Re-surveys of Aquatic Invertebrate Diversity at Little Ouse River (Blo' Norton section), Broomscot Common, and Scarfe Meadows

Carried out for:

Little Ouse Headwaters Project

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1 Introduction

Abrehart Ecology was commissioned by Little Ouse Headwater Project (LOHP) to assess the diversity of aquatic invertebrate species along a section of the Little Ouse River (Blo' Norton section), and adjacent habitats, which were subject to restoration works. The survey acts to highlight any species of conservation interest (such as bullhead *Cottus gobio*) and to compare biodiversity to pre-restoration levels.

The Little Ouse Headwater Project (LOHP) area encompasses the source of the Little Ouse River (Blo' Norton section, Figure 1) and the project supports the conservation of the its associated fenland habitat and upper river valley landscape. The project was set up in 2002 to support the conservation of the river following the loss of much of the fenland habitat.

The Environment Agency (EA) carried out restoration works on a two-kilometre section of the Little Ouse within the project area in 2013. The LOHP commissioned a pre-restoration survey (Abrehart 2013) and the Suffolk Wildlife Trust (SWT) commissioned a survey of the river over a longer section of the river to the west (Chalkley 2014), to monitor the biological effects of the works - particularly with regards to the associated modification of the macro-invertebrate communities present in the channel sediments.

This report details the results of the aquatic invertebrate survey carried out in September 2018, following works carried out by the EA.

Broomscot Common (Figures 1 & 3) is within the parish of Garboldisham and has been leased by the LOHP from the Garboldisham Parish Charities since late 2010. The Common covers an area of 11.4 hectares and, although not directly adjacent to the Little Ouse, is linked to the river by a small stream that flows from the Common through Garboldisham Old Fen to the LOHP's site at Scarfe Meadows. It is designated as a County Wildlife Site and contains a mix of habitats ranging from wet fen at the northern end of the site to very dry, sandy grassland - much like that found further west in the Brecks.

Scarfe Meadows (Figures 1 & 4) was purchased by the LOHP in 2010. The purchase was funded by donors to the LOHP's River Link Appeal and donations from LOHP members. Restoration of the site is funded by the Heritage Lottery Fund. This is a secluded area, comprising flood meadows, hedges, and reed-filled ditches adjacent to the Little Ouse River in the parish of Garboldisham, at the western end of the LOHP project area.

The aim of the survey detailed in this report was to monitor/assess aquatic diversity and conservation value of the Little Ouse River, and associated ditches, following restoration works. This can then be used to inform future mitigation, monitoring, and assist the effective management of the sites. The main survey objectives were to provide information on:

- Species richness (of macro-invertebrates);
- Species abundance (of macro-invertebrates);
- The presence and extent of any species of conservation interest, such as *Cottus gobio*;
- Environmental variables and ditch characteristics; and
- To provide information to inform future management.

Figure 1. Location of survey area.

2 Methods

Sampling points were distributed along the Little Ouse River (Blo' Norton section) and ditches/tributaries within Broomscot Common and Scarfe Meadows, to include aquatic habitat subject to restoration works. An existing standard protocol for assessing watercourses (Drake et al. 2013) was followed throughout the survey. All staff at Abrehart Ecology Ltd. are familiar with using this protocol. Data and sample collection were undertaken by a pair of surveyors, including an experienced on-site surveyor (Toby Abrehart MCIEEM FLS) and a second team member responsible for recording ditch features and assisting with sample collection (Alister Killingsworth BSc (Hons) MSc GradCIEEM). All the sampling was undertaken on the 26th September 2018.

2.1 Aquatic invertebrate sampling

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.

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 70% 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.

2.2 Biocontrol

As sampling comprised moving from one marsh system to another, the check, clean, and dry methods were employed as standard; however, protocol also included changing of nets and trays from one site to another. Prior to entering a new set of marshes, the net and trays from one site were washed in a solution of Virkon and left to dry. A clean and dry set was then used in the new marsh system. This prevented species, or pathogens, being transmitted from one area to another. On return to the laboratory the nets were washed again in Virkon solution and left to dry for at least one day before being taken into the field.

On site, in addition to the nets, only waterproof boots enter the watercourse, and these too are washed in Virkon at the end of sampling effort within a marsh system.

2.3 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 Little Ouse Headwaters Project and associated ditches/streams at Broomscot Common and Scarfe Meadows, to assess water quality, and to highlight any species of conservation interest already present.

2.4 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 the survey these species were found and identified in the field and released. The remainder of the specimens were preserved as normal in isopropanol alcohol as above.

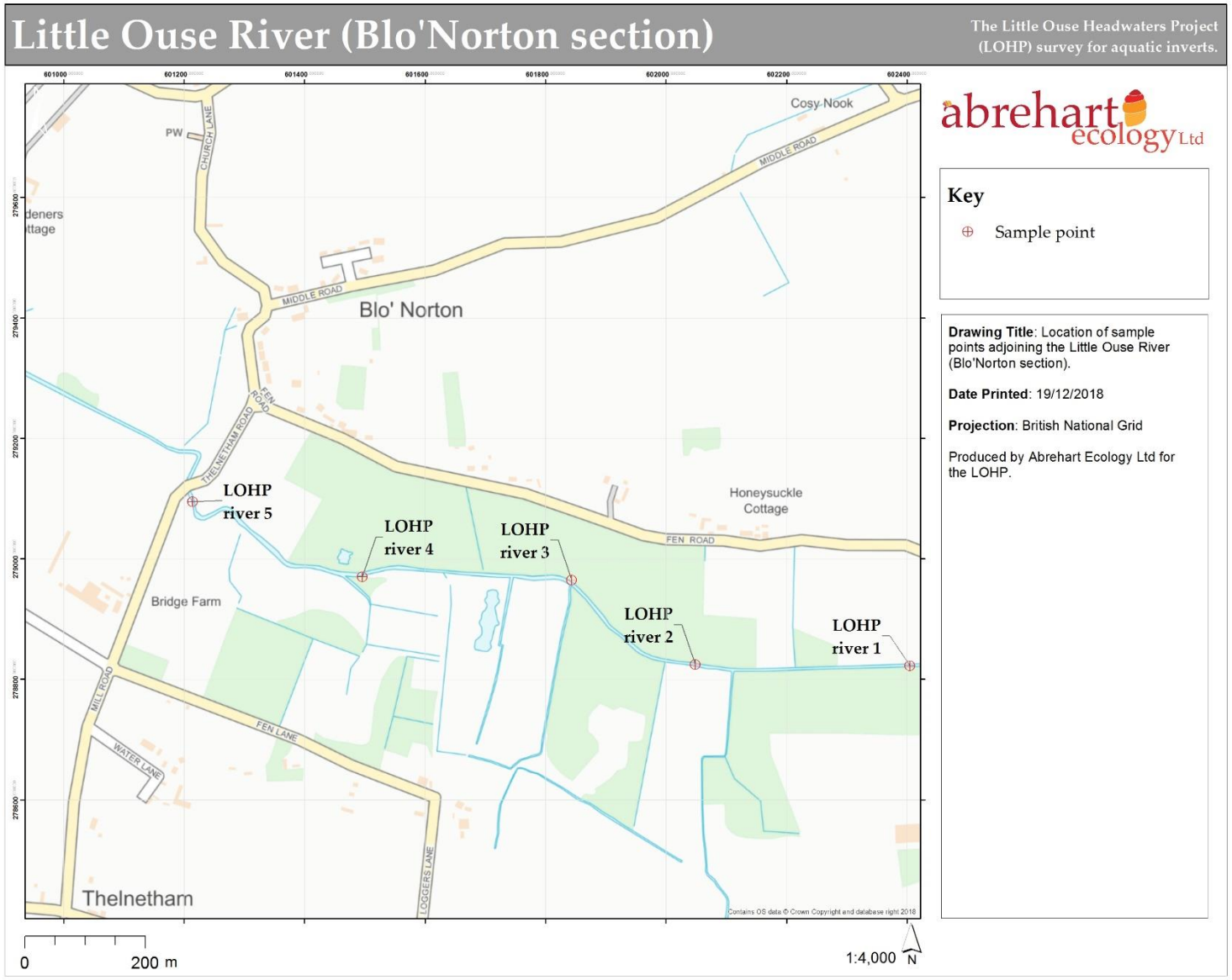

Figure 2. Locations of sampling points along the Little Ouse River (Blo' Norton section)

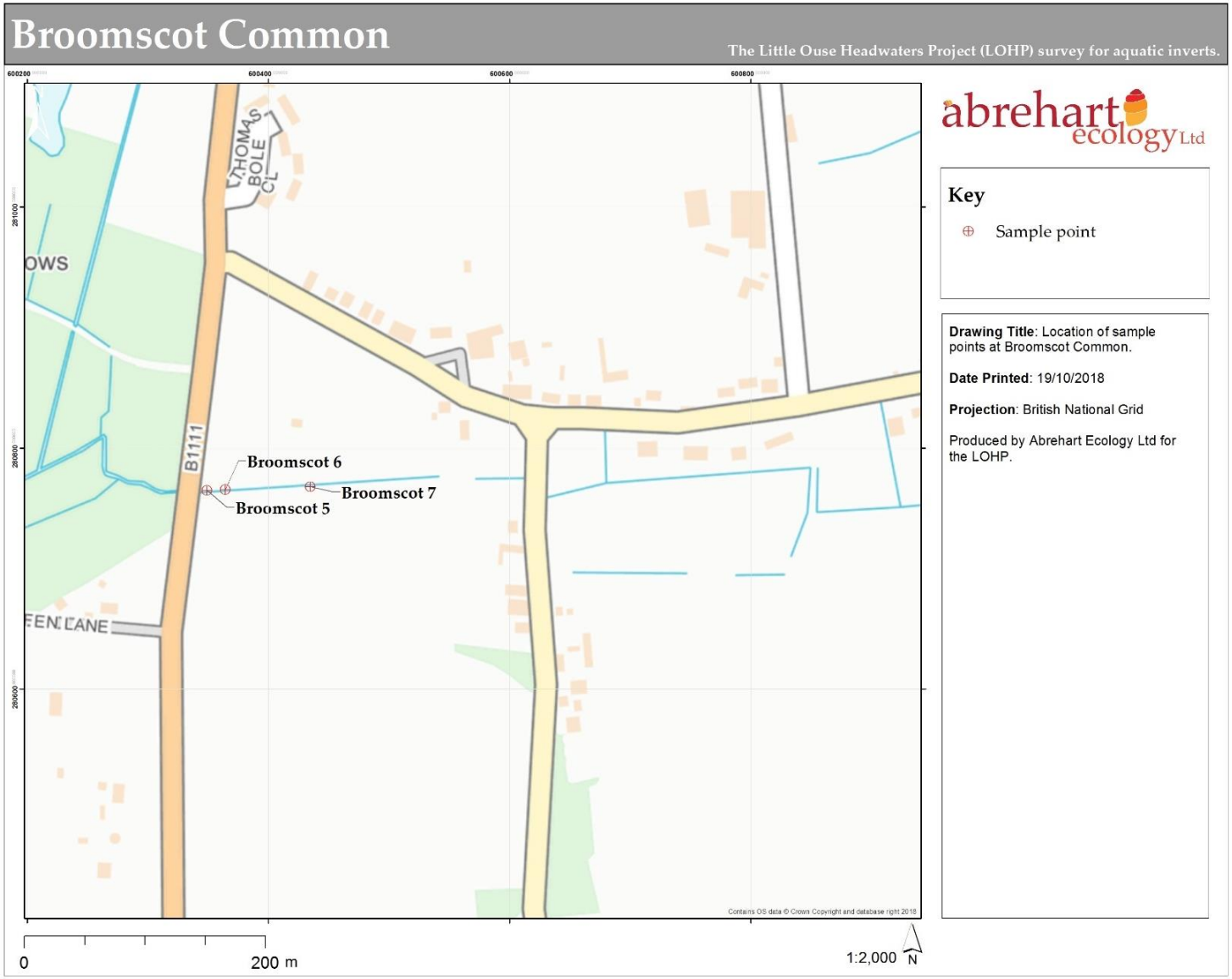

Figure 3. Locations of sampling points at Broomscot Common

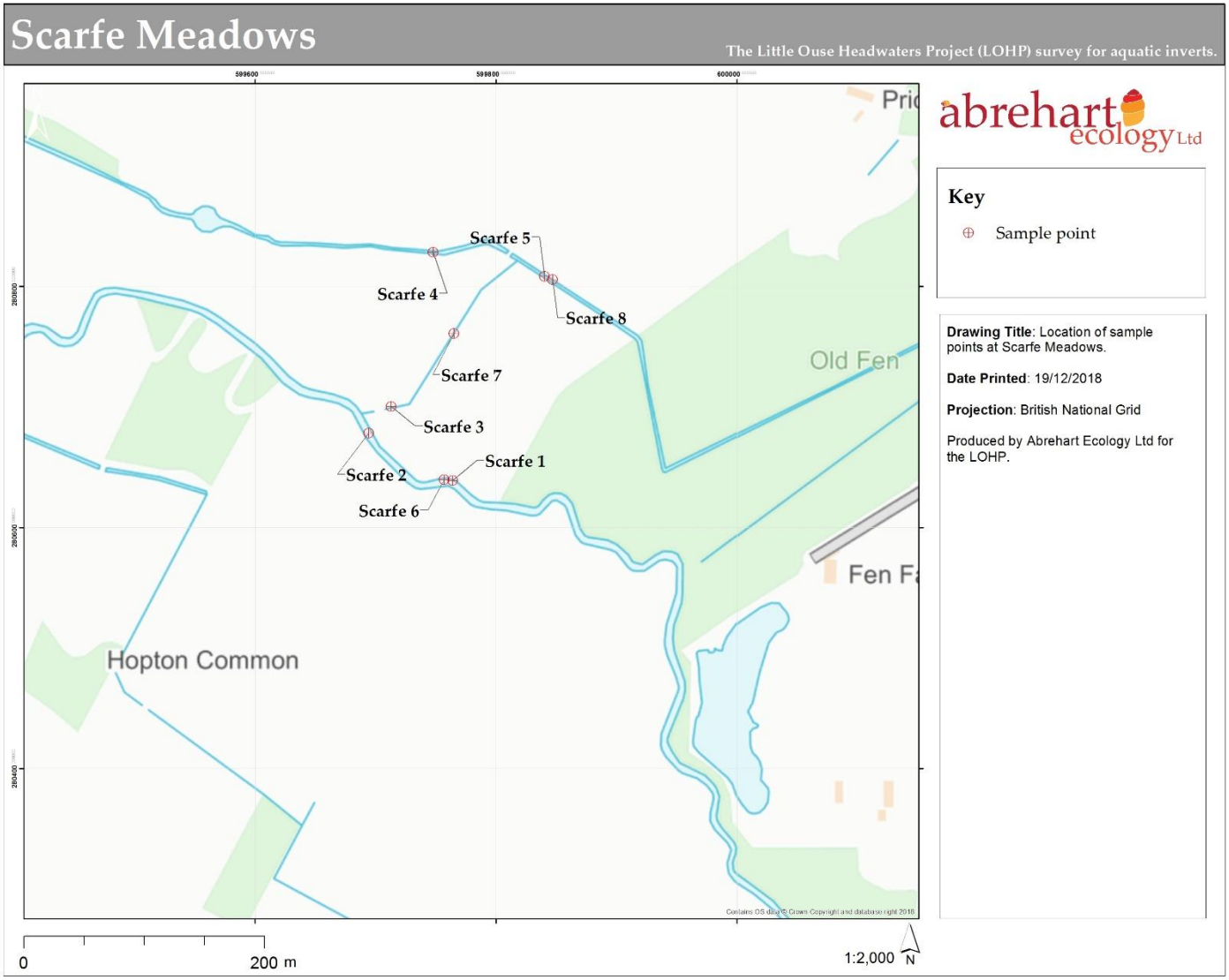

Figure 4. Locations of sampling points at Scarfe Meadows

3 Results

This section shows the distribution of species of aquatic invertebrate combined for each sample area under the study. The appendices contain the full detailed sample data for each sample site surveyed in the 2018 survey period. Samples were collected at five survey points along the Little Ouse River (Blo' Norton section), three sample points at Broomscot Common, and eight sample points at Scarfe Meadows (Figures 2-4).

*Table 1 – **Full Species List***

Class/Family		Status	Broomscot Common 2018	LOHP River 2018	Scarfe Meadows 2018
Arachnida	**Water mites and spiders**				
	Acari sp.		BC	LOHP	
	Halacaridae sp.				SM
	Hydrachna sp.			LOHP	SM
	Araneae sp.				SM
Amphidoda	**Freshwater shrimps**				
Gammaridae	Crangonyx pseudogracilis	Locally common	BC		SM
Gammaridae	Gammarus pulex	Very common	BC	LOHP	SM
Coleoptera	**Water Beetles**				
Chaetarthriinae	Anacaena globulus	Very common		LOHP	
Chaetarthriinae	Anacaena limbata	Very common			SM
Hydrophilidae	Cercyon sternalis	Nb			SM
Elmidae	Elmis aenea	Very common			SM
Elmidae	Elmis sp. larvae		BC	LOHP	SM
Enchrus	Enochrus coarctatus	Local			SM
Haliplidae	Haliplus lineatocollis	Very common		LOHP	
Helophoridae	Helophorus brevipalpis	Very common			SM
Hydraenidae	Hydraena gracilis	Local			SM
Hydraenidae	Hydraena nigrita	Nb		LOHP	
Hydraenidae	Hydraena riparia/britteni	Local		LOHP	SM
Hydraenidae	Hydraena testacea	Nb		LOHP	SM
Dytiscidae	Hydroporus memnonius	Common			SM
Dytiscidae	Hygrotus impressopunctatus	Local			SM
Dytiscidae	Hygrotus inaequalis	Common			SM
Dytiscidae	Ilybius fenestratus	Nb			SM
Dytiscidae	Ilybius fuliginosus	Very common		LOHP	SM
Dytiscidae	Ilybius sp. larvae			LOHP	SM
Hydrophilidae	Laccobius striatulus	Local			SM
Hydraenidae	Ochthebius minimus	Very common		LOHP	SM
Diptera	**Fly larvae**				
Athericidae	Atherix sp.			LOHP	
Beridinae	Beridinae sp.		BC		
Crambidae	Crambidae sp.				SM
Culicidae	Culicidae sp.		BC		

Class/Family		Status	Broomscot Common 2018	LOHP River 2018	Scarfe Meadows 2018
Culicoides	Culicoides sp.				SM
	Dixa sp.		BC	LOHP	SM
Limoniidae	Limoniidae sp.		BC		
Oligochaetidae	Oligochaeta sp.		BC		
Orthocladidae	Orthocladius sp.		BC	LOHP	SM
Oxyceridae	Oxycera sp.				SM
Pericomidae	Pericoma sp.				SM
Psychodidae	Psychoda sp.				SM
Psychodidae	Psychodidae pupa		BC		
Ptychopteridae	Ptychoptera sp.		BC		
Simuliidae	Simulium argyreatum			LOHP	
Simuliidae	Simulium aureum			LOHP	
Simuliidae	Simulium reptans			LOHP	
Simuliidae	Simulium sp.			LOHP	
Tipulidae	Tipula sp.			LOHP	SM
Ephemeroptera	**Mayflies**				
Baetidae	Baetis vernus	Common		LOHP	
Caenidae	Cloeon dipterum	Very common		LOHP	
Caenidae	Cloeon sp.			LOHP	
Hemiptera	**Aquatic bugs**				
Corixidae	Callicorixa praeusta	Frequent			SM
Corixidae	Corixa punctata	Very common		LOHP	
Corixidae	Hesperocorixa linnaei	Occasional		LOHP	
Corixidae	Hesperocorixa moesta	Nb			SM
Corixidae	Hesperocorixa sahlbergi	Common		LOHP	
Corixidae	Sigara dorsalis	Very common			SM
Mesoveliidae	Mesovelia furcata	Nr			SM
Notonectidae	Notonecta glauca	Very common		LOHP	
Hirundineaedae	**Leeches**				
Arhynchobdellida	Erpobdella testacea	Occasional			SM
Arhynchobdellidae	Erpobdella octoculata	Very common	BC	LOHP	SM
Arhynchobdellidae	Helobdella stagnalis	Very common		LOHP	
Glossiphoniidae	Glossiphonia complanata	Very common	BC	LOHP	SM
Isopoda	**Water slaters - Hog lice**				
Asellidae	Asellus aquaticus	Common	BC	LOHP	SM
Megaloptera	**Alder flies**				
Sialidae	Sialis lutaria	Common		LOHP	SM
Bivalve	**Bivalves and Univalve Mussels**				
Sphaeriidae	Pisidium casertanum	Very common			SM
Sphaeriidae	Pisidium milium	Occasional	BC	LOHP	SM
Sphaeriidae	Pisidium nitidum	Occasional	BC	LOHP	SM

Class/Family		Status	Broomscot Common 2018	LOHP River 2018	Scarfe Meadows 2018
Sphaeriidae	Pisidium personatum	Frequent	BC	LOHP	SM
Sphaeriidae	Pisidium subtruncatum	Very common	BC	LOHP	SM
Sphaeriidae	Sphaerium corneum	Very common		LOHP	SM
Sphaeriidae	Pisidium sp.	Common	BC	LOHP	
Gastrapoda	**Molluscs**				
Acroloxidae	Acroloxus lacustris	Common		LOHP	SM
Bithyniidae	Bithynia leachii	Local			SM
Bithyniidae	Bithynia tentaculata	Very common			SM
Hydrobiidae	Potamopyrgus antipodarum	Very common		LOHP	SM
Lymnaeidae	Galba truncatula	Occasional	BC	LOHP	SM
Lymnaeidae	Lymnaea palustris	Common	BC	LOHP	SM
Lymnaeidae	Lymnaea stagnalis	Very common		LOHP	SM
Lymnaeidae	Radix balthica	Very common	BC	LOHP	SM
Physidae	Physa fontinalis	Very common		LOHP	SM
Planorbidae	Anisus vortex	Very common	BC	LOHP	SM
Planorbidae	Bathyomphalus contortus	Common		LOHP	SM
Planorbidae	Planorbarius corneus	Frequent		LOHP	SM
Planorbidae	Planorbis planorbis	Very common		LOHP	SM
Planorbidae	Gyraulus crista	Common		LOHP	SM
Succinea	Oxyloma elegans	Common			SM
Succinea	Succinea putris	Very common	BC	LOHP	SM
Valvatidae	Valvata cristata	Common			SM
Zonitoididae	Zonitoides nitidus	Occasional	BC	LOHP	SM
Physidae	Aplexa hypnorum	Local		LOHP	
Helididae	Cepaea hortensis	Common		LOHP	
Cochlicopidae	Cochlicopa lubrica	Common		LOHP	
Euconulidae	Euconulus alderi	Local	BC		
Odonata	**Dragonflies and damselflies**				
Calopterygidae	Calopteryx splendens	Common	BC	4	SM
Coenagrionidae	Coenagrion puella	Common		LOHP	SM
Coenagrionidae	Coenagrion sp.			LOHP	SM
Coenagrionidae	Ischnura elegans	Very common		LOHP	SM
Coenagrionidae	Pyrrhosoma nymphula	Frequent		LOHP	SM
Annelida	**True worms**				
Annelidae sp.	Annelidae sp.		BC		
Lumbriculus sp.	Lumbriculus sp.				SM
Artinopterygii	**fish**				
	Gasterosteus aculeatus	Commmon	BC	LOHP	SM
Gasterosteiformes	Pungitius pungitius	Common		LOHP	SM
Scorpaeniformes	Cottus gobio	Local	BC	LOHP	SM
Plectoptera	**Stoneflies**				
Ephemerellidae	Leuctra nigra	Occasional		LOHP	

Class/Family		Status	Broomscot Common 2018	LOHP River 2018	Scarfe Meadows 2018
Ephemerellidae	Nemurella pictetii	Occasional	BC	LOHP	
Ephemerellidae	Nemurella sp. damaged		BC	LOHP	
Trichoptera	**Caddis or Sedge Flies**				
Apataniidae	Apatania sp. partial specimen				SM
Limnephilidae	Limnephilus sp. partial specimen				SM
Phryganeidae	Phryganea bipunctata	Common			SM
Phryganeidae	Phryganea sp. partial specimen				SM
Baraedae	Beraea pullata	Common	BC		
Leptoceridae	Mystacides sp. 1st instar			LOHP	
Limnephilidae	Limnephilus lunatus	Very common		LOHP	
Limnephilidae	Limnephilus sp. 1st instar		BC	LOHP	
Limnephilidae	Limnephilus sp. early instar cases		BC		
Molannidae	Molanna angustata	Common			SM
Lepidoptera					
Crambidae	Crambidae sp.				SM
Tricladida	**Flatworms**				
Tricladidae	Tricalda sp.			LOHP	SM

4 Discussion of Results

4.1 Little Ouse River (Blo' Norton section)

In total, at least 68 taxa of aquatic invertebrates were recorded; of which, 51 were identified to species. The overall species richness of aquatic invertebrates varied from a minimum of 23 taxa to a maximum of 37 taxa in a sample. Areas of high overall species richness were predominantly found at the western end of the survey area, corresponding with 'good' water quality. Sample sites with lower diversity and reduced water quality were observed at the eastern end of the survey area (Figure 3). Full species lists for each sampling point are provided in the accompanying spreadsheet and appendices. The water depth was similar across all the sample points at approximately 0.5-1m deep, the banks were steep sided with a friable substrate, across the river channel there was much sedimentation across the width with large amounts were the emergent vegetation was at its' highest density. The emergent vegetation was dominated with *Sparganium erectum* and scattered areas of occasional *Phragmites australis* and *Berula erecta*. Aquatic macrophytes were limited to small stands of *Potamogeton natans* and *Callitriche stagnalis*.

Of the aquatic invertebrates found in the samples, two regionally notable species were identified during the survey (Table 5; Figure 6). The occurrence of species of conservation interest coincided with high overall species richness of aquatic invertebrates (Table 4; Figure 5). The main invertebrate communities were riverflies – nine species, molluscs (including bivalves) - 22 species and water beetles – nine species.

The Annex II species *Cottus gobio* (bullhead) were also recorded within two samples (locations detailed in Figure 6 and Appendix A).

Two invasive species, the amphipod *Crangonyx pseudogracilis* and the mollusc *Potamopyrgus antipodarum*, were found to be widespread throughout the survey area. Uncommon beetles included *Hydraena nigrita* (Nb), *Hydraena Testacea* (Nb) and *Hydraena riparia/britteni* (Local). *Aplexa hypnorum* was an uncommon mollusc species found within the sample collected in the river, this is not a typical habitat for the species though not unheard of.

Table 2. ***Water Characteristics***

Site ref	1	2	3	4	5
pH	7.2	7.1	7.1	7.0	7.0
Conductivity µs/m (25°C)	1293	1288	1260	1102	990
DO	5.3	5.0	5.2	5.1	4.5
Temperature °C	13	12.5	12.5	12	12

4.2 Scarfe Meadows

In total, at least 79 taxa of aquatic invertebrates were recorded; of which, 58 were identified to species. The overall species richness of aquatic invertebrates varied from a minimum of 20 taxa to a maximum of 38 taxa in a sample. Areas of high overall species richness were scattered across the site, with the upper river samples and the ditches to the north supporting the highest diversity. Full species lists for each sampling point are provided in the accompanying spreadsheet and appendices. The water depth varied across the site with the river channel having a depth at the sampling station of 1m. The ditches had varying densities of emergent plant species, including several which were densely choked and had limited water depth and one which was close to 2m deep and much more open. The banks were equally wide ranging, from steep-sided river banks with very limited vegetation cover to shallow ditch margins with dense bankside and emergent vegetation. The sediment in the river channel was initially firm; however, once the net had broken through the upper surface it was very soft for at least 50cm. The emergent vegetation was dominated with *Sparganium erectum* and

scattered areas of occasional *Phragmites australis* and *Berula erecta*. Aquatic macrophytes were limited to small stands of *Potamogeton natans* and *Callitriche stagnalis*.

Of the aquatic invertebrates found in the samples four Regionally Notable species were identified in total during the survey (Table 5; Figure 8). The occurrence of species of conservation interest coincided with high overall species richness of aquatic invertebrates (Table 5; Figure 7).

The Annex II species *Cottus gobio* (bullhead) was also recorded within samples (locations detailed in Sections 3.1.1-3.1.11).

Two invasive species, the amphipod *Crangonyx pseudogracilis* and the mollusc *Potamopyrgus antipodarum*, were found to be widespread throughout the survey area. Uncommon beetles included *Hydraena nigrita* (Nb), *Hydraena Testacea* (Nb) and *Hydraena riparia/britteni* (Local), *Ilybius fenestratus* (local). Uncommon hemiptera included *Hesperocorixa moesta, Mesovelia furcate, Enochrus brevipalpis* and *Sigara dorsalis*.

Table 3 ***Water Characteristics***

Site ref	1	2	3	4	5	6	7	8
pH	7.35	7.35	7.3	7.3	7.5	7.35	7.6	7.5
Conductivity µs/m (25°C)	1430	1430	990	940	920	1430	930	920
DO	7.5	7.5	9.3	9.5	7.3	7.5	7.4	7.3
Temperature °C	12.5	12.5	13	12	12	12.5	12	12

4.3 Broomscot Common

In total, at least 34 taxa of aquatic invertebrates were recorded; of which, 18 were identified to species. The overall species richness of aquatic invertebrates varied from a minimum of 19 taxa to a maximum of 23 taxa in a sample. There were no areas of high species richness. Sample sites with lower diversity and reduced water quality were observed at the eastern end and central section of the survey area (Figure 7). Full species lists for each sampling point are provided in the accompanying spreadsheet and appendices. The water depth was limited to 5cm at its deepest with a full covering of vegetation across the width of the channel. Below this floating vegetation was an area of wetter muds to 30cm deep. The banks were shallow, with no more than 30cm of freeboard to the water. The water in the channel was flowing very slowly to the west, although this was almost imperceptible until the vegetation was depressed. The emergent vegetation was dominated by *Berula erecta* and aquatic macrophytes were limited to small stands of *Callitriche stagnalis*.

The main invertebrate communities were molluscs (including bivalves) - 21 species and water beetles – 16 species.

The Annex II species *Cottus gobio* (bullhead) and the invasive amphipod *Crangonyx pseudogracilis* were found in sample point 7 (see Figure 9).

Water Characteristics

Unable to collect enough sample for water analysis, water was very shallow over dense vegetation.

4.4 SAFIS analysis

Full results from SAFIS are presented in Table 3.

Little Ouse River (Blo' Norton section)

Water quality was predominantly classified as 'good', with one sample classified as 'moderate'. This reduced water quality was consistent with lower taxa being recorded – 21 taxa recorded compared to 24-35 within other samples. The quality of the invertebrates improved down the river with the 'Wetscore' starting at 0 leading to 23 at Sample 5 near to the ford in the west.

In this survey 70 taxa (with 52 identified to species) and a specimen count of 2310 were made, in the 2014 (Chalkley survey) 54 species were recorded with a count of 1525 - showing that there has been little basic change in the number of species found. This survey was undertaken in September, whereas the 2014 survey was carried out in July 2013. The summer of 2018 was very long and hot and the with almost no rainfall. This will undoubtedly have impacted water levels and water flow within the river channel.

The conservation value started with 'low' at Sample 1 ending on 'fairly high' at Sample 5. The 'CCI' score also increased the further down the river the samples were taken.

Scarfe Meadows

The water quality at Scarfe Meadows was classified as 'good', across the site. The quality of the invertebrate communities was similarly good with between 18 to 34 species found in the samples.

In this survey 79 taxa (with 58 identified to species) and a specimen count of 1910 were recorded; in the 2013 survey 46 taxa of 36 species were recorded from the eight samples. A total of 23 species of mollusc, two species of fish, and 22 species of invertebrate were identified.

The conservation value at Samples 2 and 5 were classified as 'low' (a river and ditch sample respectively), with the Samples at 1 and 6 being 'high'. The river sample at site 2 was taken in the most suitable habitat available; however, it was poor habitat and the scores from SAFIS are accordingly poor.

Broomscot Common

The water quality of the channel at Broomscot Common was 'moderate' or 'good' (with the 'good' quality water found at the western end of the survey area). The diversity of the invertebrate community was also more limited, with only 12-14 species found in the three samples.

According to the CCI value produced by SAFIS, most of the sample sites surveyed are of 'Moderate' conservation importance. 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).

In this monitoring survey, 34 taxa of invertebrate (with 18 identified to species) were recorded; this included six species of mollusc, one species of fish, and a specimen count of 1643.In the 2013 survey, 23 taxa of 15 species were recorded from the two samples; comprising seven species of mollusc, one species of fish, and 15 species of invertebrate.

4.5 Analysis Methods

For each of the thirteen sample sites six standard measurements or metrics3 have been calculated allowing an assessment of the condition of the watercourse as revealed by the invertebrate community it supports. These metrics are:

- The Biological Monitoring Working Party Score (BMWP)
- The Average Score Per Taxon4 (ASPT)
- The Lincoln Quality Index (LQI)
- The Community Conservation Index (CCI)
- The Lotic-Invertebrate Index for Flow Evaluation (LIFE)
- The Proportion of Sediment-sensitive Invertebrates (PSI)

These metrics were calculated using the Site Analysis for Invertebrate Surveys (SAFIS) programme version 26.1. This was written by Adrian Chalkley some years ago. By means of a detailed inbuilt species dictionary SAFIS merely automates the mathematical methods defined in the original papers for each metric which are referenced in section 7.

Interpretation of the calculations

For a full explanation of these methods the original papers should be consulted but in order to interpret the results shown in Table 3 the following may be a useful summary.

BMWP is a measure of the water conditions, of oxygenation and cleanliness. BMWP scores are industry standard and reflect the sensitivity of the families to pollution. The higher the family score, the more sensitive to oxygen depletion the family is and therefore their presence indicates a cleaner or less impacted site. The effects of pollution generally are to impose a Biological Oxygen Demand upon the receiving waters and so sensitive families are progressively excluded as the BOD increases. The revised BMWP system (2007) was used here as it was in the 2013 survey. As a guide the following may be used:

BMWP score < 25 = poor water conditions, 26-50 = moderate, 51-100 = good, 101-150 = very good, more than 150 = exceptional.

ASPT is based on the BMWP score and so also measures water quality. The BMWP score for each family present is totalled to give a site score, therefore a high score can be achieved through a large number of low scoring families as well as a small number of high scoring families.

[3] Metric ~ a quantifiable attribute of an aquatic community that is ecologically relevant and responds predictably.

4 Taxon ~ A Taxon is a single animal group, e.g. Pondskaters, Water Boatmen, Diving Beetles or Whirligig beetles.

Therefore an Average Score Per Taxa (ASPT) is also calculated which allows further interpretation of the results. The higher the ASPT, the greater the proportion of more sensitive families in the sample and therefore the better the site condition. It is useful in showing year to year changes and trends in the invertebrate population supported by the water body. Being an average score, the higher its value the more ecologically valuable the population should be.

Any value greater than 4 generally indicates good water quality but productive water bodies with large and varied populations will usually have an ASPT value between 4.5 and 5.0: ASPT <4 = poor water quality, >4 = moderate quality, >5 = good quality >6 = very good

LQI is a metric similar to and based on BMWP which indicates water quality, it not only takes account of the average score per family but habitat quality as well (from habitat rich to habitat poor). LQI is less often used these days but as the 2013 survey by Abrehart Ecology quoted LQI scores they are calculated here for comparison. LQI sites are rated with the following categories: I & H, very poor quality; G & F, poor quality; E & D, moderate quality; C & B, good quality; with A, A+ & A++ representing excellent quality water.

CCI is based on the rarity of the individual invertebrates living in the water. It gives a numerical value to the conservation importance of the aquatic community. The higher the CCI value the greater the conservation interest.

CCI values can range from less than 5 for a site with little or no conservation value to a score greater than 20 for sites with very high conservation interest. This group of highest CCI values often indicate a site that is of national importance and of potential SSSI status.

LIFE is a method which evaluates the prevailing flow regime in a water body. It is often used to evaluate the effects of water abstraction upon the benthic macroinvertebrate community.

Species (or families) are assigned a flow group based on their recognised association with flow regime as shown below.

PSI is a sediment-sensitive macro-invertebrate metric which provides a proxy to describe the extent to which the surface of river beds are composed of, or covered by, fine sediments. Where suitable biomonitoring data exist, the index can be calculated retrospectively to track trends in fine sediment deposition, and its ecological impact, through time. Increased fine sediment deposition and entrainment in rivers can arise from a combination of factors; including low flows, habitat modification and excessive sediment delivery from the catchment. This deposition can have negative impacts upon the biological health of the river and is one driver for the increasing adoption of restoration projects. PSI values given here for 2014 should provide a useful comparison for future post restoration surveys as there is a clear need for describing the degree to which riverine substrates are composed of fine sediment and/or impacted by fine sediment deposition. Site-specific target standards are also required to allow local impacts to be generically defined and to align with WFD classification schemes.

When calculating PSI results each species, or family if a specimen was not identified to species, is assigned to a group from A to D with a Sediment Sensitivity Rating as follows:

A= Taxa highly sensitive to sedimentation,

B= moderately sensitive,

C= moderately insensitive,

D= highly insensitive to sedimentation

A Sediment Sensitivity Score is assigned based on the log abundance category of each species in the sample (1-9, 10-99, 100-999 and 1000+ individuals present). The PSI score is then calculated as:

$$\frac{\sum \text{Scores for Sediment Sensitivity Groups A \& B}}{\sum \text{Scores for all Sediment Sensitivity Groups A, B, C \& D}} \times 100$$

PSI scores can be interpreted by the following:

81-100 Minimally sedimented / Unsedimented

61-80 Slightly sedimented

41-60 Moderately sedimented

21-40 Sedimented

0-20 Heavily sedimented

Table 4. ***Overall conservation value of invertebrate communities based on SAFIS analysis.***

Little Ouse River (Blo' Norton section)														
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	TM0240378827	24	21	549	68	4.25	16	Good	B	6.45	12.5	4.71	Low	0
2	TM0205378820	21	14	434	34.2	3.42	10	Moderate	E	6.43	18.52	1.07	Low	0
3	TM0184178969	35	27	531	69	4.6	15	Good	A	6.85	36.54	13.67	Fairly high	1
4	TM0149678970	30	23	298	51.1	3.93	13	Good	C	6.4	20	15.11	High	1
5	TM0121479095	32	27	129	65.2	4.08	16	Good	C	5.81	5.77	13.72	Fairly high	1
Scarfe Meadows														
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	TL9976380648	36	34	329	84.6	4.7	18	Good	A+	6.06	11.67	15.17	High	2
2	TL9970180684	19	18	127	54.9	4.58	12	Good	A+	6.22	6.45	4.8	Low	0
3	TL9971280697	39	32	199	66.3	4.14	16	Good	B	5.87	5.9	10	Moderate	0
4	TL9974880834	28	24	220	54.4	3.89	14	Good	C	5.64	4.44	10	Moderate	0
5	TL9984880812	32	29	130	63.7	3.98	16	Good	C	5.92	6.52	5.09	Low	0
6	TL9975780640	39	34	349	80.2	4.72	17	Good	A	5.97	10.17	16.17	High	2
7	TL9976580761	34	29	319	72	4	18	Good	C	5.78	6.25	13.71	Fairly high	2
8	TL9984780806	31	28	252	69.3	4.08	17	Good	C	5.81	6	10.65	Fairly high	0
Broomscot Common														
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
5	TM0034980765	22	19	523	56	5.09	11	Good	A+	5.87	27.27	6.69	Moderate	0
6	TM0036180770	18	18	705	38.1	3.81	10	Moderate	D	5.82	14.29	7.15	Moderate	0
7	TM0043580767	20	15	405	32.4	3.6	9	Moderate	E	6.1	7.14	6	Moderate	0

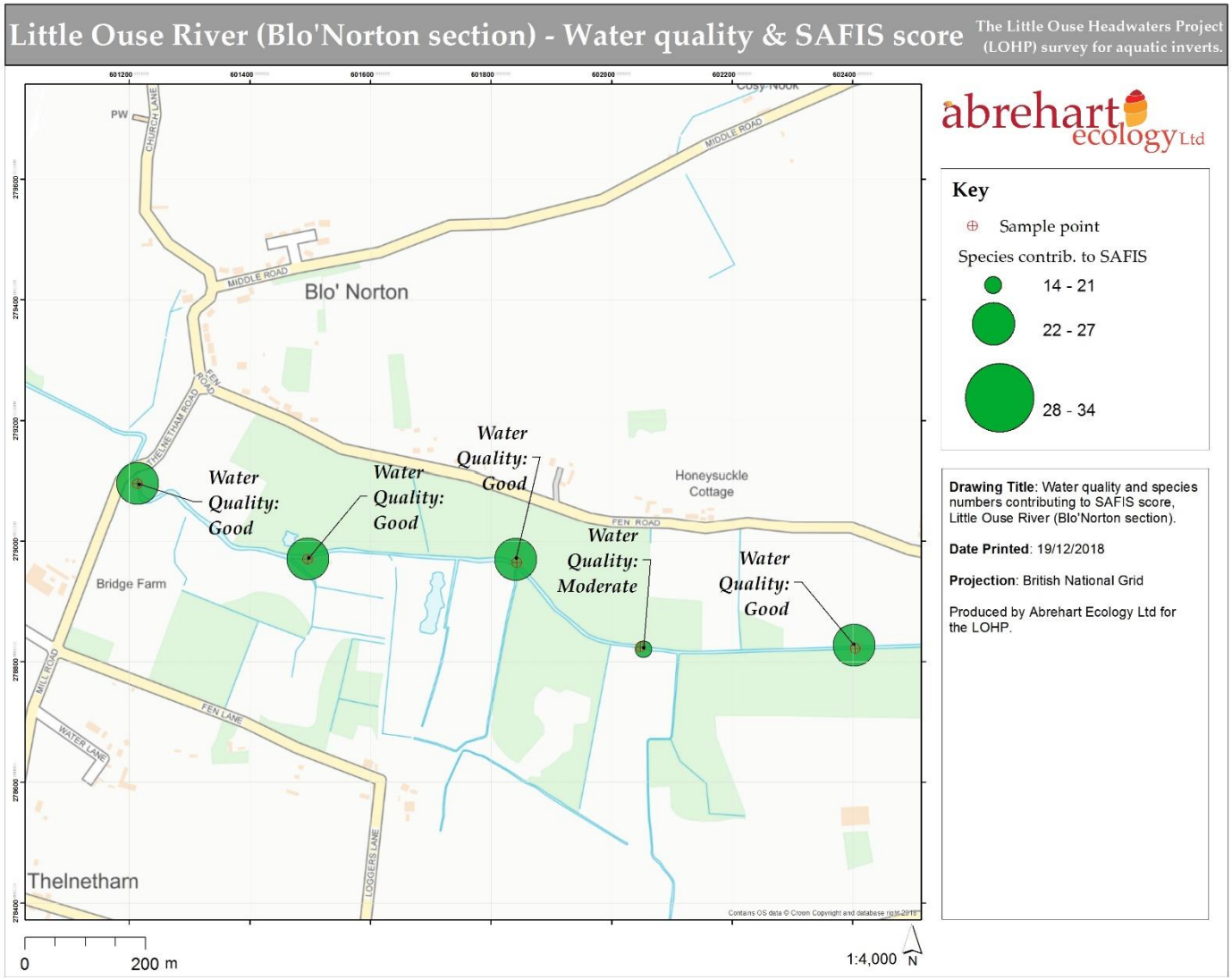

Figure 5. Species richness of aquatic invertebrates across the Little Ouse River (Blo' Norton section) survey area and water quality at sample points.

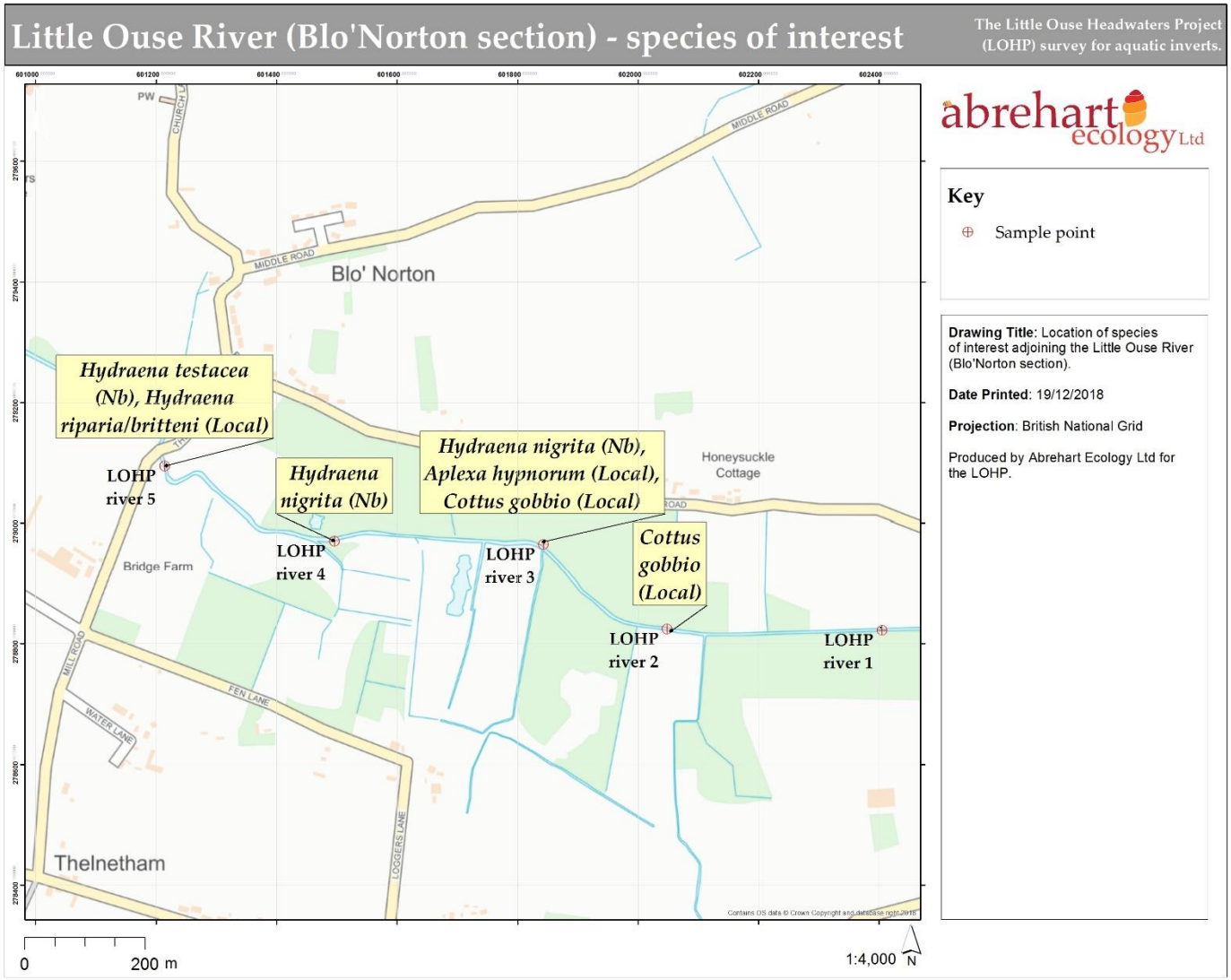

Figure 6. Distribution of red-listed and notable aquatic invertebrate species across the Little Ouse River (Blo' Norton section) survey area.

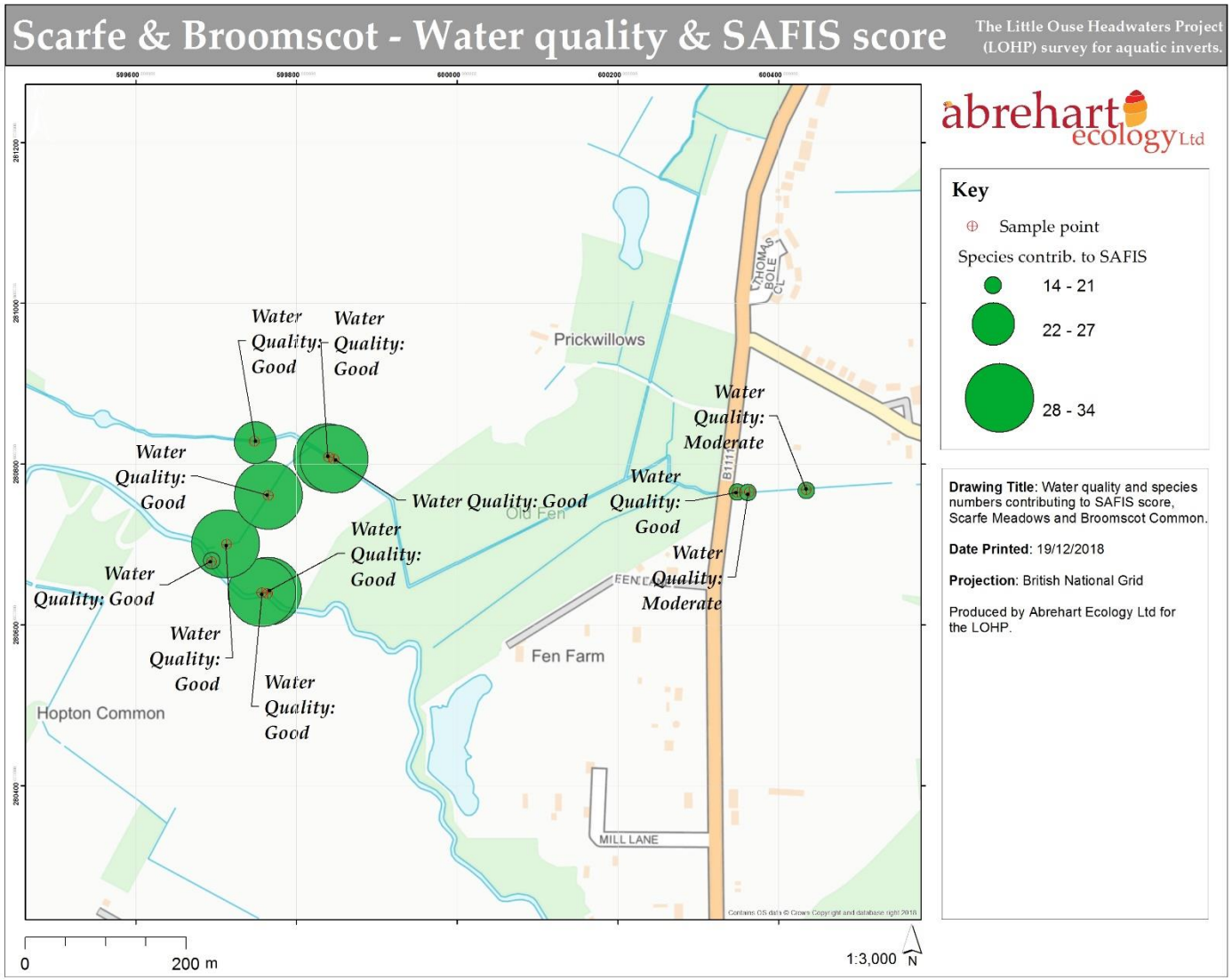

Figure 7. Species richness of aquatic invertebrates across the Broomscot Common and Scarfe Meadows survey area and water quality at sample points.

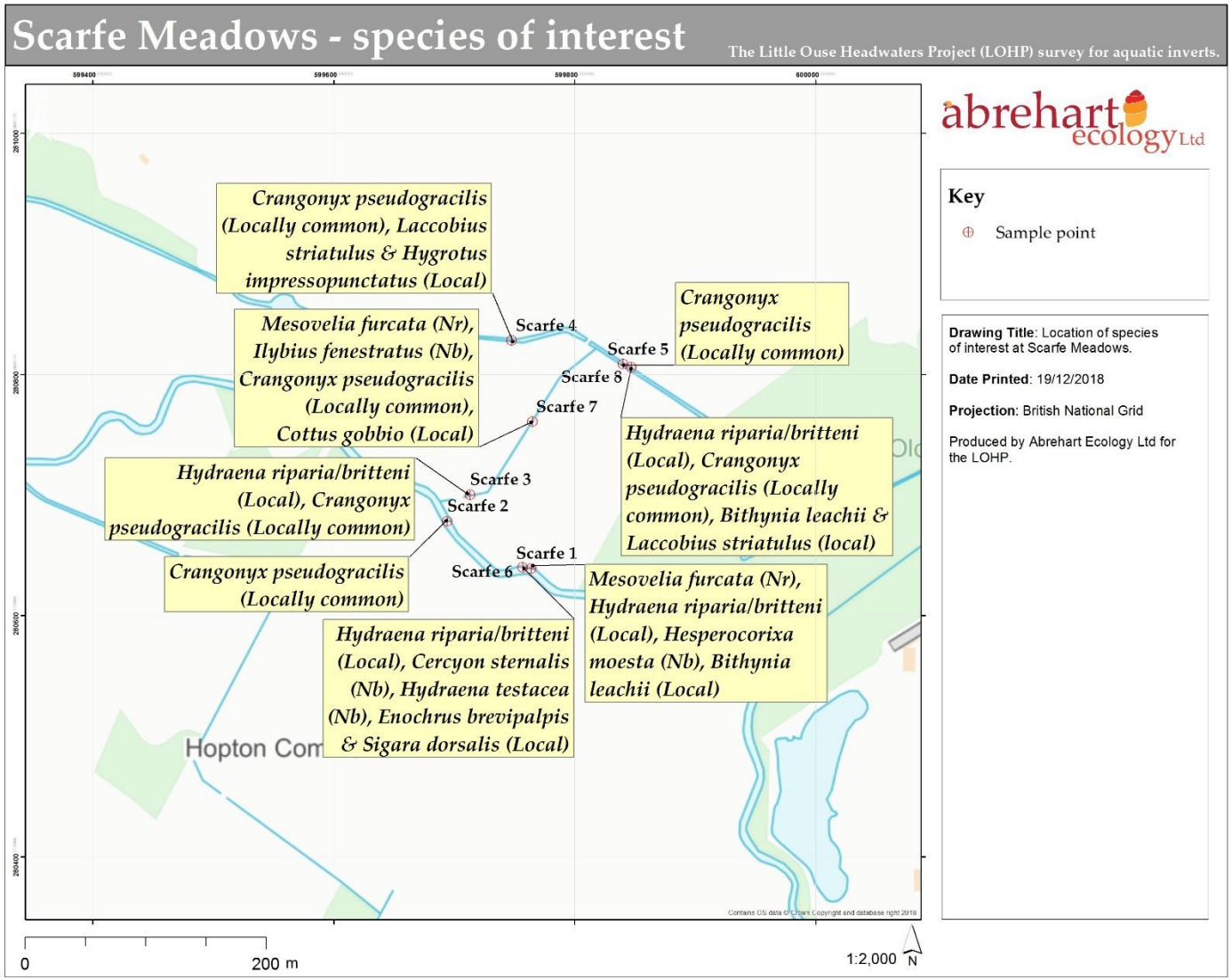

Figure 8. Distribution of red-listed and notable aquatic invertebrate species across the Scarfe Meadows survey area.

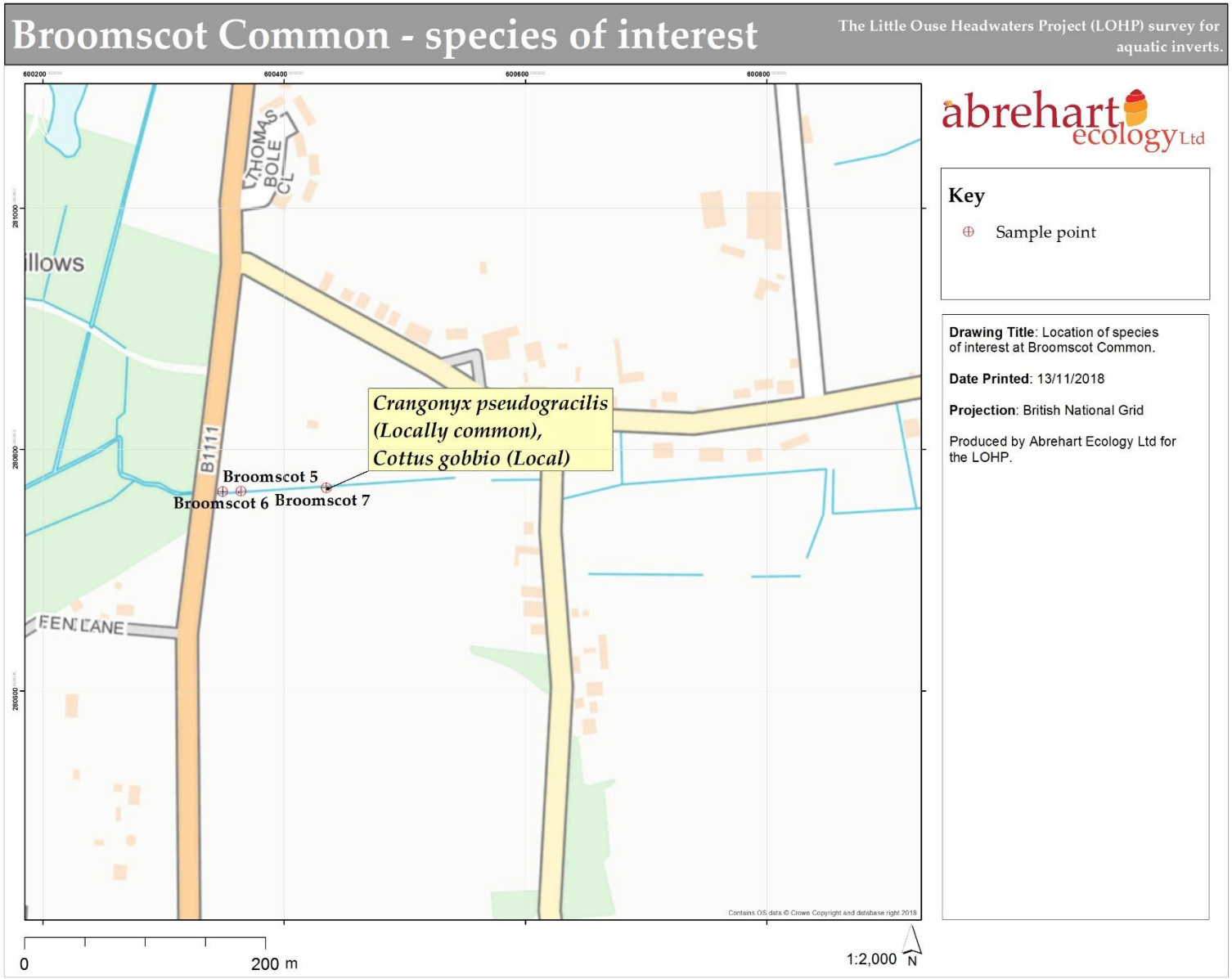

Figure 9. Distribution of red-listed and notable aquatic invertebrate species across the Broomscot Common survey area.

4.6 Rare and notable species

Of the five samples collected from the Little Ouse River (Blo' Norton section), two held notable species and four species which were considered 'local' were identified. The habitat requirements, and local and national status for each are briefly detailed below:

Of the three samples taken in the channel at Broomscot Common the upper sample had one species considered local (bullhead).

Of the eight samples taken across Scarfe Meadows, five species were notable, seven were local and one was locally common.

Table 5: ***Occurrences of uncommon species per sample sites across the three areas surveyed***

	Sample sites													
	Broomscot Common	Little Ouse Headwaters Project River				Scarfe Meadows								
Species	BC7	LO2	LO3	LO4	LO5	SC1	SC2	SC3	SC4	SC5	SC6	SC7	SC8	**Total of notable records**
Aplexa hypnorum (Local)			1											1
Bithynia leachii (Local)						1							1	2
Cercyon sternalis (Nb)											1			1
Cottus gobbio (Local)	1	1	1									1		4
Crangonyx pseudogracilis (Locally common)	1						1	1	1	1		1	1	7
Enochrus brevipalpis (local)											1			1
Hesperocorixa moesta (Nb)						1								1
Hydraena nigrita (Nb)			1	1										2
Hydraena riparia/britteni (Local)					1	1		1			1		1	5
Hydraena testacea (Nb)					1						1			2
Hygrotus impressopunctatus (Local)									1					1
Ilybius fenestratus (Nb)												1		1
Laccobius striatulus (local)									1				1	2
Mesovelia furcata (Nr)						1						1		2
Sigara dorsalis (Local)											1			1
Total of notable records	2	1	3	1	2	4	1	2	3	1	5	4	4	33

Bullhead *Cottus gobio (Linnaeus, 1758)*

National Status

The bullhead is widespread and often common in rivers across Europe. This is a species protected under Annex II species of the Habitats Directive.

Local Status

The Bullhead is restricted in distribution across Norfolk and Suffolk, with populations centred in the central portion of several rivers running through to the coasts. There are no records away from these river habitats. The population in the Little Ouse River is considered to be of local importance and appears to be recovering.

Habitat

The bullhead is a small bottom-dwelling fish that inhabits a variety of rivers, streams and stony lakes. However, in East Anglia, it also occurs in lowland situations, on softer substrates, so long as the water is well-oxygenated and there is sufficient cover (this habitat was found across the sampling area). It is not found in badly polluted rivers.

It is considered that there will be no issues with the continued presence of this species in the Little Ouse River, unless there are pollution incidents.

5 Discussion

The surveys detailed in this report assessed the diversity and conservation value of aquatic invertebrate communities at sixteen locations along the Little Ouse River and ditches at Broomscot Common and Scarfe Meadows in Norfolk.

It was observed that high sedimentation was still prevalent within the river channel - a continuing issue for this section of the Little Ouse.

Little Ouse River (Blo' Norton section): changes in the fauna over the three surveys has shown that prior to pre-restoration works the diversity within the river was relatively poor. The post-restoration survey showed that several additional species had colonised the river/become more abundant and the restored habitat was doing well. This monitoring survey has shown that there is a similar community, though lacking the diversity of beetles found in the 2014 survey. This is likely due to the time of year for the sampling (September) and a long hot summer that may have had an effect on several groups of invertebrates. This effect was seen in other surveys within the lower Waveney Valley in 2018.

Scarfe Meadows: the communities were slightly richer in this survey than in the 2013 survey, this is likely due to four more samples being taken and slight changes in management on the site. It was good to see Bullhead in the river and the ditches on site.

Broomscot Common: the species diversity/richness recorded here over the two survey periods show that the community has improved slightly. The sample area was still very heavily choked with vegetation and held very small 'pools' of water, often no larger than 10cm x 10cm with a depth of 2cm. When pressing into this pool to collect a sample the water quickly became dirty with the sediment from below. The only area of more open water was at the eastern end of the survey area, near the path. This was where the bullhead was collected.

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.

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Appendix A– Full species lists

Species/Taxa recorded in Little Ouse River (Blo' Norton section) aquatic invertebrate samples

Species/Taxa	1	2	3	4	5
Acari sp.		3			
Acroloxus lacustris				4	13
Anacaena globulus					1
Anisus vortex	24	35	20		7
Aplexa hypnorum			2		
Asellus aquaticus	61	36	74	4	16
Atherix sp.			1		
Baetis vernus		13	25	3	
Bathyomphalus contortus	11	13	7	4	5
Caddis cases			6	5	
Calopteryx splendens			2		
Cepaea hortensis				1	
Cloeon dipterum		1	2	2	
Cloeon sp.	1				
Cochlicopa lubrica	1			1	2
Coleoptera sp. larvae					22
Corixa punctata					2
Cottus gobio		1	1		
Dixa sp.		1		1	
Elmis sp.	2				
Erpobdella octoculata	9	5	16	7	10
Galba truncatula	1				
Gammarus pulex	295	274	110	84	89
Gasterosteus aculeatus	4	3	5		4
Glossiphonia complanata	8	1	20	31	11
Gyralus albus		3			
Haliplus lineatocollis					1
Helobdella stagnalis	1				
Hesperocorixa linnaei					33
Hesperocorixa sahlbergi				15	47
Hydrachna sp.			33	3	10
Hydraena nigrita			2	3	
Hydraena riparia/britteni					1
Hydraena testacea					1
Ilybius fuliginosus		1			
Ilybius sp. larvae	7	1	1	3	
Leuctra nigra			1		
Limnephilus lunatus	5		6	3	
Limnephilus sp.	4			4	5
Lymnaea palustris					3
Lymnaea stagnalis		4		1	5
Mystacides sp.	3				6

Species/Taxa	1	2	3	4	5	
Nemurella pictetii		1				
Nemurella sp.			1			
Notonecta glauca					7	
Ochthebius minimus					4	
Orthocladius sp.	25	21	43	16	26	
Physa fontinalis	2	7	15	3	2	
Pisidium milium	26			26	5	
Pisidium nitidum			3	7	9	
Pisidium personatum				3		
Pisidium sp	38	7	7	58	64	
Pisidium subtruncatum	4		4		13	
Planorbarius corneus				1		
Planorbis planorbis			1			
Potamopyrgus antipodarum	14	3	11			
Pungitius pungitius			11		4	
Radix balthica		1			8	
Sialis lutaria	5		1		11	
Simulium argyreatum			49	3		
Simulium aureum			3			
Simulium reptans			1			
Simulium sp.	2		57			
Sphaerium corneum			1		26	
Succinea putris			3	1		
Tipula sp.			1			
Trichotria sp.		3	2			
Zonitoides nitidus				1		
Totals for each site	553	438	548	298	473	2310

Species/Taxa recorded in Broomscot Common aquatic invertebrate samples

Species/Taxa	5	6	7	
Acari sp.			1	
Anisus vortex			1	
Annelidae sp.			3	
Asellus aquaticus	14	4	50	
Beraea pullata	2			
Beridinae sp.			1	
Caddis Case	3			
Cottus gobio			7	
Crangonyx pseudogracilis			7	
Culicidae sp.	1			
Dixa sp.	2		6	
Elmis sp.	11	1		
Erpobdella octoculata	11	11	5	
Euconulus alderi		1		
Galba truncatula	23	3		
Gammarus pulex	310	125	8	
Gasterosteus aculeatus		3		
Glossiphonia complanata	3	1		
Limnephilus sp.	1			
Limoniidae sp.	1	1		
Lymnaea palustris	22	37		
Nemoura sp.	1			
Oligochaeta sp.		6	225	
Orthocladius sp.	1		32	
Pisidium milium	45	83	11	
Pisidium nitidum	6	9	2	
Pisidium personatum	24	18	14	
Pisidium sp	29	21	9	
Pisidium sp.		355		
Psychodidae pupa			7	
Ptychoptera sp.			1	
Radix balthica	6	22	16	
Succinea putris	5	6	1	
Zonitoides nitidus	2	1	5	
Grand Total	523	708	412	1643

Species/Taxa recorded in Scarfe Meadows aquatic invertebrate samples

Species/taxa	1	2	3	4	5	6	7	8
Acroloxus lacustris	6	1	2	9	2	3	4	13
Anacaena limbata						1		
Anisus vortex	5		13	27	9	1	9	28
Apatania sp.	1							
Araneae sp.			6	5		2	3	
Asellus aquaticus	5	1	18	26	18	4	11	19
Bathyomphalus contortus	2		14	10	8	3	37	43
Bithynia leachii	1							1
Bithynia tentaculata			3		1		5	
Callicorixa praeusta	5			2	1	2		
Calopteryx splendens	3					1		
Cercyon sternalis						1		
Coenagrion puella			2					
Coenagrion sp.			2					
Cottus gobio							1	
Crambidae sp.			1				2	2
Crangonyx pseudogracilis		1	10	16	6		5	5
Culicoides sp.			2					
Dixa sp.					1		2	2
Elmis aenea	1							
Elmis sp.	1	1	1					
Enochrus coarctatus						1		
Erpobdella octoculata				3	3		5	3
Erpobdella testacea				1				
Galba truncatula			1	11	3		1	10
Gammarus pulex	67	2	29	21	11	90	73	36
Gasterosteus aculeatus	2	1					4	
Glossiphonia complanata				1	1		2	
Gyraulus crista	2	1	4					
Halacaridae sp.					1			
Helophorus brevipalpis						1		
Hesperocorixa moesta	1							
Hydrachna sp.						1		
Hydrachnidiae sp.			1					
Hydraena gracilis						1		
Hydraena riparia/britteni	4		2			22		1
Hydraena testacea						1		
Hydroporus memnonius					1			
Hygrotus impressopunctatus				1				
Hygrotus inaequalis						1		
Ilybius fenestratus							1	
Ilybius fuliginosus	1					1	2	
Ilybius sp.	1		1	3	2	2	3	2
Ischnura elegans			4					

Species/taxa	1	2	3	4	5	6	7	8	
Laccobius striatulus				1				1	
Limnephilus sp.		2	11	36	23	10	10	18	
Lumbriculus sp.				1				1	
Lymnaea palustris			5	3			18		
Lymnaea stagnalis	17	1	3	21	1	14	68	1	
Mesovelia furcata	1						1		
Molanna angustata	2					2			
Ochthebius minimus	1		2			2		1	
Orthocladius sp.	2		8	2	2	2			
Ostracod sp.		1							
Oxycera sp.					1	1	2	3	
Oxyloma elegans			1	1		1	1		
Pericoma sp.					1				
Phryganea bipunctata	1	1			2	3		3	
Phryganea sp.	3	3				13	1	9	
Physa fontinalis	2		2	6	2	4	4	9	
Pisidium casertanum	9	8			6				
Pisidium milium			1						
Pisidium nitidum	21	4				5			
Pisidium personatum	25	2	5		3	9		2	
Pisidium subtruncatum	36	31	4		8	47	2	7	
Planorbarius corneus	1		8				10	4	
Planorbis planorbis	1								
Potamopyrgus antipodarum	48	52				8			
Psychoda sp.				1					
Pungitius pungitius			1		1		1	2	
Pyrrhosoma nymphula			16		1		16	1	
Radix balthica	2	1	2	7	2		4		
Sialis lutaria	7	7	2			6	2	2	
Sigara dorsalis						1			
Sphaerium corneum	38	7	4	4	3	57	1	2	
Succinea putris	2		6	1	6	2	8	18	
Tipula sp.			1			1			
Valvata cristata			2				5	4	
Zonitoides nitidus					1				
Totals	327	128	200	220	131	327	324	253	1910