern Distributor Road: Landscape Monitoring Report

Figure A12: Norwich NDR Detailed Planting Proposals 12



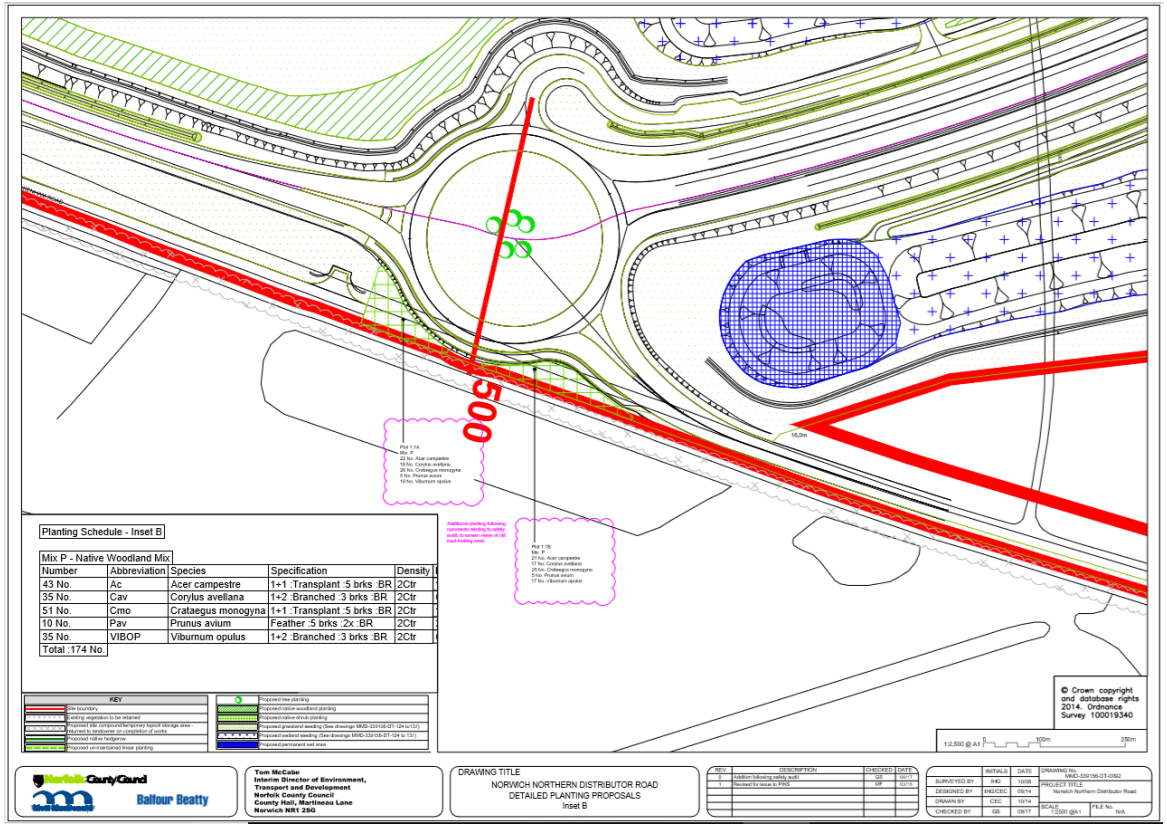
Source: Norwich Northern Distributor Road: Landscape Monitoring Report

Figure A13: Norwich NDR Detailed Planting Proposals Inset A



Source: Norwich Northern Distributor Road: Landscape Monitoring Report

Figure A14: Norwich NDR Detailed Planting Proposals Inset B



Source: Norwich Northern Distributor Road: Landscape Monitoring Report

B. Biodiversity and Nature Conservation

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Appendix B: Indicator 2: Biodiversity and Nature Conservation

1 NDR Ecological Post-Construction Monitoring – Bats

Table B1: Survey conditions for manned static surveys of crossing

Location	Date	Time	Starting temperature (ºC)	Weather conditions	Cloud cover
G1	14/06/2018	AM	15	Moderate breeze, intermittent light rain	8/8
	06/07/2018	AM	17	Dry, misty	8/8
	24/07/2018	PM	23	Still, dry	0/8
G2	06/06/2018	PM	13	Slight breeze, dry	3/8
	25/07/2018	AM	17	Slight breeze, dry	2/8
	29/08/2018	AM	14	Slight breeze	4/8
G3	08/06/2018	AM	12	Slight breeze, dry	8/8
	14/06/2018	PM	21	Slight breeze, intermittent light rain	8/8
	04/07/2018	AM	11	Still, dry	6/8
G4	07/06/2018	PM	15	Still, dry	4/8
	03/07/2018	AM	15	Still, dry	0/8
	23/07/2018	PM	27	Slight breeze, dry	0/8
G5	07/06/2018	PM	12	Slight breeze, dry	7/8
	03/07/2018	AM	16	Slight breeze, dry	0/8
	23/07/2018	PM	26	Dry	0/8
G6	07/06/2018	AM	12	Slight breeze, dry	0/8
	02/07/2018	PM	17	Slight breeze	0/8
	25/07/2018	AM	20	Still, dry	0/8
G7	03/07/2018	PM	19	Still, dry	1/8
	24/07/2018	PM	24	Slight breeze	7/8
	27/08/2018	AM	20	Still	0/8
GB1	26/04/2018	PM	13	Slight breeze, dry	2/8
	04/07/2018	AM	16	Still, dry	1/8
	27/07/2018	AM	19	Slight breeze, dry	2/8
GB2	22/05/2018	PM	14	Dry	0/8
	02/07/2018	AM	20	Still, dry	4/8
	25/07/2018	AM	17	Dry	0/8
GB3	08/06/2018	AM	12	Slight breeze, dry	0/8
	04/07/2018	AM	12	Dry	2/8

Location	Date	Time	Starting temperature (ºC)	Weather conditions	Cloud cover
	24/07/2018	PM	19	Slight breeze, dry	1/8
DC1	13/06/2018	AM	12	Slight breeze, dry	0/8
	03/07/2018	PM	18	Slight breeze, dry	7/8
	26/07/2018	AM	19	Slight breeze, dry	4/8
UN1	13/06/2018	AM	12	Dry	0/8
	03/07/2018	PM	17	Dry, moderate breeze	7/8
	26/07/2018	AM	12	Still, dry	1/8

Source: NDR Ecological Post-Construction Monitoring – Bats

Table B2: Survey conditions for roost counts

Roosts	Survey	Date	Starting temperature (ºC)	Weather	Cloud cover
Roost 1 – B5	1	12/06/2018	15	Still	7/8
	2	30/08/2018	18	Slight breeze	4/8
Roost 2 – B55	1	13/06/2018	19	Moderate breeze, dry	8/8
	2	25/07/2018	20	Slight breeze, dry	6/8
Roost 3 – GB5	1	14/06/2018	16	Still, dry	1/8
	2	17/09/2018	21	Slight breeze, dry	1/8
Roost 4 – B81	1	05/07/2018	20	Slight breeze, dry	0/8
	2	03/09/2018	19	Still, dry	1/8
Roost 5 – B82	1	05/07/2018	21	Still, dry	8/8
	2	03/09/2018	19	Still, dry	1/8
Roost 6 – B85	1	04/07/2018	19	Still, dry	3/8
	2	18/09/2018	21	Slight breeze, dry	4/8
Roost 7 – B90	1	04/07/2018	19	Still, dry	1/8
	2	15/08/2018	19	Still, dry	4/8
Roost 8 – W11B	1	TREE FELLED			
	2	TREE FELLED			
Roost 9 – W11D	1	11/06/2018	17	Slight breeze, dry	4/8
	2	16/08/2018	19	Still, dry	4/8
Roost 10 – W11N	1	11/06/2018	17	Slight breeze, dry	4/8
	2	16/08/2018	19	Still, dry	4/8
Roost 11 – 475B	1	24/07/2018	23	Slight breeze, dry	6/8
	2	06/09/2018	16	Slight breeze, dry	2/8
Roost 12 - 490	1	23/07/2018	27	Slight breeze, dry	4/8
	2	16/08/2018	16	Moderate breeze, humid	4/8
Roost 13 - 290	1	15/08/2018	24	Slight breeze, dry	7/8
	2	04/09/2018	16	Slight breeze, dry	1/8
Roost 14 - 511	1	16/08/2018	18	Moderate breeze, dry	2/8
	2	06/09/2018	15	Still, dry	4/8
Roost 15 - 380	1	24/07/2018	24	Slight breeze, dry	2/8

Roosts	Survey	Date	Starting temperature (ºC)	Weather	Cloud cover
	2	14/08/2018	23	Slight breeze, dry	3/8
Roost 16 - 415	1	26/07/2018	23	Still, dry	0/8
	2	04/09/2018	17	Slight breeze, dry	2/8
Roost 17 - 451	1	26/07/2018	25	Slight breeze, dry	2/8
	2	04/09/2018	17	Slight breeze, dry	2/8

Source: NDR Ecological Post-Construction Monitoring – Bats

Table B3: Static detector results

Location	Species	Inside total count	Outside total count	Inside nightly mean	Outside nightly mean
G1	Barbastelle	1	4	0.08	0.5
G1	Serotine	2	3	0.17	0.38
G1	Daubenton's bat	4	9	0.33	1.13
G1	Natterer's bat	3	6	0.25	0.75
G1	Myotis	6	5	0.5	0.63
G1	Noctule	134	55	11.17	6.88
G1	Nathusius' pipistrelle	2	1	0.17	0.13
G1	Common pipistrelle	156	172	13	21.63
G1	Soprano pipistrelle	144	96	12	12
G1	Brown long eared bat	48	68	4	8.5
G2	Barbastelle	69	101	6.9	12.63
G2	Serotine	6	3	0.6	0.38
G2	Daubenton's bat	5	3	0.5	0.38
G2	Natterer's bat	6	2	0.6	0.25
G2	Myotis	9	0	0.9	0
G2	Noctule	29	49	2.9	6.13
G2	Nathusius' pipistrelle	0	2	0	0.25
G2	Common pipistrelle	339	755	33.9	94.38
G2	Soprano pipistrelle	200	81	20	10.13
G2	Brown long eared bat	31	41	3.1	5.13
G3	Barbastelle	5	129	0.5	10.75
G3	Serotine	1	6	0.1	0.5
G3	Daubenton's bat	1	4	0.1	0.33
G3	Natterer's bat	1	2	0.1	0.17
G3	Myotis	2	11	0.2	0.92
G3	Noctule	22	64	2.2	5.33
G3	Nathusius' pipistrelle	1	1	0.1	0.08
G3	Common pipistrelle	1300	481	130	40.08
G3	Soprano pipistrelle	572	70	57.2	5.83
G3	Brown long eared bat	6	64	2.2	5.33
G4	Barbastelle	1	18	0.13	1.8

Location	Species	Inside total count	Outside total count	Inside nightly mean	Outside nightly mean
G4	Serotine	3	9	0.38	0.9
G4	Daubenton's bat	15	16	1.88	1.6
G4	Natterer's bat	0	2	0	0.2
G4	Myotis	4	18	0.5	1.8
G4	Noctule	36	15	4.5	1.5
G4	Nathusius' pipistrelle	1	2	0.13	0.2
G4	Common pipistrelle	254	1436	31.75	143.6
G4	Soprano pipistrelle	455	716	56.88	71.6
G4	Brown long eared bat	4	7	0.5	0.7
G5	Barbastelle	10	12	0.83	1
G5	Serotine	4	4	0.33	0.33
G5	Daubenton's bat	4	2	0.33	0.17
G5	Natterer's bat	2	0	0.17	0
G5	Myotis	0	2	0	0.17
G5	Noctule	36	28	3	2.33
G5	Nathusius' pipistrelle	14	4	1.17	0.33
G5	Common pipistrelle	128	203	10.67	16.92
G5	Soprano pipistrelle	255	195	21.25	16.25
G5	Brown long eared bat	8	1	0.67	0.08
G6	Barbastelle	17	18	2.13	2.25
G6	Serotine	4	3	0.5	0.38
G6	Daubenton's bat	4	3	0.5	0.38
G6	Natterer's bat	1	0	0.13	0
G6	Myotis	5	3	0.63	0.38
G6	Noctule	104	30	13	3.75
G6	Nathusius' pipistrelle	6	5	0.75	0.63
G6	Common pipistrelle	207	153	25.88	19.13
G6	Soprano pipistrelle	137	93	17.13	11.63
G6	Brown long eared bat	23	12	2.88	1.5
G7	Barbastelle	51	11	4.25	0.92
G7	Serotine	5	7	0.42	0.58
G7	Daubenton's bat	11	0	0.92	0
G7	Natterer's bat	0	0	0	0
G7	Myotis	12	15	1	1.25
G7	Noctule	56	45	4.67	3.75
G7	Nathusius' pipistrelle	838	11	69.83	0.92
G7	Common pipistrelle	2308	3057	192.33	254.75
G7	Soprano pipistrelle	445	814	37.08	67.83
G7	Brown long eared bat	16	6	1.33	0.5
GB1	Barbastelle	3	4	0.25	0.33

Location	Species	Inside total count	Outside total count	Inside nightly mean	Outside nightly mean
GB1	Serotine	5	4	0.42	0.33
GB1	Daubenton's bat	0	0	0	0
GB1	Natterer's bat	0	0	0	0
GB1	Myotis	9	8	0.75	0.67
GB1	Noctule	52	53	4.33	4.42
GB1	Nathusius' pipistrelle	20	31	0	2.58
GB1	Common pipistrelle	1211	1134	100.92	94.5
GB1	Soprano pipistrelle	122	79	10.17	6.58
GB1	Brown long eared bat	33	27	2.75	2.25
GB2	Barbastelle	2	2	0.29	0.25
GB2	Serotine	3	5	0.43	0.63
GB2	Daubenton's bat	1	0	0.14	0
GB2	Natterer's bat	0	0	0	0
GB2	Myotis	1	6	0.14	0.75
GB2	Noctule	163	270	23.29	33.75
GB2	Nathusius' pipistrelle	5	4	0.71	0.5
GB2	Common pipistrelle	56	93	8	11.63
GB2	Soprano pipistrelle	10	41	1.43	5.13
GB2	Brown long eared bat	4	5	0.57	0.63
DC1	Barbastelle	9	7	0.75	0.58
DC1	Serotine	0	2	0	0.17
DC1	Daubenton's bat	1	4	0.08	0.33
DC1	Natterer's bat	1	0	0.08	0
DC1	Myotis	2	3	0.17	0.25
DC1	Noctule	55	34	4.58	2.83
DC1	Nathusius' pipistrelle	4	4	0.33	0.33
DC1	Common pipistrelle	637	472	53.08	39.33
DC1	Soprano pipistrelle	32	27	2.67	2.25
DC1	Brown long eared bat	24	21	2	1.75
DC2	Barbastelle	4	6	0.33	0.5
DC2	Serotine	22	39	1.83	3.25
DC2	Daubenton's bat	11	12	0.92	1
DC2	Natterer's bat	7	2	0.58	0.17
DC2	Myotis	10	3	0.83	0.25
DC2	Noctule	617	1402	51.42	116.83
DC2	Nathusius' pipistrelle	8	14	0.67	1.17
DC2	Common pipistrelle	426	396	35.5	33
DC2	Soprano pipistrelle	130	119	10.83	9.92
DC2	Brown long eared bat	165	151	13.75	12.58
UN1	Barbastelle	1	6	0.13	0.5

Location	Species	Inside total count	Outside total count	Inside nightly mean	Outside nightly mean
UN1	Serotine	34	27	4.25	2.25
UN1	Daubenton's bat	23	15	2.88	1.25
UN1	Natterer's bat	1	5	0.13	0.42
UN1	Myotis	10	31	1.25	2.58
UN1	Noctule	81	128	10.13	10.67
UN1	Nathusius' pipistrelle	4	8	0.5	0.67
UN1	Common pipistrelle	279	219	34.88	18.25
UN1	Soprano pipistrelle	273	446	34.13	37.17
UN1	Brown long eared bat	17	8	2.13	0.67

Source: NDR Ecological Post-Construction Monitoring – Bats

Table B4: Bat activity for manned crossing surveys

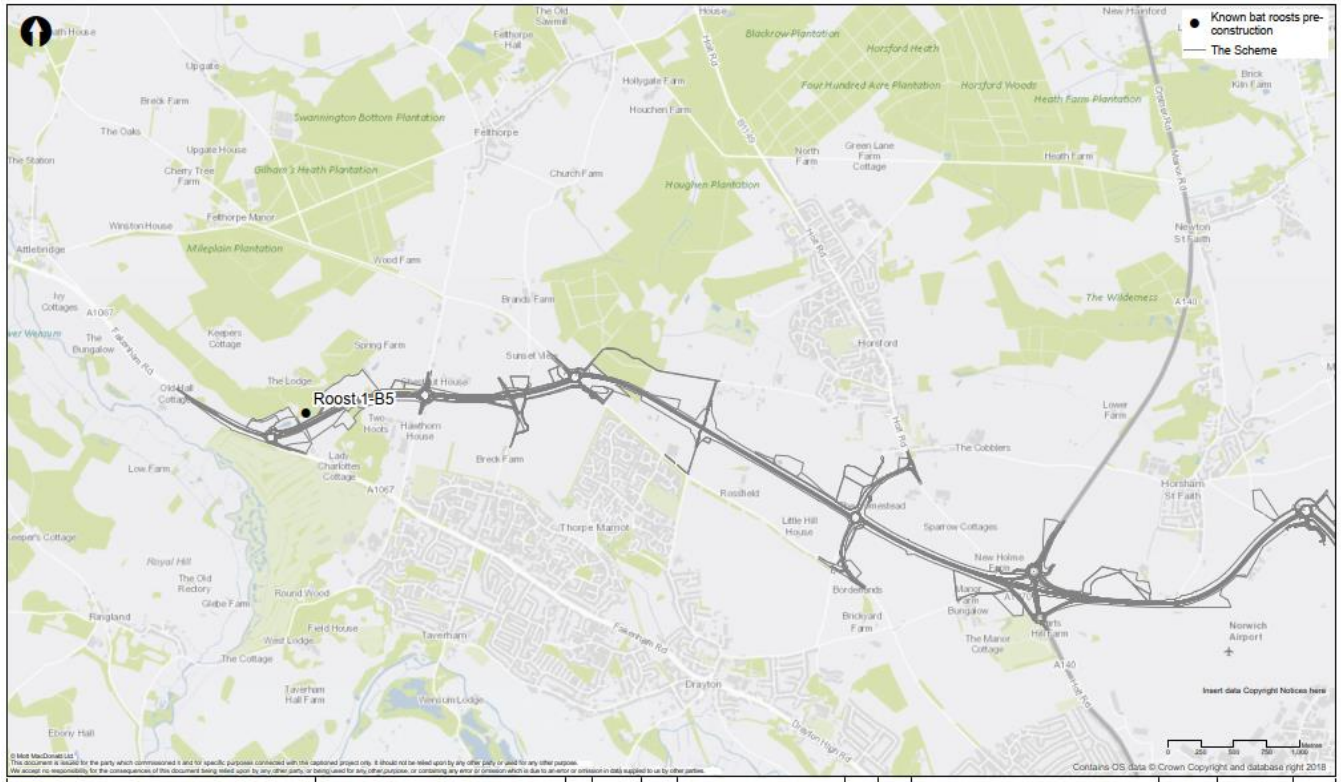
Location	Date	Species recorded inside	Species recorded outside
G1	14/06/2018	8 noctules, 1 soprano pipistrelle 3 common pipistrelle, 1 barbastelle, 3 brown long-eared bat	1 brown long-eared bat, 2 soprano pipistrelle, 14 noctule
G1	06/07/2018	3 common pipistrelle, 5 soprano pipistrelle, 4 brown long-eared bat, 1 Daubenton's bat, 5 noctule	10 noctule, 20 common pipistrelle, 8 soprano pipistrelle, 3 brown longeared bat
G1	24/07/2018	5 common pipistrelle, 3 soprano pipistrelles	2 50 pipistrelles, 3 noctule, 3 common pipistrelle, 4 soprano pipistrelle
G2	06/06/2018	26 common pipistrelle, 3 soprano pipistrelle, 1 brown long-eared bat, 1 barbastelle	No access
G2	25/07/2018	26 common pipistrelle, 3 soprano pipistrelle, 1 brown long-eared bat, 1 barbastelle	No access
G2	29/08/2018	26 common pipistrelle, 3 soprano pipistrelle, 1 brown long-eared bat, 1 barbastelle	No access
G3	08/06/2018	1 brown long-eared bat, 1 soprano pipistrelle, 5 common pipistrelle, 1 noctule, 1 myotis	1 brown long-eared bat, 1 soprano pipistrelle, 2 common pipistrelle, 3 noctule
G3	14/06/2018	1 barbastelle, 5 common pipistrelle, 1 soprano pipistrelle	1 barbastelle, 9 common pipistrelle, 1 soprano pipistrelle, 2 brown longeared bat
G3	04/07/2018	1 barbastelle, 5 common pipistrelle, 1 soprano pipistrelle	7 soprano pipistrelle, 6 common pipistrelles
G4	07/06/2018	5 soprano pipistrelle, 2 noctule, 1 barbastelle, 2 brown long-eared bat, 1 Natterer's bat	60+ common pipistrelle, 20+ soprano pipistrelle, 4 brown long-eared bat, 3 noctule, 1 barbastelle
G4	03/07/2018	2 50 pipistrelles, 1 myotis, 6 noctules, 7 common pipistrelle, 1 soprano pipistrelle	4 soprano pipistrelle, 4 noctule, 40+ common pipistrelle,
G4	23/07/2018	10 soprano pipistrelle, 11 common pipistrelles	5 soprano pipistrelle, 8 common pipistrelle

Location	Date	Species recorded inside	Species recorded outside
G5	07/06/2018	2 50 pipistrelles, 1 soprano pipistrelle, 4 noctule	2 soprano pipistrelle, 4 common pipistrelle, 5 noctule
G5	03/07/2018	3 soprano pipistrelle	3 noctule, 1 soprano pipistrelle
G5	23/07/2018	4 noctule, 1 50 pipistrelle, 4 soprano pipistrelle	3 soprano pipistrelle, 3 noctule
G6	07/06/2018	2 50 pipistrelles, 2 soprano pipistrelle, 5 noctule, 9 common pipistrelle	1 barbastelle, 1 nathusius pipistrelle, 3 noctule, 6 soprano pipistrelle, 7 common pipistrelle
G6	02/07/2018	5 soprano pipistrelle, 35 common pipistrelle, 1 noctule, 1 serotine	1 barbastelle, 5 noctule, 8 common pipistrelle, 5 soprano pipistrelle
G6	25/07/2018	2 barbastelle, 4 noctule, 5 common pipistrelle, 7 soprano pipistrelle	3 soprano pipistrelle, 4 noctule, 30+ common pipistrelle
G7	03/07/2018	4 soprano pipistrelle, 2 noctule, 50+ common pipistrelle	3 soprano pipistrelle, 4 noctule, 30+ common pipistrelle
G7	24/07/2018	1 50 pipistrelle, 5 soprano pipistrelle, 6 noctule, 30+ common pipistrelle.	Detector malfunction
G7	27/08/2018	4 soprano pipistrelle, 7 common pipistrelle, 4 noctule 1 serotine	20+ soprano pipistrelle, 20+ common pipistrelle, 1natterers, 2 noctule
Green Bridge 1 – Marriots Way	26/04/2018	1 Noctule, 5 common pipistrelle	1 noctule, 7 common pipistrelle
	04/07/2018	5 common pipistrelle, 1 soprano pipistrelle	6 common pipistrelle, 1 soprano pipistrelle
	27/07/2018	1 soprano pipistrelle, 1 noctule, 1 common pipistrelle	1 soprano pipistrelle, 1 noctule, 1 common pipistrelle
Green Bridge 2 – Middle Road	22/05/2018	4 noctules, 1 soprano pipistrelle	5 noctules, 1 soprano pipistrelle
	02/07/2018	6 common pipistrelle, 1 soprano pipistrelle, 4 noctule	6 common pipistrelle, 1 soprano pipistrelle, 4 noctule
	25/07/2018	1 soprano pipistrelle, 4 noctule	2 soprano pipistrelle, 4 noctule
Dark Corridor 1 – Buxton Road	08/06/2018	1 Myotis, 1 Noctule, 1 Barbastelle	
	04/07/2018	3 Noctule	
	24/07/2018	1 common pipistrelle, 1 soprano pipistrelle, 3 noctule	
Dark Corridor 2 – Newman Road	13/06/2018	1 brown long-eared bat, 1 serotine, 1 common pipistrelle, 2 Myotis, 2 Noctule	1 noctule, 1 serotine, 1 brown long eared bat, 1 common pipistrelle
	03/07/2018	1 noctule, 1 soprano pipistrelle, 11 common pipistrelle.	1 noctule, 8 common pipistrelle
	26/07/2018	3 noctule, 4 soprano pipistrelle, 2 brown longeared bat	2 serotine, 2 Daubenton's, 16 Noctule, 11 common pipistrelle, 2 soprano pipistrelle, 4 brown long eared bat
Underpass	13/06/2018	No bats recorded	1 soprano pipistrelle, 1 noctule
	03/07/2018	7 noctule, 3 common pipistrelle, 1 soprano pipistrelle	5 noctules, 5 common pipistrelle, 2 soprano pipistrelle

Location	Date	Species recorded inside	Species recorded outside
	26/07/2018	5 noctule, 5 soprano pipistrelle, 1 common pipistrelle	3 noctule, 4 soprano pipistrelle, 1 brown long eared bat

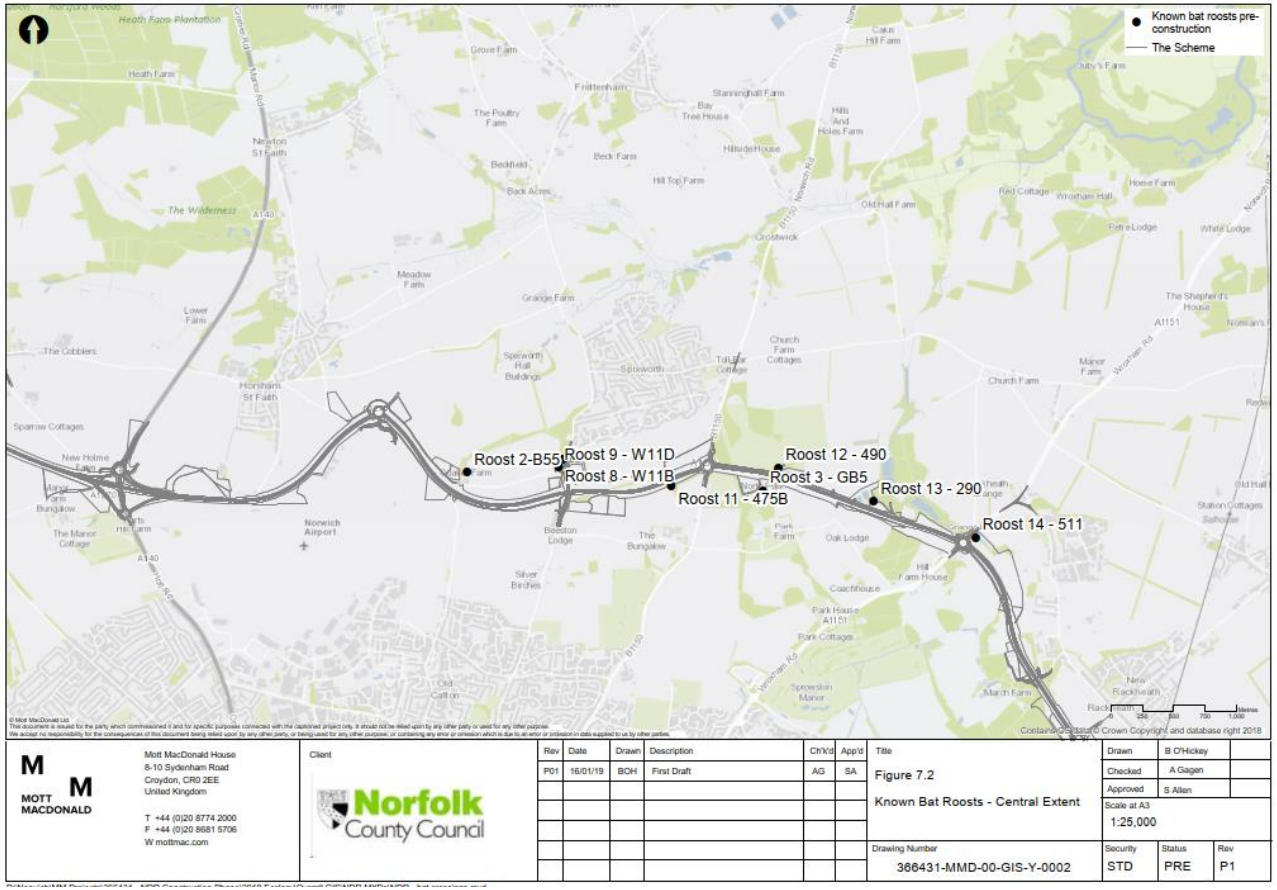
Source: NDR Ecological Post-Construction Monitoring – Bats

Figure B1: Known Bat Roosts – Western Extent



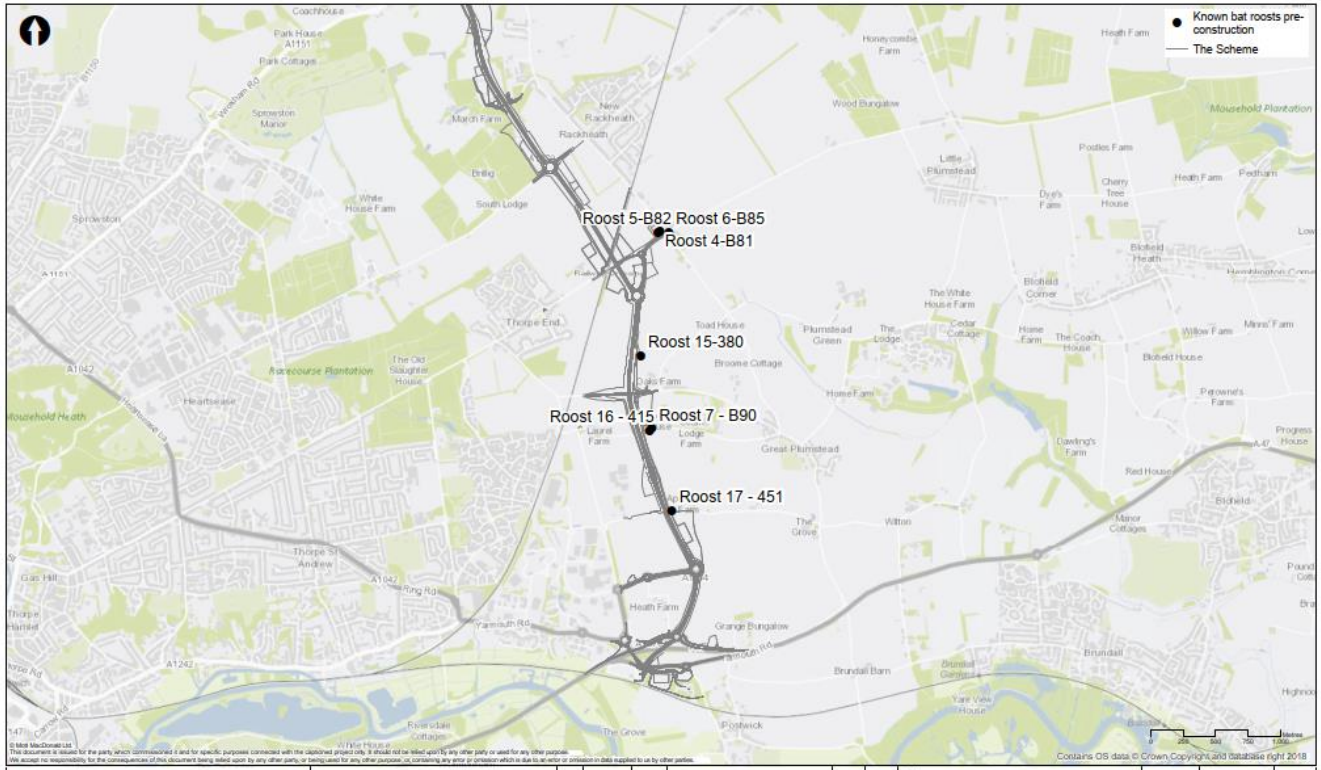
Source: NDR Ecological Post-Construction Monitoring – Bats

Figure B2: Known Bat Roosts – Central Extent



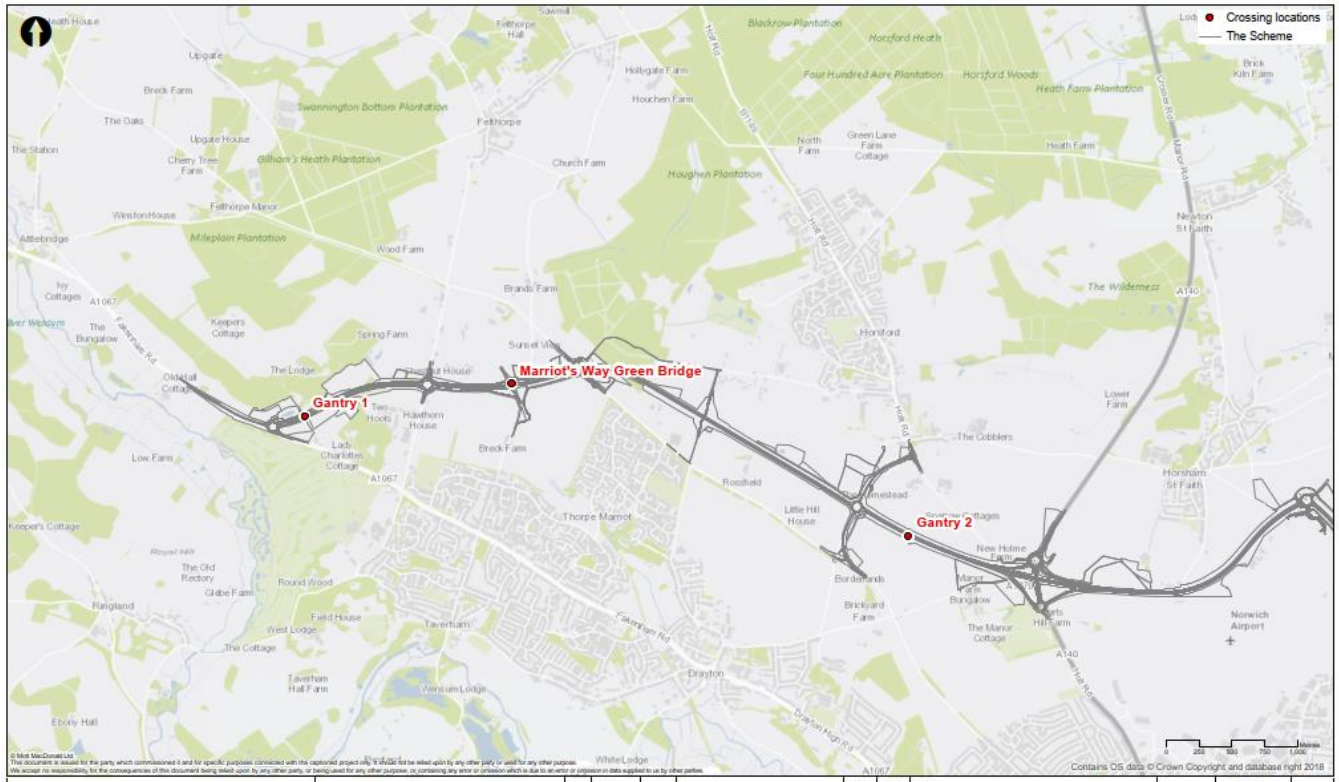
Source: NDR Ecological Post-Construction Monitoring – Bats

Figure B3: Known Bat Roosts – Eastern Extent



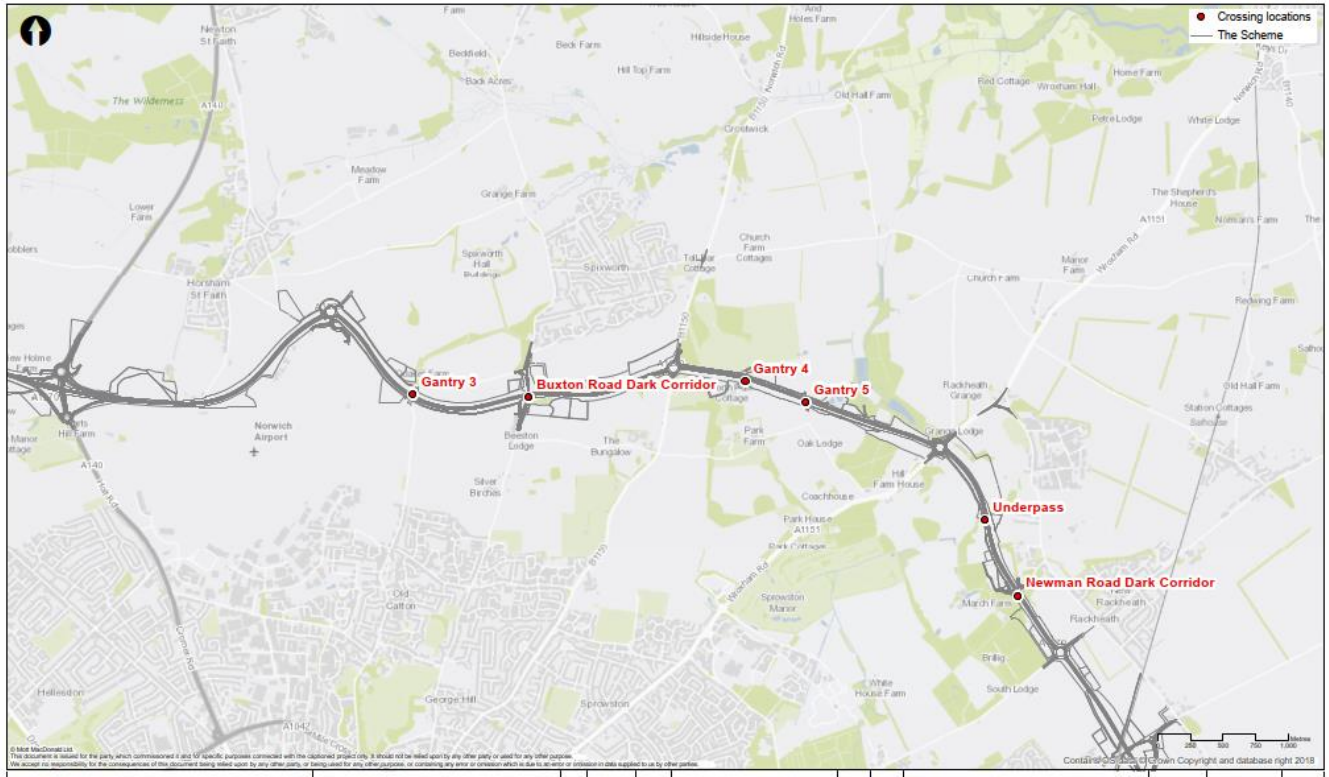
Source: NDR Ecological Post-Construction Monitoring – Bats

Figure B4: Bat Crossings – Western Extent



Source: NDR Ecological Post-Construction Monitoring – Bats

Figure B5: Bat Crossings – Central Extent



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Rev	Date	Drawn	Description	Ch'k'd	App'd
P01	16/01/19	BOH	First Draft	AG	SA

Title: Figure 7.5 Bat Crossings - Central Extent

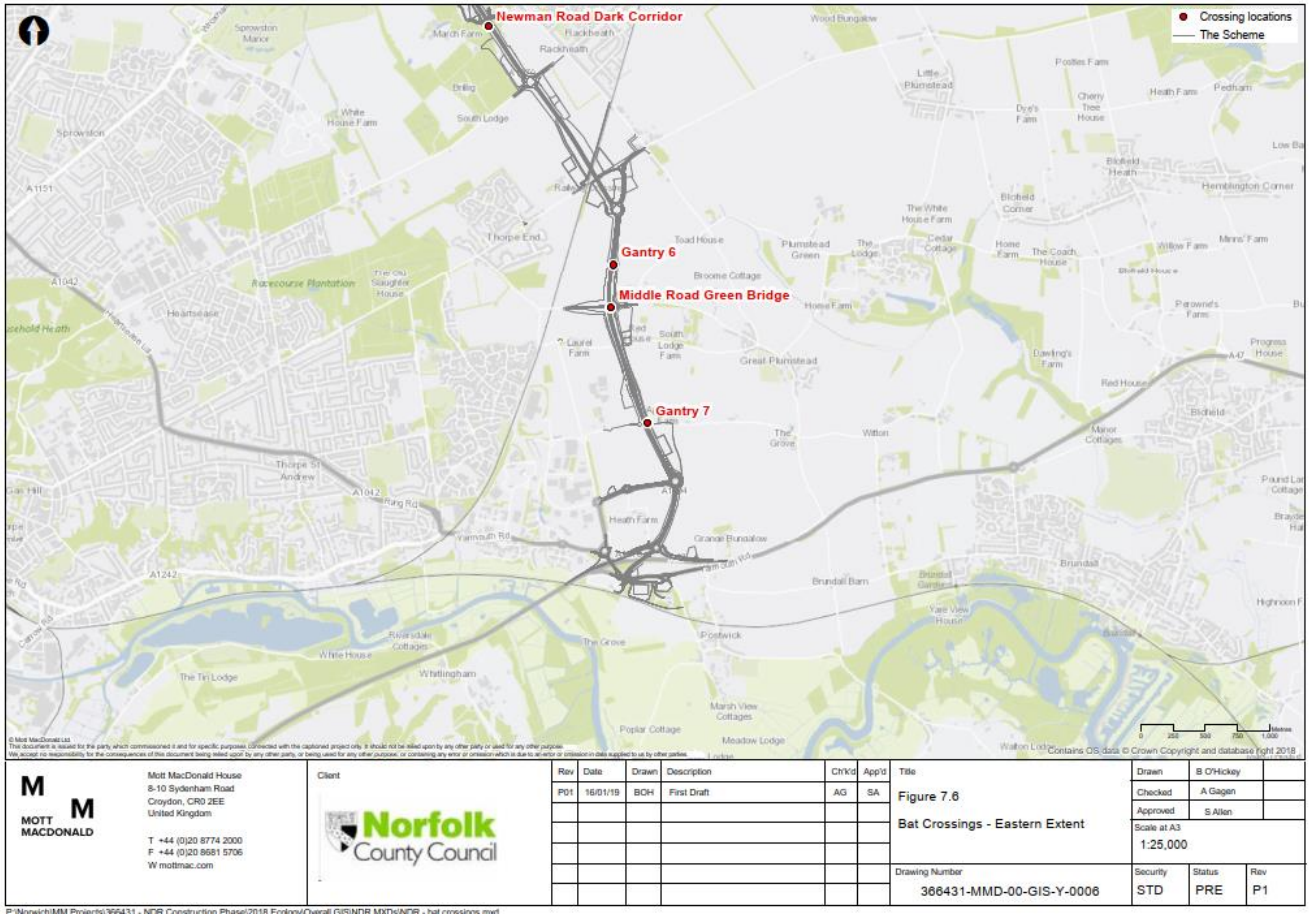
Drawn	B O'Hickey	
Checked	A Gagen	
Approved	S Allen	
Scale at A3	1:25,000	

Drawing Number: 366431-MMD-00-GIS-Y-0005

Security	Status	Rev
STD	PRE	P1

Source: NDR Ecological Post-Construction Monitoring – Bats

Figure B6: Bat Crossings – Eastern Extent

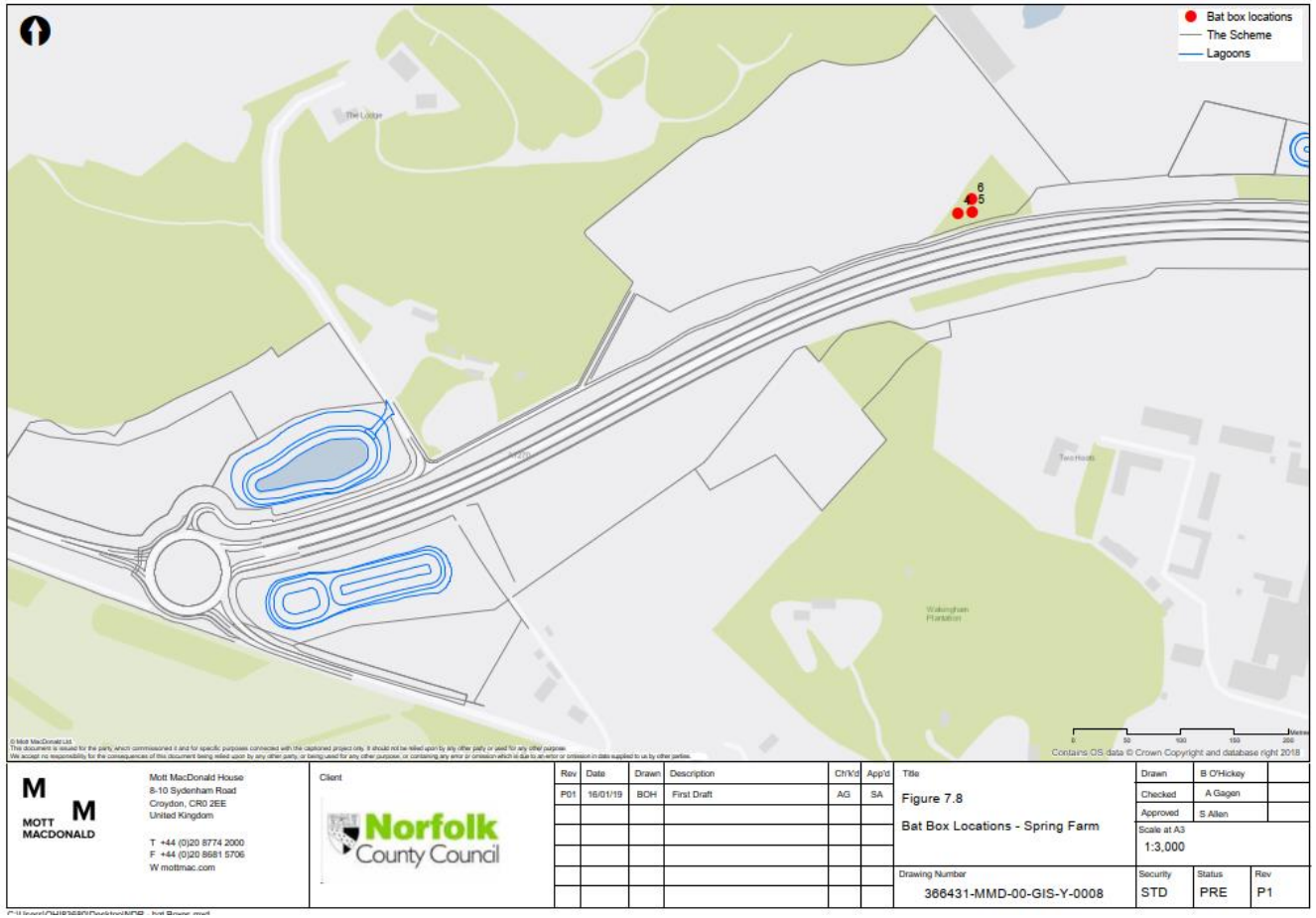


Source: NDR Ecological Post-Construction Monitoring – Bats

Figure B7: Bat Box Locations - Fakenham

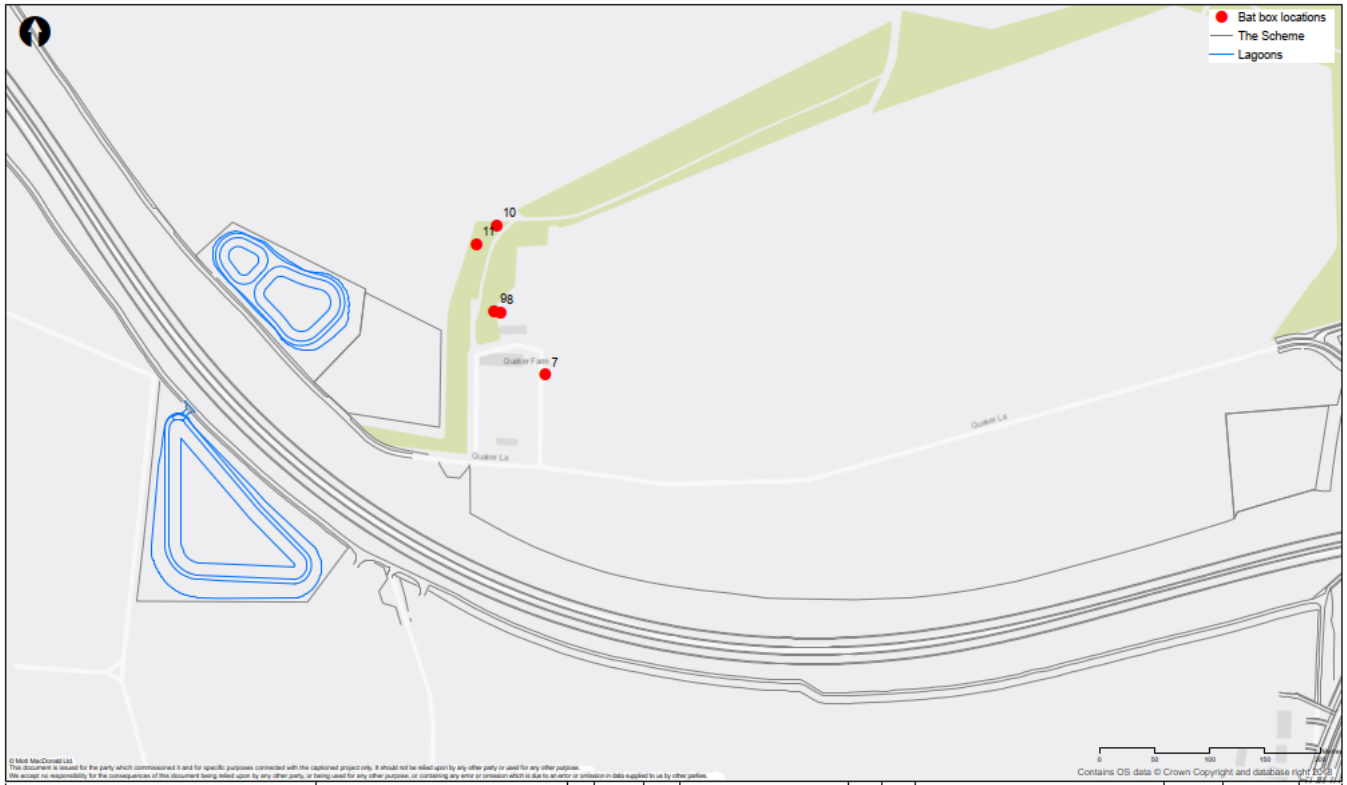
Source: NDR Ecological Post-Construction Monitoring – Bats

Figure B8: Bat Box Locations – Spring Farm



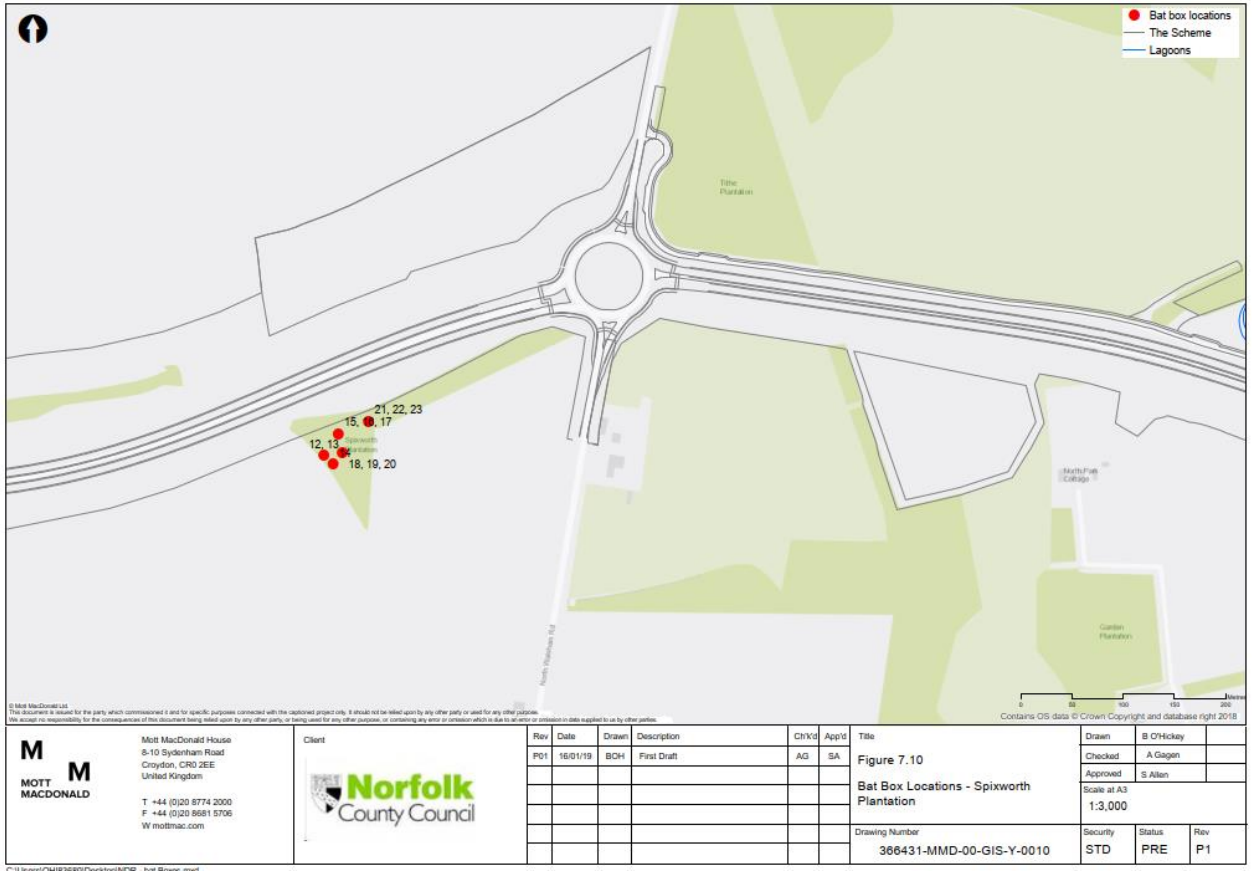
Source: NDR Ecological Post-Construction Monitoring – Bats

Figure B9: Bat Box Locations – Quaker Farm



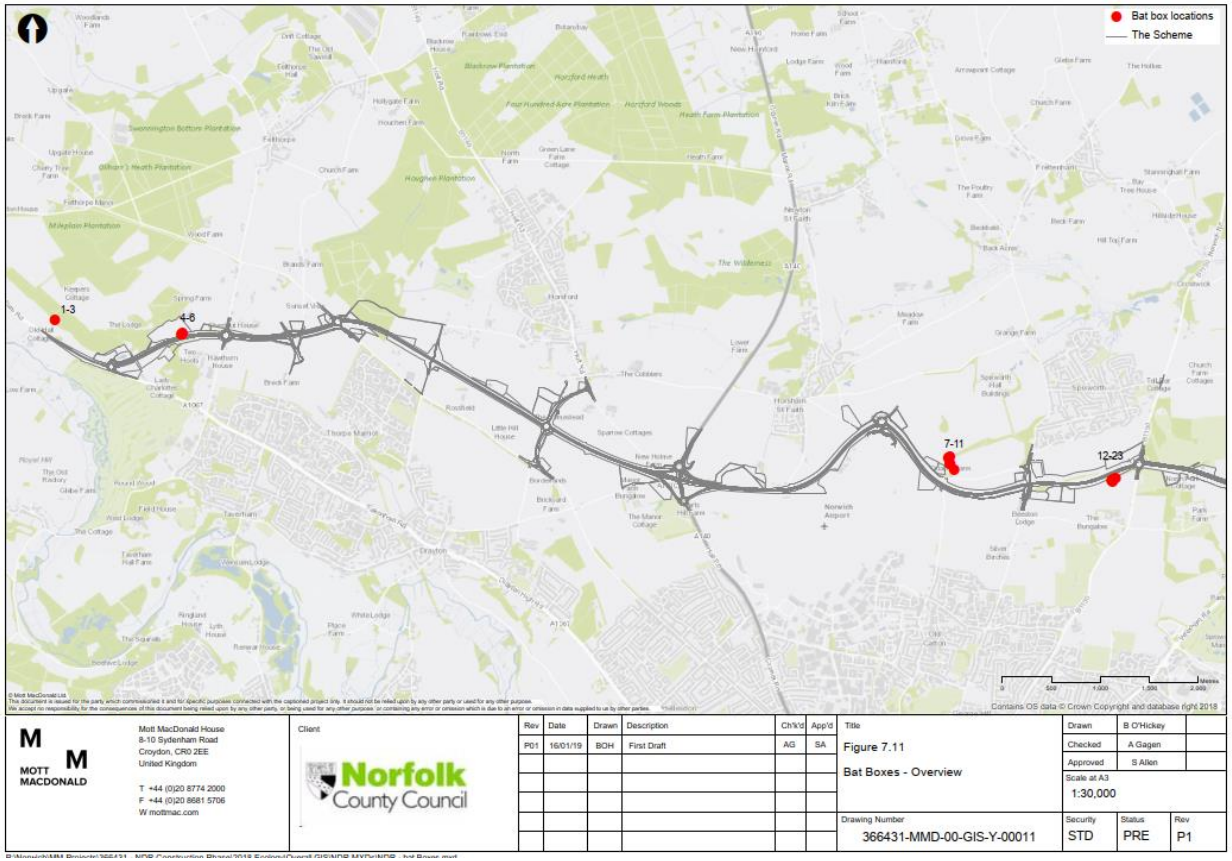
Source: NDR Ecological Post-Construction Monitoring – Bats

Figure B10: Bat Box Locations – Spixworth Plantation



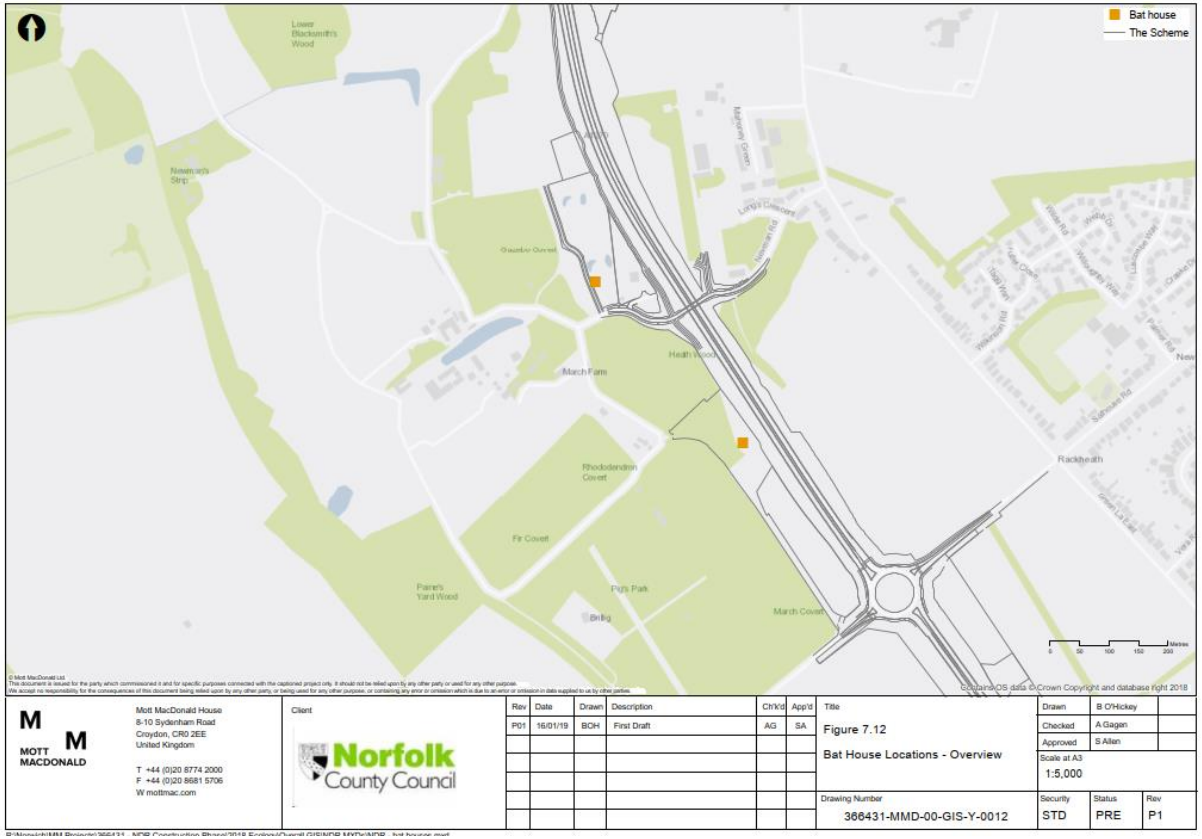
Source: NDR Ecological Post-Construction Monitoring – Bats

Figure B11: Bat Boxes – Overview



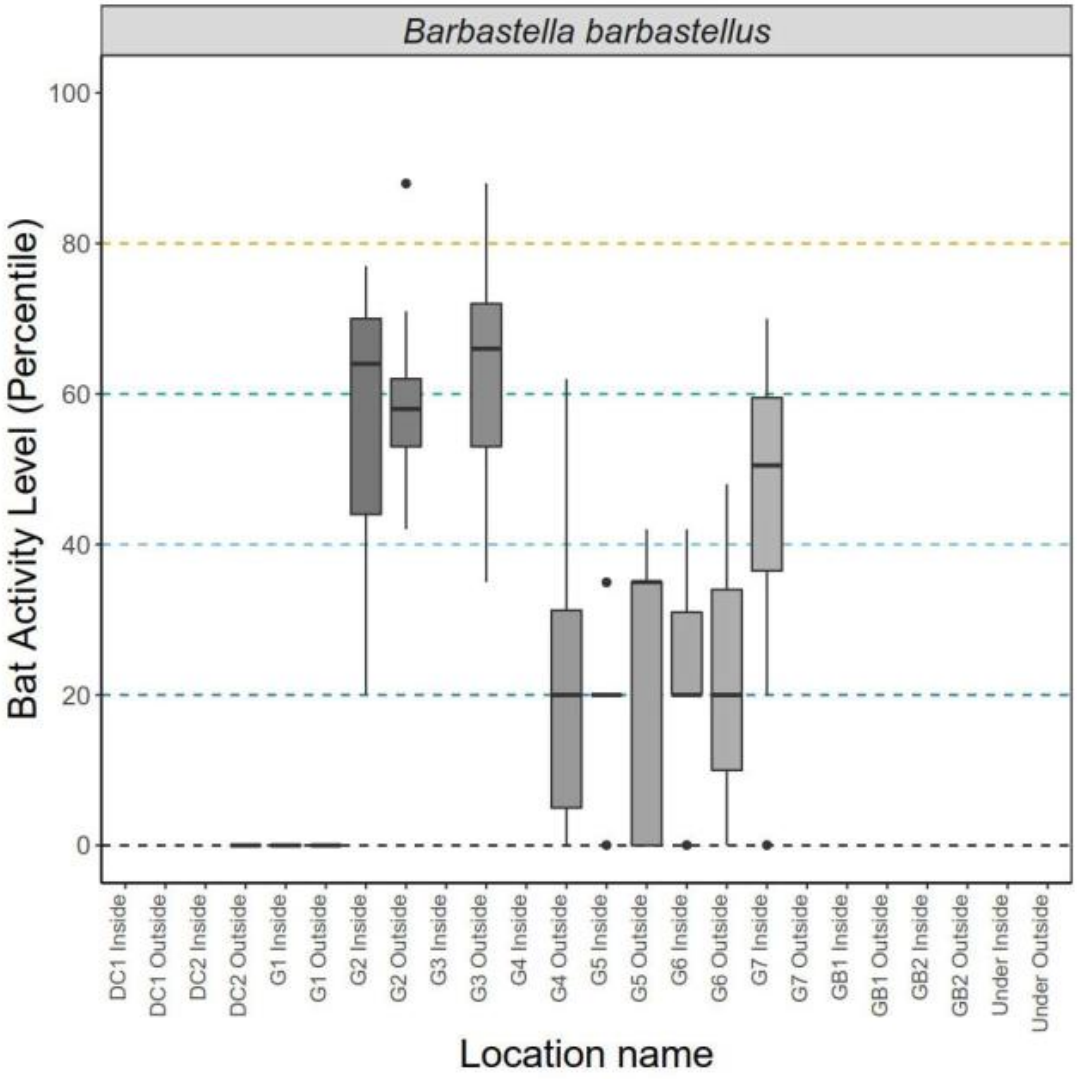
Source: NDR Ecological Post-Construction Monitoring – Bats

Figure B12: Bat House Locations – Overview



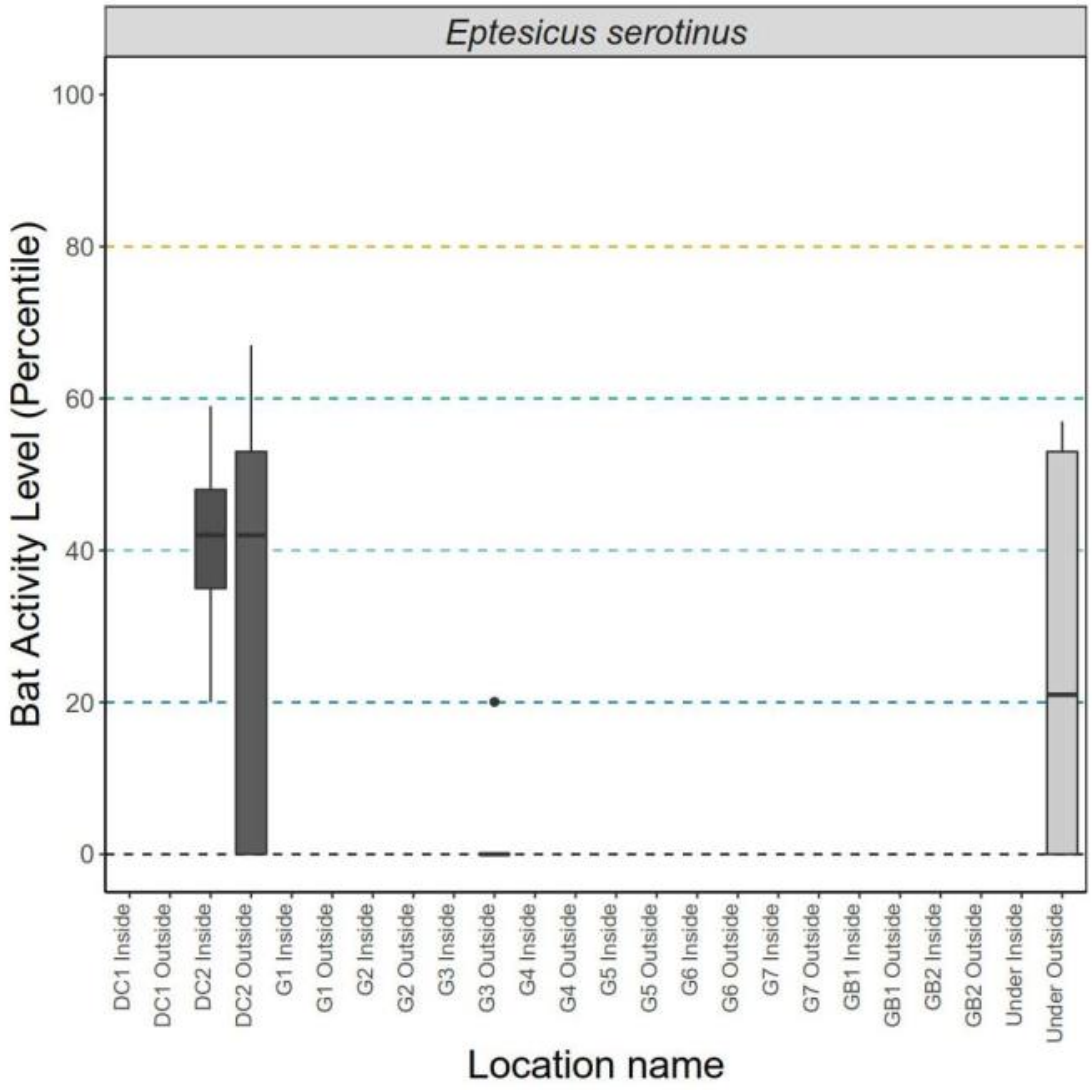
Source: NDR Ecological Post-Construction Monitoring – Bats

Figure B13: Differences in activity between static detector locations for barbastelles



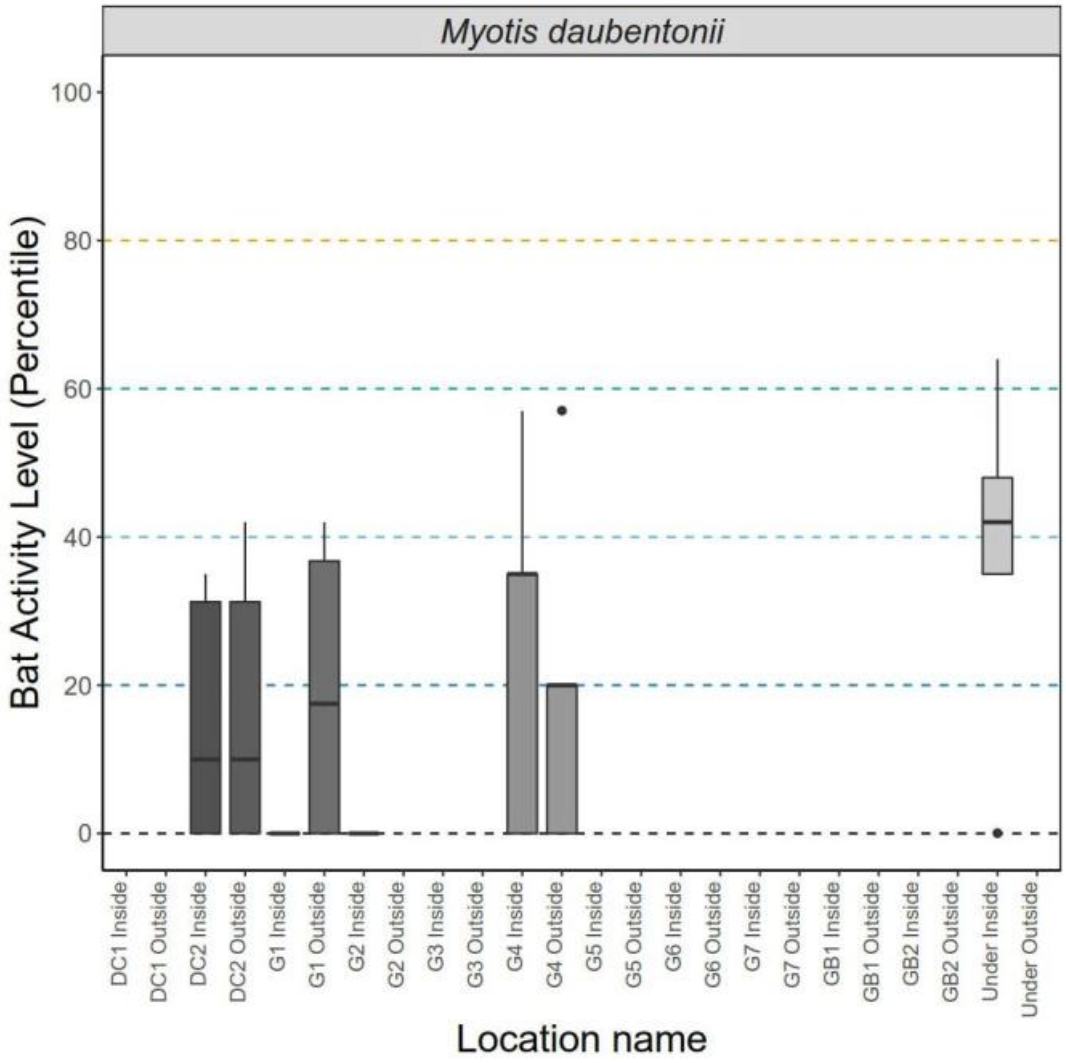
Source: NDR Ecological Post-Construction Monitoring – Bats

Figure B14: Differences in activity between static detector locations for serotines



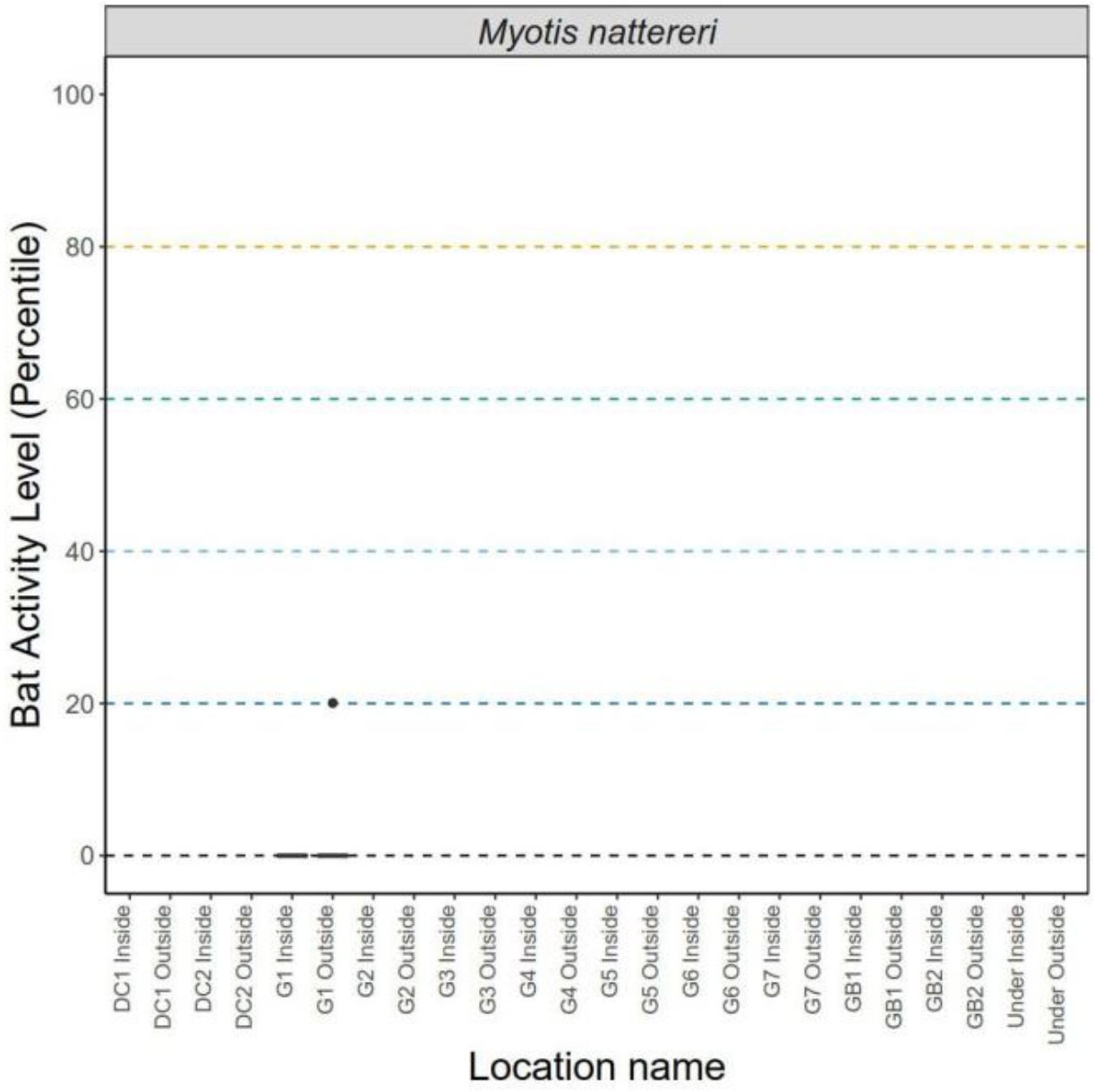
Source: NDR Ecological Post-Construction Monitoring – Bats

Figure B15: Differences in activity between static detector locations for Daubenton's bat



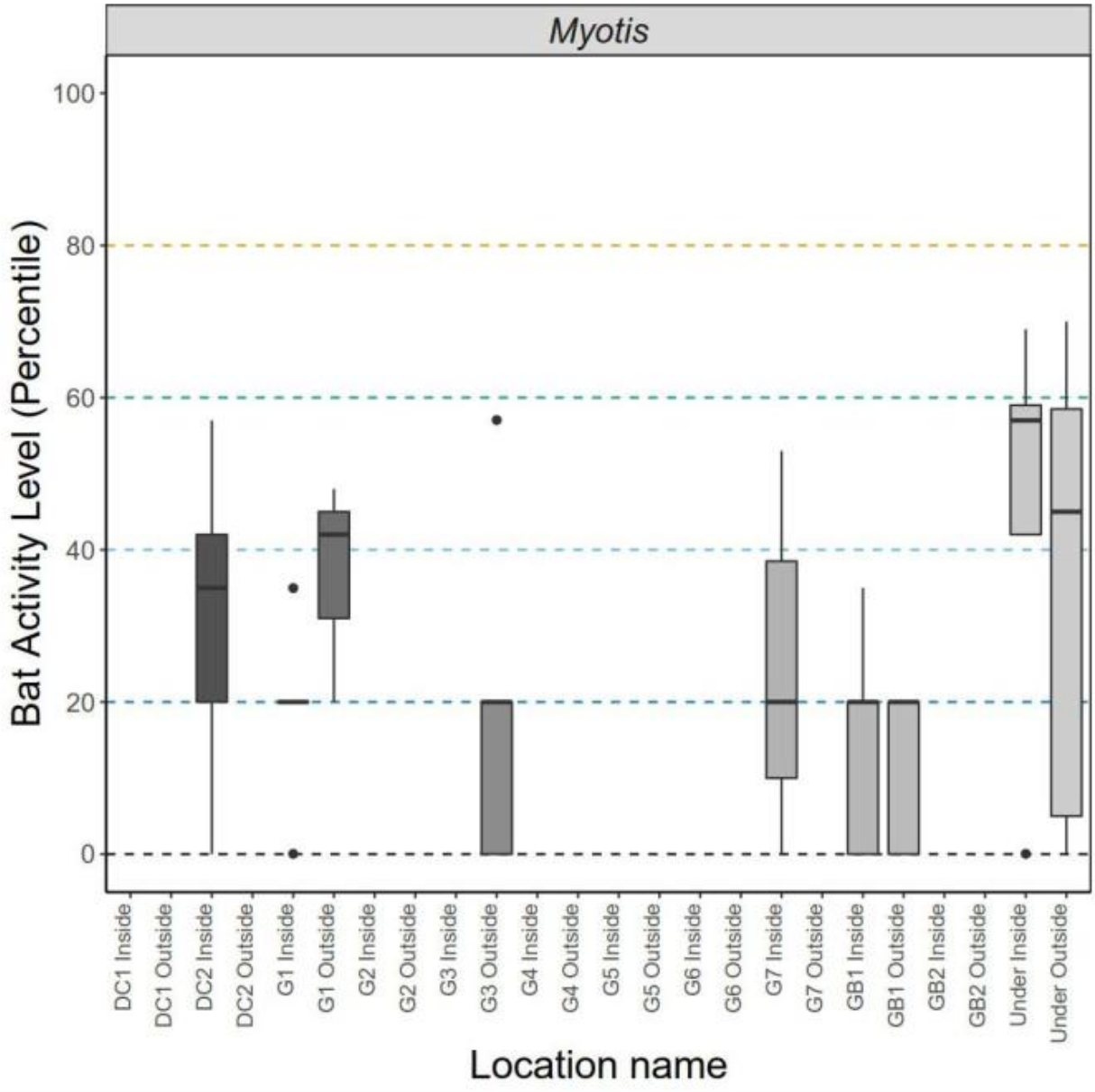
Source: NDR Ecological Post-Construction Monitoring – Bats

Figure B16: Differences in activity between static detector locations for Natterer's bat



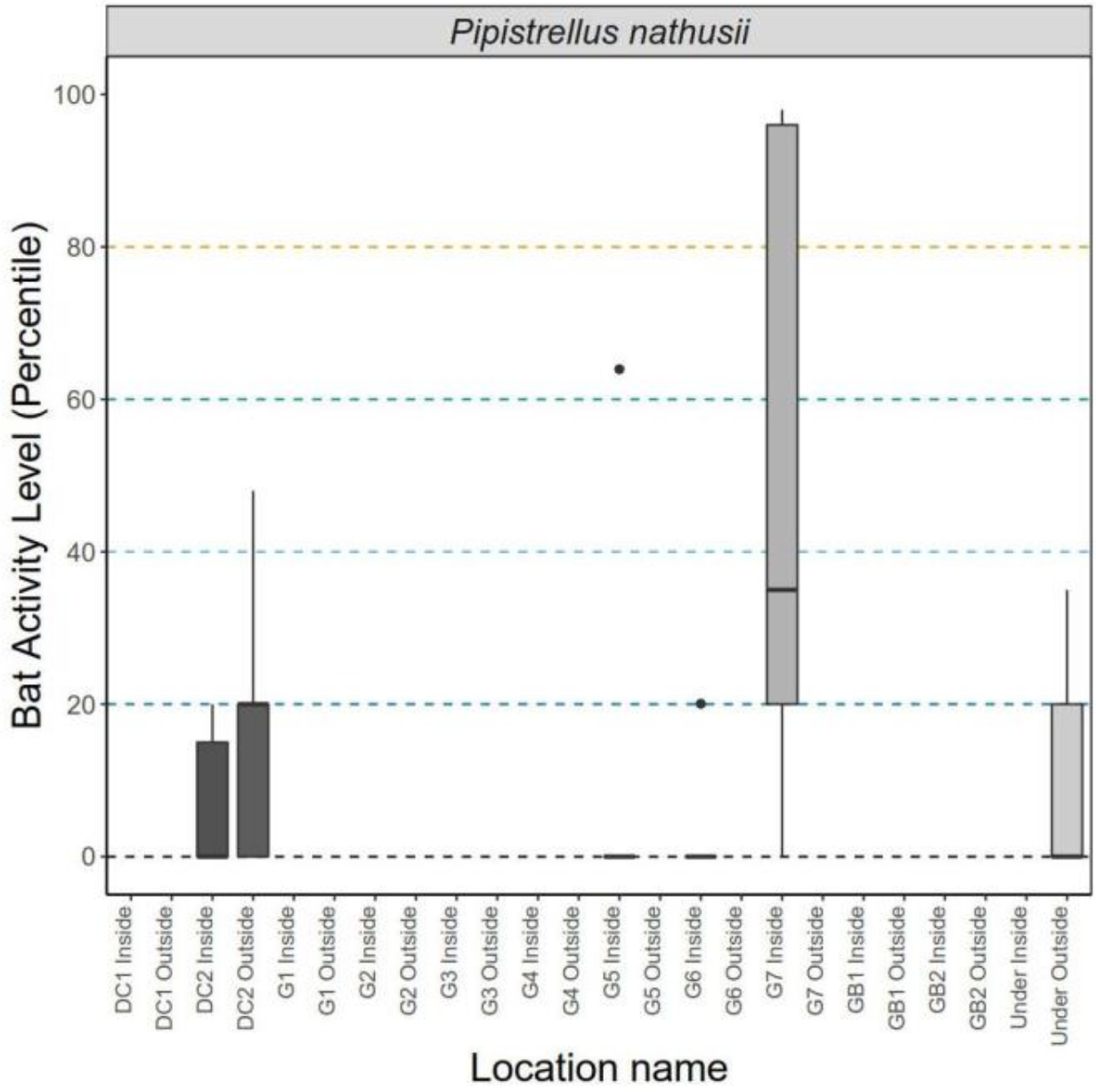
Source: NDR Ecological Post-Construction Monitoring – Bats

Figure B17: Differences in activity between static detector locations for Myotis



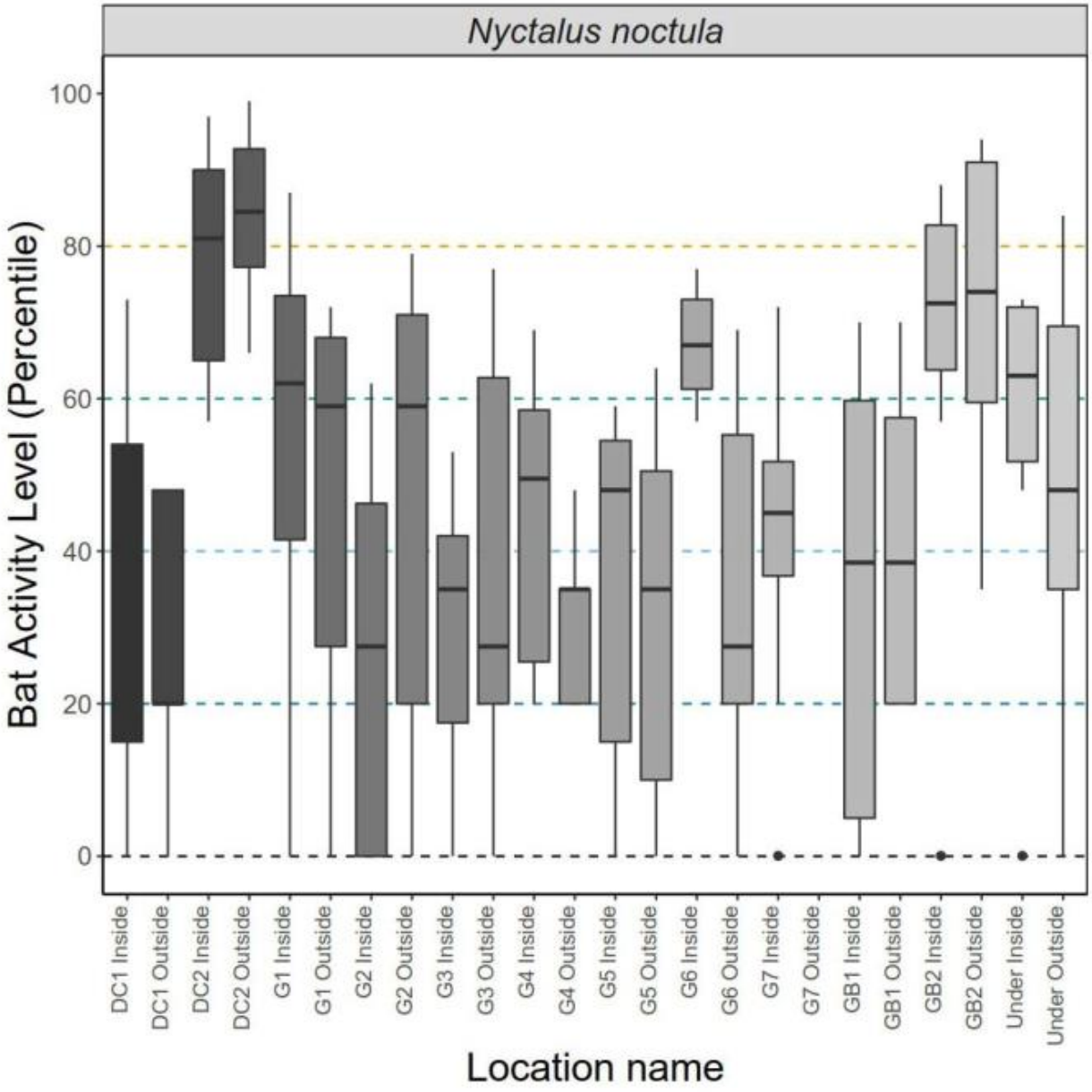
Source: NDR Ecological Post-Construction Monitoring – Bats

Figure B18: Differences in activity between static detector locations for Nathusius' pipistrelle



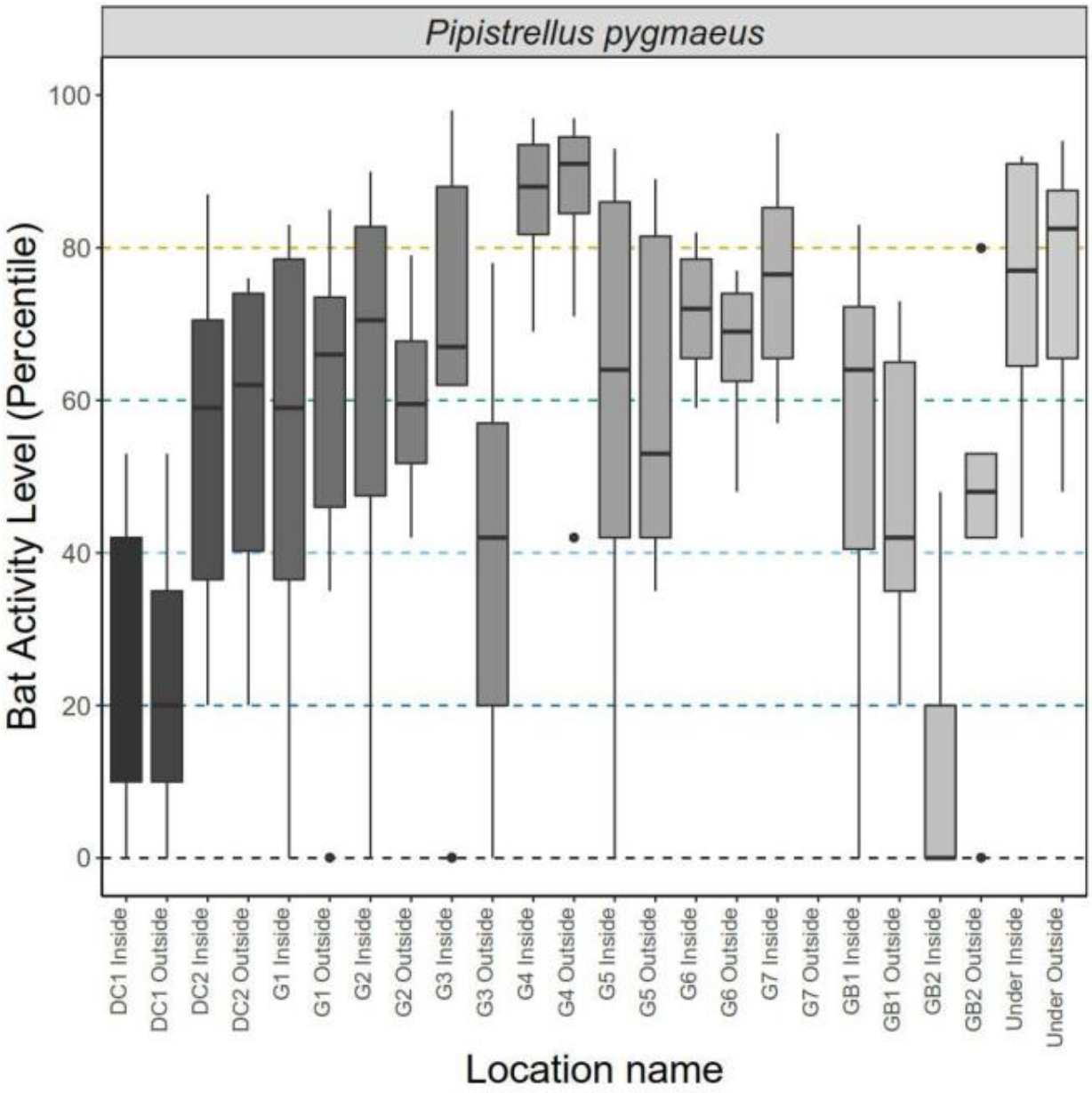
Source: NDR Ecological Post-Construction Monitoring – Bats

Figure B19: Differences in activity between static detector locations for noctule



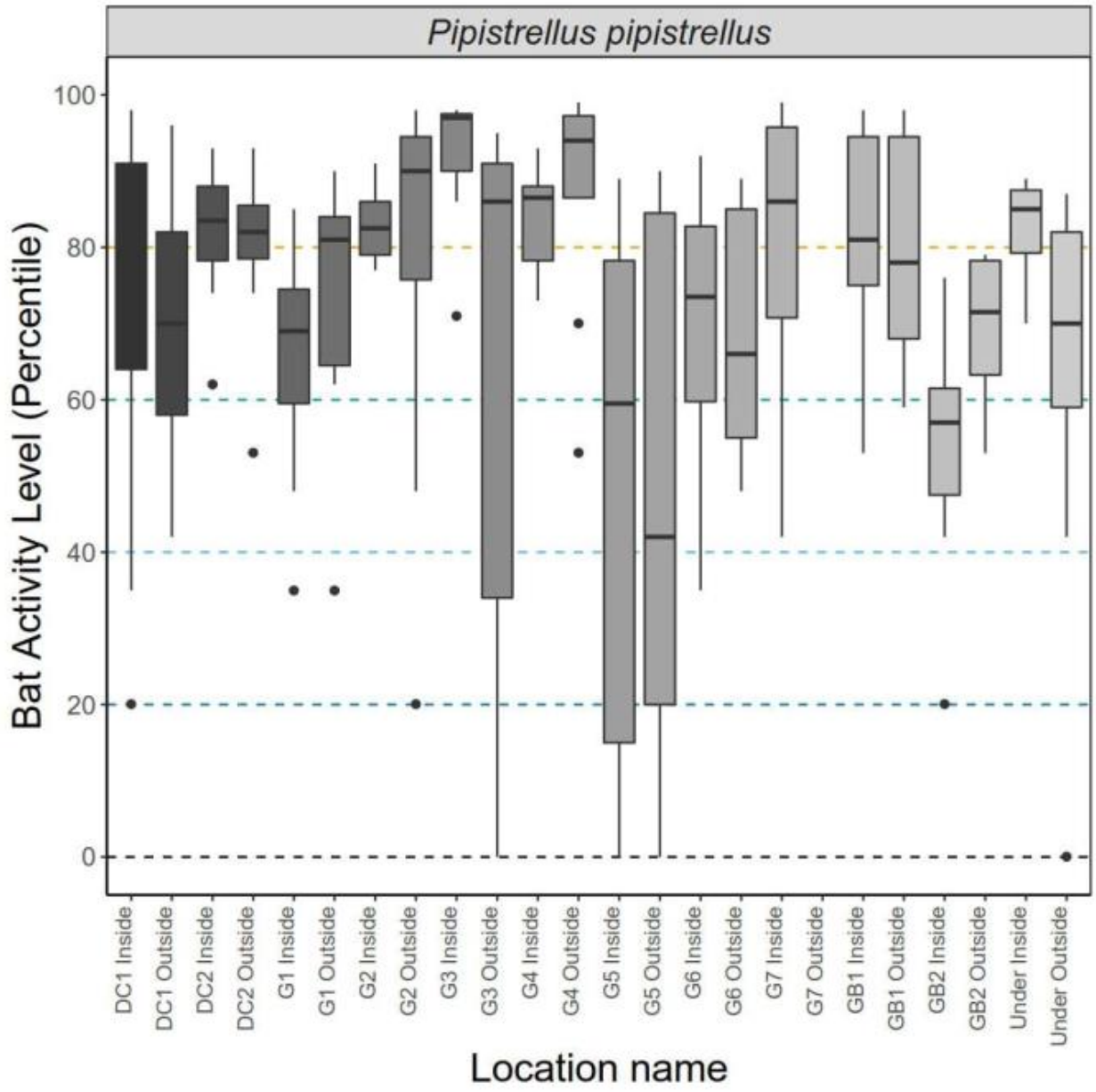
Source: NDR Ecological Post-Construction Monitoring – Bats

Figure B20: Differences in activity between static detector locations for soprano pipistrelle



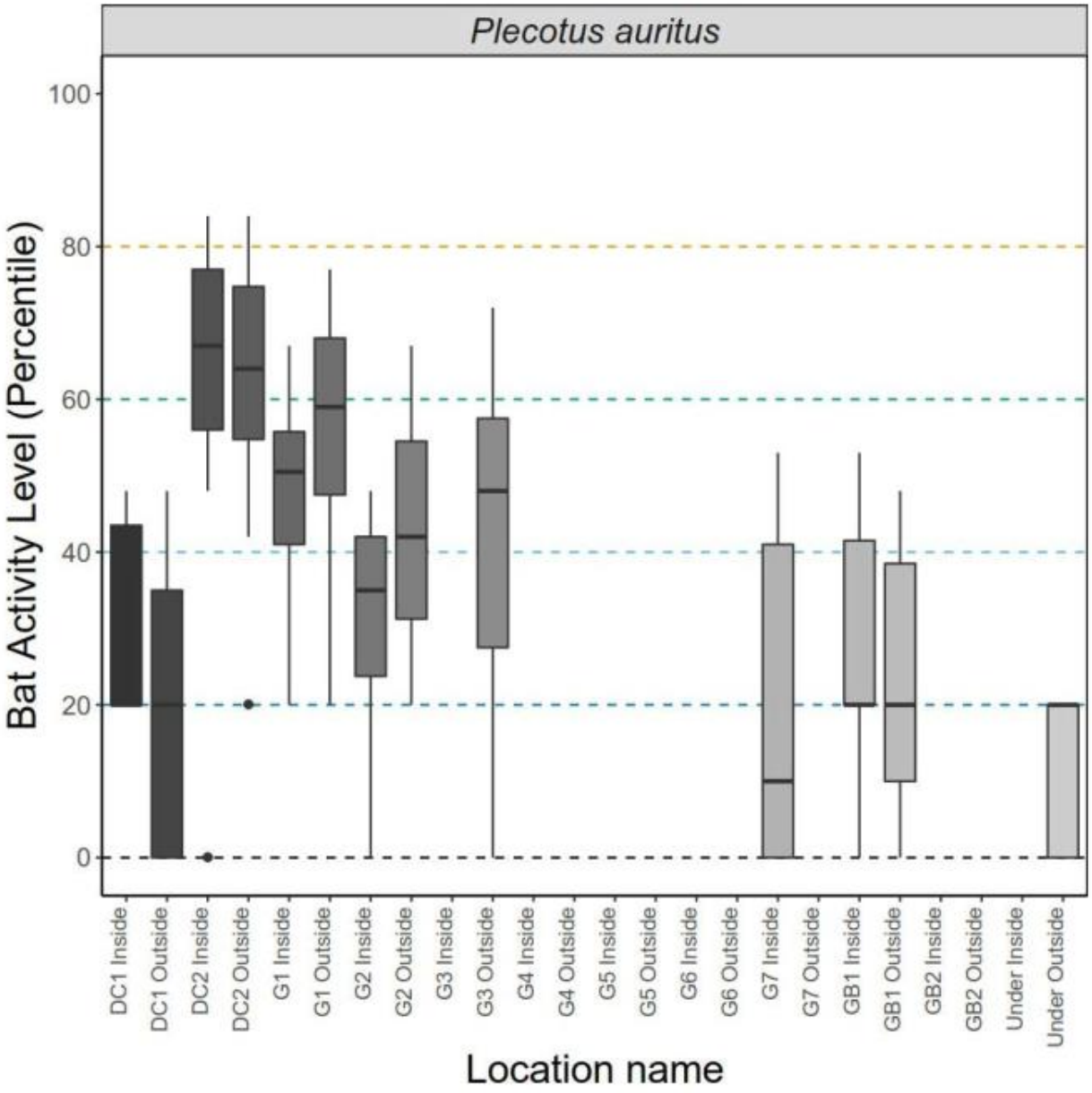
Source: NDR Ecological Post-Construction Monitoring – Bats

Figure B21: Differences in activity between static detector locations for common pipistrelles



Source: NDR Ecological Post-Construction Monitoring – Bats

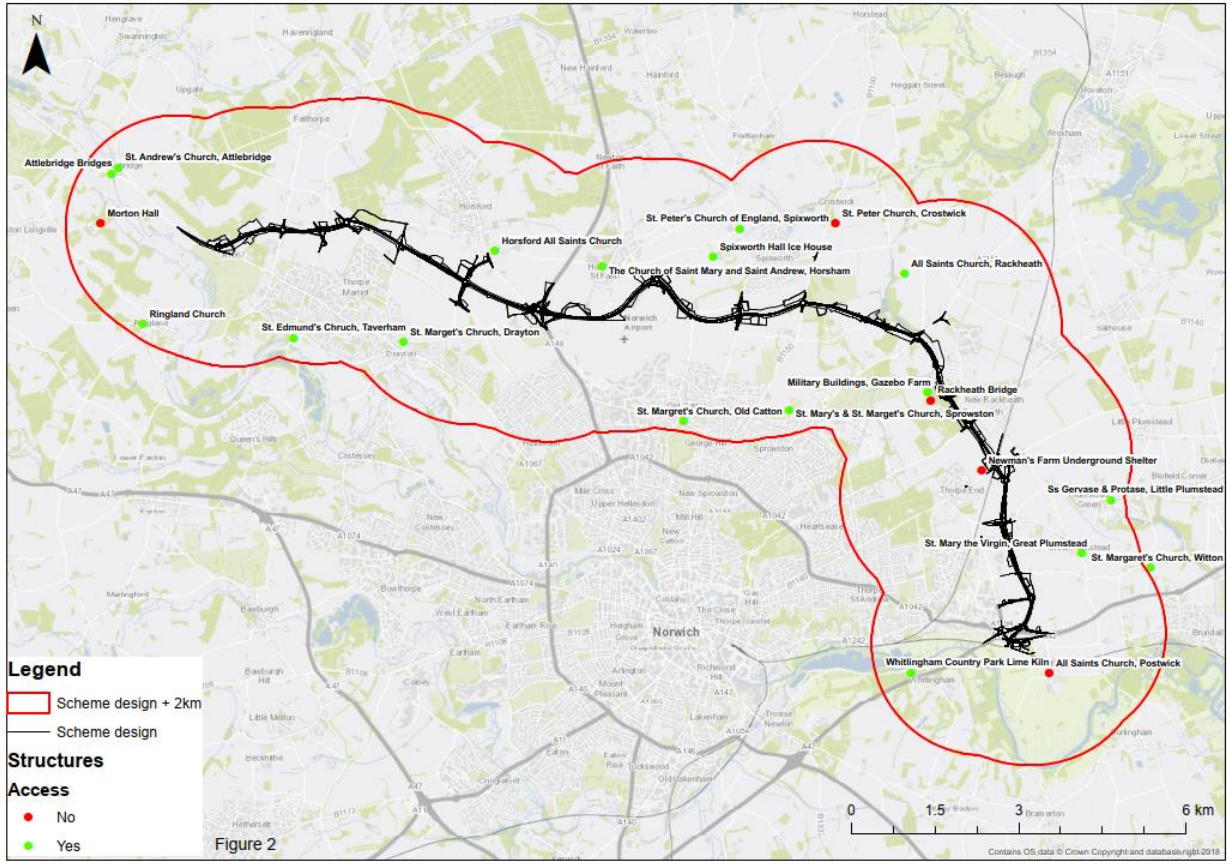
Figure B22: Differences in activity between static detector locations for Brown long-eared bats



Source: NDR Ecological Post-Construction Monitoring – Bats

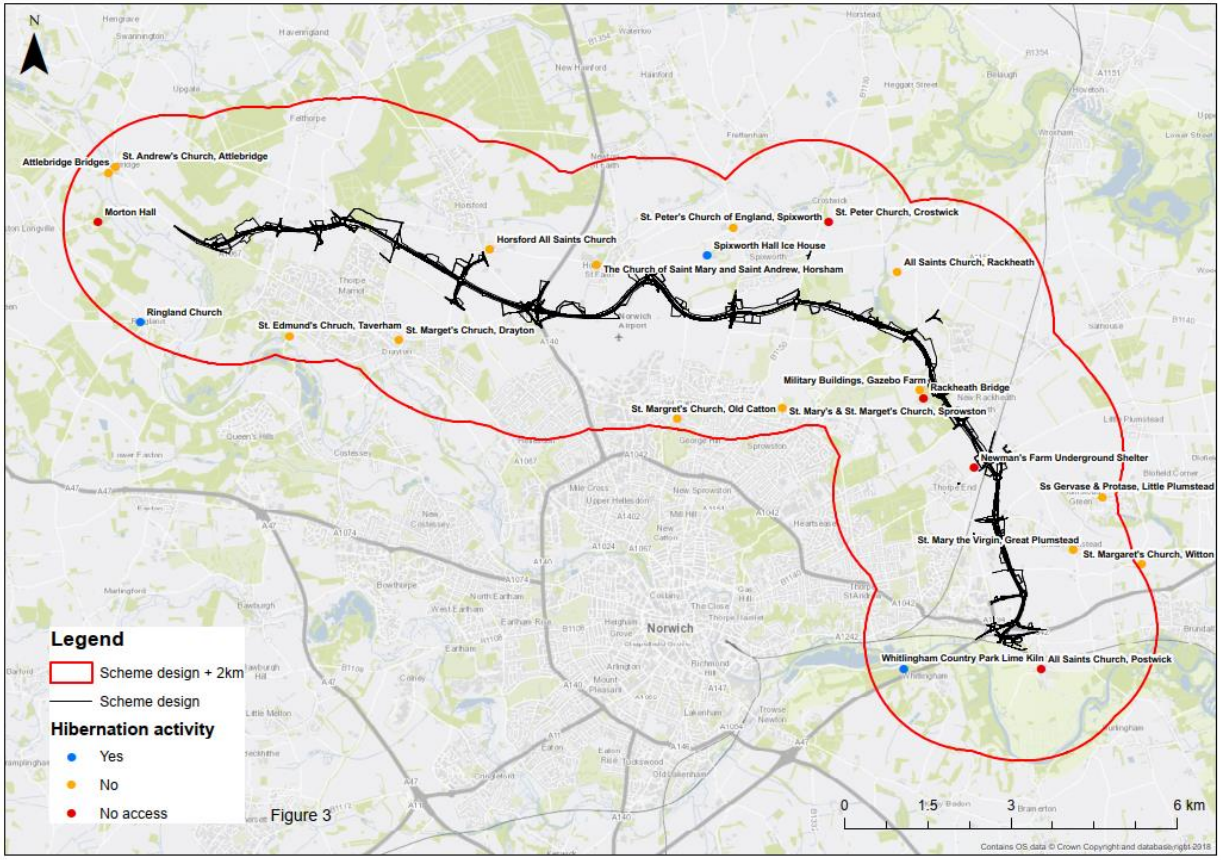
2 NDR Post- Construction Monitoring – Hibernating Bats

Figure B23: Hibernating bats - Structures



Source: NDR Post-Construction Monitoring – Hibernating Bats

Figure B24: Hibernating bats – Hibernation activity



Source: NDR Post-Construction Monitoring – Hibernating Bats

3 NDR Ecological Post-Construction Monitoring – Barn Owl boxes

Figure B25: Photograph 1 – Barn own box furthest north at Taverham Mill

Source: Barn Owl Box Monitoring Report Northern Distributor Road: Year 1 Post-construction checks 2018

Figure B26: Photograph 2 – Barn owl box located furthest south seen on the ground at Taverham Mill

Source: Barn Owl Box Monitoring Report Northern Distributor Road: Year 1 Post-construction checks 2018

Figure B27: Photograph 3 – Box located furthest west at Loke Farm in use by an adult stock dove seen flying from the box

Source: Barn Owl Box Monitoring Report Northern Distributor Road: Year 1 Post-construction checks 2018

Figure B28: Photograph 4 – Evidence of barn owl roosting activity identified in the box furthest east at Loke Farm in the form a single pellet

Source: Barn Owl Box Monitoring Report Northern Distributor Road: Year 1 Post-construction checks 2018

Figure B29: Photograph 5 – Stock dove chicks in the barn owl box furthest east at Bluebell Burial Park

Source: Barn Owl Box Monitoring Report Northern Distributor Road: Year 1 Post-construction checks 2018

Figure B30: Photograph 6 – Stock dove chicks in the barn owl box furthest west at Bluebell Burial Park

Source: Barn Owl Box Monitoring Report Northern Distributor Road: Year 1 Post-construction checks 2018

Figure B31: Photograph 7 – Barn owl box located in the garden of Upper Barn Farm, Reepham

Source: Barn Owl Box Monitoring Report Northern Distributor Road: Year 1 Post-construction checks 2018

4 NDR Ecological Post-Construction Monitoring – Aquatic invertebrate and Desmoulin's Whorl Snail

Table B5: SAFIS results – Sweep samples

Sample ID	Grid reference	Taxa	Species Contributing to SAFIS	Specimen count	Revised BMWP	ASPT	Families contributing to BMWP	Water quality	LQI	LIFE	PSI	CCI	Conservation value	Species of interest
1	TG26933 14078	34	30	931	80.5	3.83	21	Good	C	5.44	0.00	10.00	Moderate	0
2	TG27000 14050	27	26	619	56.3	3.52	16	Good	D	5.43	0.00	8.33	Moderate	0
3	TG26842 14125	34	29	284	76.9	4.05	19	Good	C	5.69	2.27	11.00	Fairly high	0
4	TG26904 14176	32	29	755	76.5	3.83	20	Good	C	5.42	2.13	9.26	Moderate	0
5A	TG26933 14178	24	19	1357	56	4.00	14	Good	C	6.25	5.56	10.00	Moderate	0
5B	TG26933 14178	22	14	380	48.1	4.01	12	Moderate	D	6.00	3.70	5.33	Moderate	0
6A	TG26843 14198	32	29	1544	54	3.38	16	Good	D	5.28	0.00	9.62	Moderate	0
6B	TG26843 14198	26	26	2132	45.2	3.23	14	Moderate	E	5.38	0.00	9.60	Moderate	0

Source: Aquatic invertebrate and Vertigo moulinsiana report Northern Distributor Road: Year 1 Post-construction Survey 2018

Table B6: SAFIS results – Dredge samples

Sample ID	Grid reference	Taxa	Species Contributing to SAFIS	Specimen count	Revised BMWP	ASPT	Families contributing to BMWP	Water quality	LQI	LIFE	PSI	CCI	Conservation value	Species of interest
1	TG26933 14078	24	20	511	42.4	3.26	13	Moderate	E	5.50	0.00	10.28	Fairly high	0
2	TG27000 14050	28	27	647	57.4	3.59	16	Good	D	5.44	0.00	9.79	Moderate	0
3	TG26842 14125	31	29	299	65.1	3.83	17	Good	C	5.81	0.00	9.60	Moderate	0

Sample ID	Grid reference	Taxa	Species Contributing to SAFIS	Specimen count	Revised BMWP	ASPT	Families contributing to BMWP	Water quality	LQI	LIFE	PSI	CCI	Conservation value	Species of interest
4	TG26904 14176	34	30	637	76.9	3.85	20	Good	C	5.57	0.00	10.29	Fairly high	0

Source: Aquatic invertebrate and Vertigo moulinsiana report Northern Distributor Road: Year 1 Post-construction Survey 2018

Figure B32: <Insert Figure Caption>

Species	Sample Site																
	A1	A2	A3	A4	A5	B1	B2	B3	B4	C1	C2	C3	C4	D1	D2	D3	D4
Bathyomphalus contortus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bithynia tentaculata	-	-	-	-	-	-	-	-	-	-	2	1	1	-	-	-	-
Cepaea hortensis	-	-	-	1	-	1	-	1	-	-	-	-	-	-	-	-	1
Capaea nemoralis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-
Deroceras reticulatum	2	4	8	3	2	-	4	2	-	-	-	1	1	-	-	2	-
Galba truncatula	2	8	6	4	3	-	-	-	-	-	-	-	-	-	-	-	-
Oxychilus cellarius	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Succinea putris	3	6	2	2	4	1	23	3	1	-	-	3	2	4	-	-	-
Vitrina pellucida	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Zonitoides nitidus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Source: Aquatic invertebrate and Vertigo moulinsiana report Northern Distributor Road: Year 1 Post-construction Survey 2018

Figure B33: <Insert Figure Caption>

Species	Sample Site											
	F1	F2	F3	F4	F5	G1	G2	G3	G4	G5	H1	H2
Bathyomphalus contortus	-	-	-	-	1	-	-	-	-	-	-	-
Bithynia tentaculata	-	-	-	-	-	-	-	-	-	-	-	-
Cepaea hortensis	-	-	-	-	-	1	2	-	-	-	-	-
Capaea nemoralis	-	-	-	-	-	-	-	-	-	-	-	-
Deroceras reticulatum	-	1	2	1	2	-	-	1	2	-	-	-
Galba truncatula	-	-	-	1	-	-	-	-	-	1	-	-
Oxychilus cellarius	-	-	-	-	1	-	-	-	-	-	-	-
Succinea putris	-	-	-	2	8	2	8	13	3	3	2	3
Vitrina pellucida	-	-	-	-	-	-	-	-	-	-	-	-
Zonitoides nitidus	-	-	-	-	-	-	-	-	-	-	2	-

Source: Aquatic invertebrate and Vertigo moulinsiana report Northern Distributor Road: Year 1 Post-construction Survey 2018

Table B7: <Insert Table Caption>

Sample point	Grid reference	Shade (%)	Moisture (1-5)	Thatch (cm)
A1	TG 27269 13929	50	2	1
A2	TG 27269 13929	50	2	1
A3	TG 27269 13929	50	1	1
A4	TG 27269 13929	50	3	1
A5	TG 27269 13929	50	2	1
B1	TG 27053 14004	90	1	1
B2	TG 27053 14004	90	1	1
B3	TG 27053 14004	90	1	1
B4	TG 27053 14004	90	1	1
C1	TG 2685014125	100	1	1
C2	TG 2685014125	100	3	1
C3	TG 2685014125	100	1	1
C4	TG 2685014125	100	1	1
D1	TG 26935 14080	60	1	1
D2	TG 26935 14080	60	1	1
D3	TG 26935 14080	60	1	1
D4	TG 26935 14080	60	1	1
F1	TG 26824 14189	90	2	1
F2	TG 26824 14189	90	2	1
F3	TG 26824 14189	90	2	1
F4	TG 26824 14189	100	3	1
F5	TG 26824 14189	100	3	1
G1	TG 26724 14303	30	2	1
G2	TG 26724 14303	30	2	1
G3	TG 26724 14303	30	4	2
G4	TG 26724 14303	30	4	2
G5	TG 26724 14303	30	4	2

Sample point	Grid reference	Shade (%)	Moisture (1-5)	Thatch (cm)
H1	TG 26738 14291	85	4	1
H2	TG 26738 14291	85	4	1

Source: Aquatic invertebrate and Vertigo moulinsiana report Northern Distributor Road: Year 1 Post-construction Survey 2018

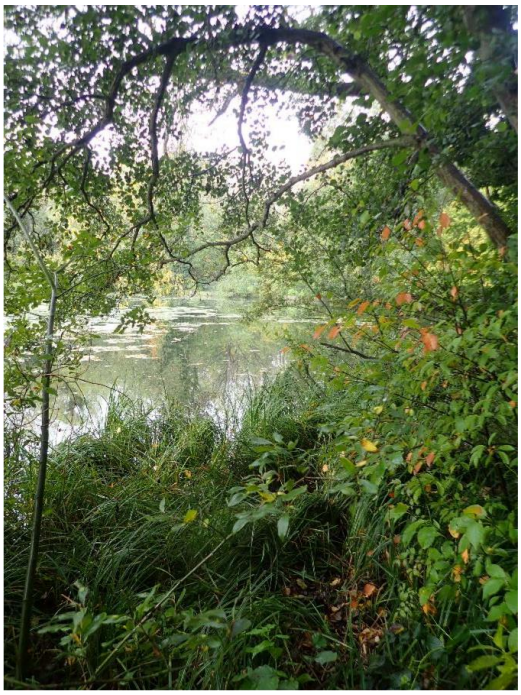
Figure B34: Sample point 1

Source: Aquatic invertebrate and Vertigo moulinsiana report Northern Distributor Road: Year 1 Post-construction Survey 2018

Figure B35: Sample point 2

Source: Aquatic invertebrate and Vertigo moulinsiana report Northern Distributor Road: Year 1 Post-construction Survey 2018

Figure B36: Sample point 3



Source: Aquatic invertebrate and Vertigo moulinsiana report Northern Distributor Road: Year 1 Post-construction Survey 2018

Figure B37: Sample point 4

Source: Aquatic invertebrate and Vertigo moulinsiana report Northern Distributor Road: Year 1 Post-construction Survey 2018

Figure B38: Sample point 5

Source: Aquatic invertebrate and Vertigo moulinsiana report Northern Distributor Road: Year 1 Post-construction Survey 2018

Table B8: Full species list

Taxonomic group	Species/Taxa
Hirudinea (Phylum Annelida)	*Erpobdella octoculata*
	Glossiphonia complanata
	Helobdella stagnalis
	Thermyzon tessulatum
Oligochaeta (Phylum Annelida)	*Lumbriculus sp.*
Seriata (Phylum Platyhelminthes)	*Dugesia lugubris*
Gastropoda (Phylum Mollusca)	*Acanthinula aculeata*
	Acroluxus lacustris
	Aegopinella nitidula
	Anisus vortex
	Bathyomphalus contortus
	Bithynia leachii
	Bithynia tentaculata
	Cepaea hortensis
	Cepaea nemoralis
	Clausilis bidentata
	Cochlicopa lubrica
	Deroceras reticulatum
	Ena montana
	Euconulus alderi
	Galba truncatula

Taxonomic group	Species/Taxa
	Gyraulus albus
	Hippeutis complanatus
	Lymnaea stagnalis
	Oxychilus cellarius
	Oxyloma elegans
	Physella acuta
	Planorbis carinatus
	Planorbis planorbis
	Potamopyrgus antipodarum
	Radix balthica
	Stagnicola palustris
	Succinea putris
	Trochulus hispida
	Valvata cristata
	Valvata piscinalis
	Vitrina pellucida
	Zonitoides nitidus
Bivalvia (Phylum Mollusca)	*Musculium lacustre*
	Pisidium henslowanum
	Pisidium nitidum
	Pisidium personatum
	Pisidium sp.
	Pisidium subtruncatum
	Sphaerium corneum
	Sphaerium nucleus
Acari (Phylum Arthropoda)	*Hydrodroma despiciens*
Crustacea (Phylum Arthropoda)	*Asellus aquaticus*
	Crangonyx pseudogracilis
Coleoptera (Phylum Arthropoda)	*Elmidae sp.*
	Haliplus confinis
	Haliplus fluviatilis
	Haliplus sp.
	Hyphydrus ovatus
	Noterus clavicornis
Trichoptera (Phylum Arthropoda)	*Holocentropus picicornis*
	Leptocerus sp.
	Limnephilus sp.
	Trichoptera sp.
	Wormaldia occipitalis
Diptera (Phylum Arthropoda)	*Chironomidae sp.*
	Diptera sp.
	Ptychoptera sp.
	Tipula sp.
Ephemeroptera (Phylum Arthropoda)	*Cloeon dipterum*
Hemiptera (Phylum Arthropoda)	*Callicorixa praeusta*
	Corixa punctata

Taxonomic group	Species/Taxa
	Corixa sp.
	Hesperocorixa sahlbergi
	Ilyocoris cimicoides
	Leptocaris sp.
	Nepa cinerea
	Notonecta glauca
	Notonecta maculata
	Notonecta viridis
	Plea minutissima
	Sigara distincta
	Sigara dorsalis
	Sigara falleni
Megaloptera (Phylum Arthropoda)	*Sialis lutaria*
Odonata (Phylum Arthropoda)	*Aeshna cyanea*
	Coenagrion puella
	Coenagrion pulchellum
	Coenagrion sp.
	Coenagrionidae sp.
	Erythromma najas
	Ischnura elegans
Lepidoptera (Phylum Arthropoda)	*Crambidae lemnata*
	Paraponyx stratiotata

Source: Aquatic invertebrate and Vertigo moulinsiana report Northern Distributor Road: Year 1 Post-construction Survey 2018

Table B9: Sample results – Sites: combined sweep and dredge species lists

Phylum	Class	Order	Species	76.1	76.2	76.3	76.4	76.5	76.6	Grand total
Arthropoda	Malacostraca	Crustracea	Asellus aquaticus	83	78	88	170	275	895	1589
			Crangonyx pseudogracilis	293	359	8	258	14	97	1029
	Insecta	Ephemoptera	Cloeon dipterum	3	27	8	2			40
		Odonata	Aeshna cyanea				1			1
			Coenagrion puella	9	3	13	24		1	50
			Coenagrion pulchellum	2						2
			Coenagrion sp.	5	1	4	10			20
			Erythromma najas				1		1	2
			Ischnura elegans	1	1		7			9
		Hemiptera	Callicorixa praeusta		1					1
			Corixa punctata		12					12
			Corixa sp.	5	13	9	2			29
			Hesperocorixa sahlbergi		1					1
			Ilyocoris cimicoides	12		1	10			23
			Nepa cinerea						1	1
			Notonecta glauca	11			6			17
			Notonecta maculata			1				1

Phylum	Class	Order	Species	76.1	76.2	76.3	76.4	76.5	76.6	Grand total
			Notonecta viridis	1			1			2
			Plea minutissima	116	4	18	72			210
			Sigara distincta	1	2				1	4
			Sigara dorsalis		1				2	3
			Sigara falleni		1	2				3
		Tricoptera	Caddis cases	5						5
			Holocentropus picicornis			1	2			3
			Leptocerus sp.	1		1		3	2	6
			Limnephilus sp.			16		2		18
			Wormaldia occipitalis					4		4
		Lepidoptera	Crambidae lemnata		1					1
			Parapoynx stratiotata	6			8			14
		Megaloptera	Sialis lutaria	1	4		5		1	11
		Coleoptera	Elmidae larvae					2		2
			Haliplus confinis		3					3
			Haliplus fluviatilis	1		1				2
			Haliplus sp.	1	2	2	1			6
			Hyphydrus ovatus	1			13			14
			Noterus clavicornis				1			1
		Diptera	Chironomidae sp.		2	5	7	70	41	125

Phylum	Class	Order	Species	76.1	76.2	76.3	76.4	76.5	76.6	Grand total
			Diptera sp.			1	1			2
			Ptychoptera sp	1				106		107
			Tipula sp.			1	2	1		4
		Arachnida	Hydrodroma despiciens	1						1
			Spider sp.	1		1	1			3
Annelida	Oligochaeta		Lumbriculus sp.		1			3	1	5
	Hirundinea		Erpobdella octoculata	3			6	7	35	51
			Glossiphonia complanata				2	9	32	43
			Helobdella stagnalis		17		2	2	83	104
			Theromyzon tessulatum			2			1	3
		Tricladida	Dugesia lugubris	1						1
Mollusca	Gastropoda		Acanthinula aculeata					2		2
			Acroloxus lacustris	1		3	1			5
			Aegopinella nitidula					4		4
			Anisus vortex	28	17	10	138		52	245
			Bathyomphalus contortus			2		9		11
			Bithynia leachii	208	41	71	131	1	106	558
			Bithynia tentaculata	266	272	59	279		443	1319
			Clausilia bidentata					2		2

Phylum	Class	Order	Species	76.1	76.2	76.3	76.4	76.5	76.6	Grand total
			Cochlicopa lubrica			1	1	1		3
			Ena montana					2		2
			Euconulus alderi			1		1		2
			Gyraulus albus	57	20	40	74	1	12	204
			Hippeutis complanatus	40	5	6	46	10	30	137
			Lymnaea stagnalis	1	2	1	2		4	10
			Oxyloma elegans			1			1	2
			Physella acuta	49	24	25	9		11	118
			Planorbis carinatus	58	18	16	28		11	131
			Planorbis planorbis	73	75	7	37		40	232
			Potamopyrgus antipodarum	2	1	1		513	147	664
			Radix balthica	4	43	15	11	1	54	128
			Stagnicola palustris						1	1
			Succinea putris	5			2			7
			Trichia hispida		1					1
			Valvata cristata			2		1		3
			Valvata piscinalis	79	169	43	13		13	317
			Zonitoides nitidus			1				1
	Bivalva		Musculium lacustre		2		1		1	4

Phylum	Class	Order	Species	76.1	76.2	76.3	76.4	76.5	76.6	Grand total
			Pisidium henslowanum			9	1	119	11	140
			Pisidium nitidum						30	30
			Pisidium personatum					7	4	11
			Pisidium sp.					565	1159	1724
			Pisidium subtruncatum		1					1
			Sphaerium corneum		41	86	3		352	482
			Sphaerium nucleus	6						6
	Total number of animals			**1442**	**1266**	**583**	**1392**	**1737**	**3676**	**10095**

Source: Aquatic invertebrate and Vertigo moulinsiana report Northern Distributor Road: Year 1 Post-construction Survey 2018

5 NDR Ecological Post-Construction Monitoring – Great Crested Newts

Figure B39: Pond Locations and Numbers – Image 1

Source: NDR Ecological Post-Construction Monitoring – Great Crested Newts

Figure B40: Pond Locations and Numbers – Image 2

Source: NDR Ecological Post-Construction Monitoring – Great Crested Newts

Figure B41: Pond Locations and Numbers – Image 3

Source: NDR Ecological Post-Construction Monitoring – Great Crested Newts

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