Commissioned by
Thames Water Utilities Limited
Clearwater Court
Vastern Road
Reading
RG1 8DB

CROSSNESS SEWAGE TREATMENT WORKS

NATURE RESERVE & SOUTHERN MARSH AQUATIC INVERTEBRATE SURVEY

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1 INTRODUCTION, BACKGROUND AND METHODOLOGY

1.1 Introduction and background

1.1.1 On 30th May 2018 **Colin Plant Associates (UK)** were commissioned by Biodiversity Team Manager, Karen Sutton on behalf of **Thames Water Utilities Ltd.** to undertake aquatic invertebrate sampling at Crossness Sewage Treatment Works on Erith Marshes, Kent. This survey was to mirror the locations and methodology of a previous survey undertaken during autumn 2016 and spring 2017. Colin Plant Associates also undertook the aquatic invertebrate sampling of this previous survey.

1.1.2 The 2016-17 aquatic survey was commissioned with the primary objective of establishing a baseline aquatic invertebrate species inventory and to determine the quality of the aquatic habitats present across both the Nature Reserve and Southern Marsh areas of the Crossness Sewage Treatment Works. The surveyors were asked to sample at twenty-four, pre-selected sample station locations, twelve in each area. Aquatic Coleoptera and Heteroptera (beetles and true bugs) were selected as target groups. A report of the previous survey was submitted in Sept 2017 (Plant 2017).

1.1.3 During December 2017 a large-scale pollution event took place and untreated sewage escaped into a section of the Crossness Nature Reserve. The primary point of egress was Nature Reserve Sample Station 1 (NR1) though because of the connectivity of much of the waterbody network on the marsh other areas were affected.

1.1.4 Following an extensive clean-up operation run during much of 2018 it was decided to repeat the 2016-17 monitoring survey with a view to determining the effects of the pollution event on the aquatic invertebrate fauna of the reserve by comparing the results across the two surveys.

1.1.5 In order to determine what changes to the aquatic invertebrate fauna may have taken place since the pollution event it was agreed that it was essential to adhere as closely as possible to the 2016-17 survey locations, timing, methodology and survey effort.

1.1.6 In Section 2 we present and discuss the results of the 2018-19 survey and compare these with 2016-17 results with a view to determining the effects of the 2017 pollution event.

1.1.7 In Section 3 we discuss the extant aquatic Coleoptera and Heteroptera found during the 2018-19 survey and provide species accounts and up to date species quality analysis.

1.1.8 The overall results are further discussed in Section 4.

1.1.9 Appendix 1 contains a full 2018-19 species list together with status codes and ecological notes.

1.2 Sample stations

1.2.1 As discussed above, the twenty-four sample stations were pre-determined prior to the commencement of the survey. The sample stations were divided between two survey areas.

1.2.2 The sample stations are named and defined in **Table 1**, below.

1.2.3 The locations of the twenty-four sample stations are indicated in map **Figure 1** (Crossness Nature Reserve) and map **Figure 2** (Crossness Southern Marsh), below.

Table 1. The Sample Stations named and defined with brief notes on their condition in 2018-19

CROSSNESS NATURE RESERVE	
Sample Station	**Notes**
NR1. Protected Area Southwest Ditch	A narrow, steep-sided ditch adjacent to the sewage works and the point of egress following the 2017 pollution event
NR2. Island Field Lagoons	A large mosaic of deep lagoons with adjacent fluctuating marsh - water levels were high during both visits enabling edge habitats to be sampled
NR3. Great Breach Dyke West	A steep-sided, reed-edged ditch with limited points of access
NR4. Protected Area Reedbed	A reedbed and ditch mosaic accessed from the boardwalk - water levels were very high during both visits
NR5. Protected Area East Ditch	A steep-sided, reed-edged ditch with limited points of access
NR6. Lagoon Field Ditch	A reed-edged ditch with shallow poached areas created by grazing horses
NR7. Access Path Ditch	A narrow, heavily vegetated ditch - some open water areas were present
NR8. Parsely Field Ditch	Grazing by horses and some management of the wader scrape made this sample station inaccessible during time of survey
NR9. Protected Area Wader Scrape	The wader scrape in front of the bird hide - water levels were very low during survey resulting in muddy margins and limited open water
NR10. Great Breach Dyke North	A steep-sided, reed-edged ditch with limited points of access - the water has some brackish influence
NR11. North Dyke / East Paddock	A narrow, well-vegetated ditch with lots of emergent vegetation and some open areas
NR12. East Ditch / East Paddock	A narrow, well-vegetated ditch with lots of emergent vegetation and some open areas - some evidence of road run-off and other pollution
CROSSNESS SOUTHERN MARSH	
SM1. Belvedere Road Ditch	A vegetation-choked ditch with areas of shading created by Salix sp.
SM2. The Wetland Reedbed	A heavily vegetated, flunctuating marsh - dry during the autumn visit, wet in the spring
SM3. The Wetland Wader Scrape	Colonised by wildfowl, hence the water is quite turbid and nutrient enriched. Sampling undertaken amongst emergent vegetation
SM4. Belvedere Road Path Ditch	A steep-sided ditch with limited access and minimal open water
SM5. Erith Marsh Dyke West	A steep-sided ditch with limited access - a sampling point was opened during the autumn visit and re-used in the spring
SM6. Erith Marsh Dyke South	Flooded during both visits with water inundating the adjacent field
SM7. Erith Marsh Dyke East Junction	A steep-sided ditch with very high water levels during both visits
SM8. Saline Meadow Dipping Pond	Very high water levels during both visits - almost no emergent vegetation remaining around the pond edge
SM9. Saline Meadow Ephemeral Pool	Dry during autumn visit - some wet areas in spring
SM10. Saline Meadow Ephemeral Pool	Dry during autumn visit - some wet areas in spring
SM11. Erith Marsh Dyke East Bridge	Water levels very high during spring visit and water showed signs of run-off from the adjacent road
SM12. Great Breach Dyke	A deep, large and flowing ditch that is subject to some road run-off and has limited safe access

Crossness Nature Reserve

Figure 1. Map of Crossness Nature Reserve showing location of Sample Stations

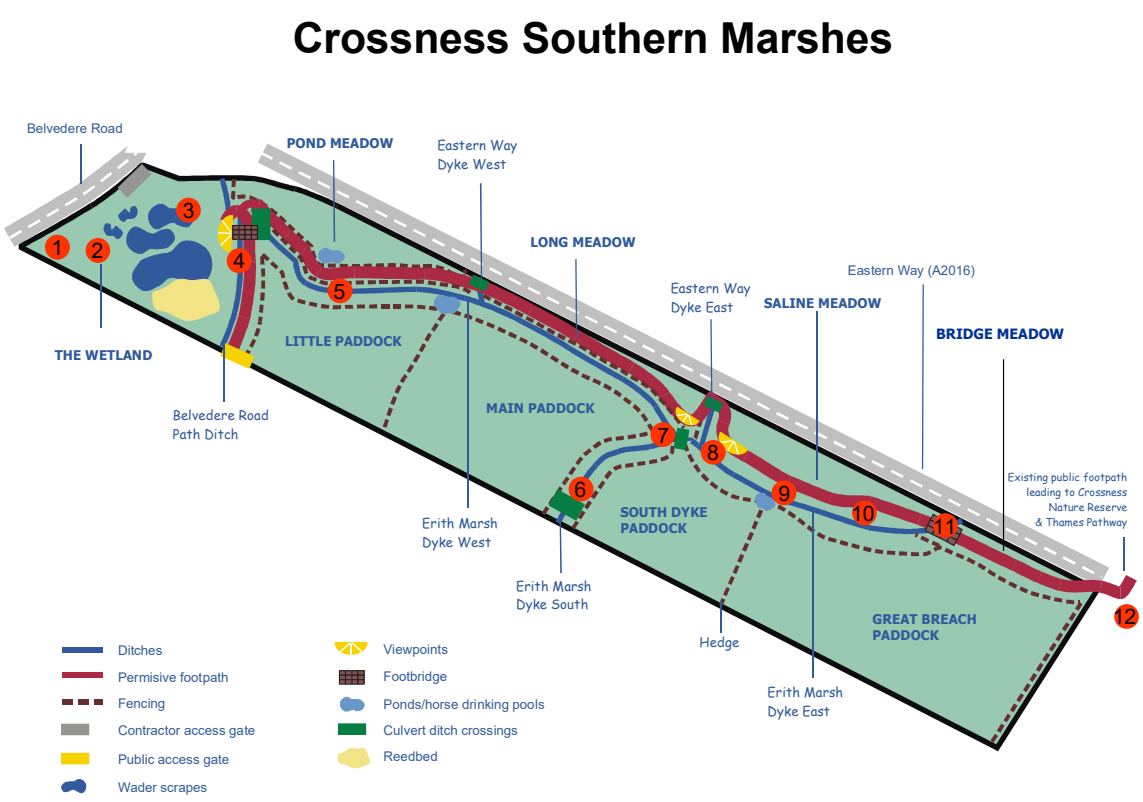

Figure 2. Map of Crossness Southern Marsh showing location of Sample Stations

1.3 Methodology

1.3.1 The autumn aquatic invertebrate sampling visits were made between 1st and 4th October 2018 and the spring visits undertaken between 17th April and 5th May 2019. This closely mirrored the timings of the 2016-17 survey.

1.3.2 Aquatic sampling was undertaken by two surveyors who worked together at all times. Each station was sampled using the methods outlined below as appropriate and each sample station was worked for approximately 60 minutes duration.

1.3.3 Aquatic invertebrate sampling was undertaken by direct field observation and capture using the following standard active sampling methods:

Aquatic sweep-netting from the shore amongst emergent and submerged vegetation using a long-handled pond net the contents of which were then tipped into trays or on to white plastic sheets for sorting, identifying and collecting.

Disturbing the substrate in shallow water and sweep-netting dislodged invertebrates from the water column using a long-handled pond net the contents of which were then tipped into trays for sorting, identifying and collecting.

Puddling soft substrate at pond margins and collecting the dislodged invertebrates in a small seive or directly into pots by hand.

1.4 Survey Constraints

1.4.1 It is the nature of all invertebrate sampling that the results represent merely a snapshot of a given habitat or area. This is particularly true of aquatic sampling where access to suitable microhabitats can be compromised by topographic or safety issues that can influence the final results. The conditions in the field at the Sample Stations are briefly outlined in the notes in Table 1 (above).

1.4.2 While some sample stations were more difficult to access and sample effectively than others we do not believe that the overall results of the survey were seriously compromised and that the changing conditions in the field were broadly similar to those encountered during the previous survey.

1.4.3 A clear change in the 2018-19 survey is the omission of Nature Reserve Sample Station 8 (NR8) which is no longer accessible - though it should be noted that growing access issues at NR8 during the 2016-17 survey meant that the species list from this sample station was unremarkable and it's omission from the current survey is not regarded as significant.

1.4.4 Also of note were the significant changes in the water levels at many of the sample stations compared to those encountered during the 2016-17 survey. While this has clearly led to some sample stations producing poorer results due to previously productive stands of emergent vegetation becoming flooded (most notably at SM8) other sample station lists were improved as higher water levels afforded greater access to previously difficult to sample areas (most notably at NR2). It is beyond the scope of this survey to discuss the long-term effects of the changing water levels at Crossness except to say that we do not believe that it has compromised the results of the 2018-19 survey.

1.4.5 In summary we believe that the current survey closely matched that of the 2016-17 survey in all key respects and as a result conclude that there are no survey constraints of note.

2 COMPARISON BETWEEN THE THE 2016-17 AND 2018-19 SURVEYS

2.1 Summary

2.1.1 A complete list of all the invertebrate taxa found during the 2016-17 and 2018-19 surveys can be found in **Table 2** (below). Only aquatic species from the orders Coleoptera and Hemiptera are included. The list is cross-referenced to the sample stations in which they were recorded.

2.1.2 In **Table 2** the entry under each sample station contains two symbols; a cross 'x' represents presence of the species while a zero 'o' represents absence. The FIRST symbol in each box refers to the 2016-17 survey while the SECOND refers to the 2018-19 survey. For clarity the box is left blank where species were not recorded at a given sample station during either survey period.

2.2 Discussion

2.2.1 Ninety-nine (99) species were recorded across the two survey periods. Comparison across the survey periods reveal that 11 taxa were recorded during the 2016-17 survey that were not found in 2018-19 while 19 species were recorded during 2018-19 that had not been recorded before. The remaining 69 species were encountered during both surveys. Of the 11 missing species 3 had a conservation status while the additional species included 4 with a status. No discernable trend was detected between the missing and additional species with regard to habitat requirements.

2.2.2 Particular attention was paid to species found at the sample stations most closely affected by the contamination, namely NR1, NR4 and NR5.

2.2.3 No species from the target groups were found at NR1 during the 2018 autumn visit. However the spring 2019 survey found 15 species. Of these, 12 were not recorded in the 2016-17 survey. Conversely 13 species recorded at NR1 in 2016-17 were not re-found in 2018-19. It is perhaps significant that only 11% of the recorded species at NR1 are constant to both surveys compared to 70% across the survey as a whole. This may indicate that NR1 is in the process of recolonisation.

2.2.4 In spite of increased water levels making sampling at NR4 and NR5 difficult both samples had 12 additional species not found in 2016-17 and fewer 'missing' species (7 and 11 species respectively). Again NR5 had only 11% of the species constant to both surveys while NR4 had 32%.

2.2.5 No discernable habitat preferences were apparent between the lists of 'missing' species and 'new' species across the NR1, NR4 and NR5 sample stations, though most of the new species are common and have generalist requirements.

2.3 Conclusion

2.3.1 With regard to the primary objective of this survey – to ascertain the effects of the pollution incident in 2017 on the aquatic invertebrate fauna at Crossness – it is our opinion that there is no discernable downward trend in the number of species present and that variations in the number of species recorded fall within the natural variation expected from aquatic invertebrate sampling.

2.3.2 In conclusion we believe that the aquatic habitats at Crossness remain largely in good health and that the areas most affected by the contamination appear to be recovering well.

Table 2. Comparison of 2016-17 and 2018-19 survey results

Species	Nature Reserve Sample Stations												Southern Marsh Sample Stations											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
COLEOPTERA																								
Curculionidae																								
Bagous subcarinatus															o x									
Dytiscidae																								
Agabus bipustulatus				x o								x o	o x	o x		o x	x o	o x				o x		
Agabus sturmii				x o														o x					o x	
Colymbetes fuscus		o x		x o							o x		x x	o x	x o	o x		o x						
Dytiscus circumflexus	x o																			x o			x o	
Dytiscus marginalis							x o			o x												o x	x o	
Graphoderus cinereus		o x																						
Graptodytes bilineatus																		o x	o x					
Graptodytes pictus									o x							o x								
Hydaticus seminiger		o x				x o										o x		o x					o x	
Hydroglyphus geminus	o x				o x														o x	o x				
Hydroporus angustatus	x o			o x	o x		o x						o x	o x	x o		x o	o x	o x	x o	o x			
Hydroporus memnonius											o x													
Hydroporus palustris	x o	o x	x x	x x	x o	x x	x x		x o	x x			x x	x x		o x	x x	o x	x x		o x		x x	
Hydroporus planus	o x		o x				o x		o x		x o	o x	o x	x x		o x	o x				o x	x x	o x	
Hydroporus tessellatus																						x o		
Hydrovatus cuspidatus		o x													o x									
Hygrotus confluens												x o			x x									
Hygrotus impressopunctatus				o x	o x					x o	x x	o x		o x	x o			o x				x o		
Hygrotus inaequalis	x x	o x	x x		x x	x x	x x	x o	x x	o x	x x	x x	x x	x x	x x	o x	x x	x x	x x			x o	x x	o x
Hygrotus parallellogrammus					o x	x x			o x	x o	x x	x x		o x	o x									
Hygrotus versicolor											x o													
Hyphydrus ovatus		o x	o x	o x	x o	x x	x x		o x	x x		o x	o x		x o	o x	x x	x x	x x	x o				
Ilybius ater											o x		o x							x o				
Ilybius quadriguttatus		o x			o x								o x			o x		o x				o x	o x	
Laccophilus minutus		o x				o x				x o		x o			x o		x o							
Liopterus haemorrhoidalis													x x				o x	o x						
Rhantus frontalis	o x	o x	x x	x x		o x	o x			x o	o x	x o	x x			x x	o x	o x				x o	o x	

Species	Nature Reserve Sample Stations												Southern Marsh Sample Stations											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Rhantus suturalis	x x	o x	o x	o x	x x	x x			o x		x x	x x	x x			x x	x o	o x	o x	x o		o x	o x	x o
Gyrinidae																								
Gyrinus caspius		o x		x o											x x	x x	x o	x x						
Gyrinus paykulli		o x													x o									
Haliplidae																								
Haliplus apicalis									x o						o x									
Haliplus flavicollis															x x									
Haliplus immaculatus		o x		o x			o x		o x		o x		x x	x o	x x	o x	o x	o x	o x					
Haliplus laminatus										x o														
Haliplus lineatocollis						o x	x x			x o	x x				o x	o x	x o		x o				o x	
Haliplus lineolatus					x o																			
Haliplus ruficollis	o x	o x	x x				x x		x x	x x	o x	o x	x x	o x	x x	o x		x x	x x					
Peltodytes caesus	o x	o x				x o				o x					o x	x o		o x	o x					
Helophoridae																								
Helophorus aequalis												o x												
Helophorus alternans	x o				o x	o x					o x	o x		o x										
Helophorus brevipalpis						o x	o x				o x	x o		x x		o x	x x					x o		
Helophorus fulgidicollis						x o																		
Helophorus grandis												x o												
Helophorus minutus	o x				x o		x o				x x	x x	x o	x x	x o		o x	x o	x o	x o		x o	x o	
Hydraenidae																								
Hydraena testacea			o x																					
Limnebius nitidus			o x							o x														
Ochthebius minimus	o x				o x	x o					x x	x o	o x	o x	o x		o x				x x			
Ochthebius nanus									x o															
Hydrochidae																								
Hydrochus ignicollis															o x	x o								
Hydrophilidae																								
Anacaena bipustulata			o x				o x			o x	o x		o x				o x				o x			
Anacaena globulus	o x				o x					o x	x x			o x							o x			
Anacaena limbata	o x	o x	o x	x x	x x	x x	x x	x o	o x	x o	x x	x x	x x	x x	x x	o x	x x	o x	x x	x x	x x	o x	x x	o x
Berosus affinis	x o					x x			x o	x o	x x		x x		x x		x o	o x	x o					
Berosus signaticollis		o x												o x	x o				o x					

Species	Nature Reserve Sample Stations												Southern Marsh Sample Stations											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Cercyon sternalis		o x												o x										
Cercyon ustulatus		o x																						
Coelostoma orbiculare		o x																						
Cymbiodyta marginellus		o x									x o	x o	x x	x x	x x	o x	x x				x x			
Enochrus bicolor							o x				x o									o x				
Enochrus coarctatus															x o									
Enochrus melanocephalus															o x									
Enochrus testaceus		o x	o x	o x		o x	o x		o x	o x			o x	o x	x x		x x	o x	o x	x o			x o	o x
Helochares lividus			o x			x o			x o				o x		o x					x o				o x
Helochares punctatus													x o											
Hydrobius fuscipes	o x	o x			o x		o x		o x		x x	x x	x x	x x	x x	o x	x x	x x	x x		x x	x x		
Hydrophilus piceus		o x							o x					o x		o x	o x	o x		x o				
Laccobius bipunctatus	o x		o x	o x	o x	x x	o x			x x	x x	x x		o x										
Hygrobiidae																								
Hygrobia hermanni		o x													o x									
Noteridae																								
Noterus clavicornis	o x	o x	x x	x x	x o	x x	x x	x o	x x	x x	x o	x x	x x	x x	x x	x x	x x	x x	x x	x x			x x	o x
Noterus crassicornis		o x	o x			x x				x x			x x	x x	x x	o x	o x	o x	o x					
HEMIPTERA: HETEROPTERA																								
Corixidae																								
Callicorixa praeusta			x x	x x		x x			x x	x x	o x				o x		x o	x x						
Corixa panzeri	x o		x o			o x					o x				x x			o x		x o				
Corixa punctata	x o	o x	x x	x o		x x	x o			x o	o x				o x	x o		o x	o x					
Cymatia coleoptrata				o x		o x				o x					o x									
Hesperocorixa linnaei	x x	o x	x x	x x	x o	x x	x x		o x	x x	o x	x x	x x	o x	x x	x x	x x	x x	x x	x o			x o	
Hesperocorixa sahlbergi	x o		o x	x x	x o		x o						x x	x o		x x	o x	o x	x x	o x	x o	x o	x o	
Paracorixa concinna	x o					x x				x o					x o		x o	x o						
Sigara dorsalis	x o	o x	o x	x o	x o	x x	x o		x x	x x		x o	o x		x x	o x	x o	x o	x x	x x		x o		
Sigara falleni				o x							o x				x o				x o	o x				
Sigara fossarum							o x		o x	o x														
Sigara iactans						o x			x o	o x					x x			o x	o x	o x				o x
Sigara lateralis	x o		x x		x o	x x			x o	o x					x x		x o	x x	o x	x o				
Sigara nigrolineata															o x									

Species	Nature Reserve Sample Stations												Southern Marsh Sample Stations											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Sigara stagnalis									x o		o x							o x						
Gerridae																								
Gerris lacustris				x o											o x									
Gerris odontogaster						x o	x o		x x	x o	o x		x o		x o		x o		x o	x o	x o			
Gerris thoracicus					x o									x o										
Hydrometridae																								
Hydrometra stagnorum										x o			o x		o x		x o			x o				
Naucoridae																								
Ilyocoris cimicoides		o x				x x	x o		o x	o x			x x		x x	x x	x x	x o		x x				
Nepidae																								
Nepa cinerea	x o	o x		o x								x o				o x	o x							
Ranatra linearis		o x				x o									o x	o x	x x			x x				
Notonectidae																								
Notonecta glauca	x x	o x		o x	x o	o x	x x		o x	o x	o x	x x	x x	o x	x x	x x	x x	x x	x x	x x			x x	o x
Notonecta viridis		o x							o x		o x							o x					o x	
Pleidae																								
Plea minutissima		o x			o x	x x	o x		o x	x x	o x		o x		x x	x x	x x	x x	x x	x x			o x	o x
Saldidae																								
Chartoscirta cincta				o x		x o	o x				o x			x x	x x					o x	x o	x x		
Saldula pallipes		o x													x x									
Veliidae																								
Microvelia pygmaea		o x	o x	x x	o x	x o	x x		x x	x x			o x			o x	o x			x o			o x	
Microvelia reticulata		o x					x x				o x				x x	o x				x x			o x	

3 INVERTEBRATE SPECIES PRESENT DURING 2018-19 SURVEY

3.1 Summary

3.1.1 The 2018-19 survey produced a total of 88 invertebrate species. These are detailed in Appendix 1 and this list is annotated with formal conservation codes which are explained in Appendix 2. Seventeen of the species were of conservation interest and these are discussed below.

3.1.2 The list is also annotated with the primary ecological associations of each species, where known. This allows species with differing habitat affinities to be immediately discerned.

3.2 Species of conservation interest

3.2.1 There are several categories of invertebrates that are of raised significance in an ecological assessment. These categories are explained in Appendix 2 and the corresponding species found during the survey are now examined.

Nationally Rare / Red Data Book species

3.2.2 The following 3 species listed in the British Red Data Books (Shirt, 1987; Bratton, 1991) or which have been elevated to the status of Nationally Rare by subsequent formal reviews were recorded by the present survey (see Appendix 2):

Graphoderus cinereus **NR** is a predatory diving beetle found in permanently flooded ponds and drainage ditches and is associated with areas of rich submerged and emergent vegetation. This is a scarce species with old records from high quaility wetland sites such as the Cambridgeshire and Huntingdonshire Fens and the Somerset Levels. Recent records have a southeastern distribution and may represent recent recolonisation from Continental Europe. Several examples were found at NR2.

Hydrochus ignicollis **NR** is found in mossy edges and reed *Phragmites* litter beside stagnant well-vegetated, often temporary, fen and pingo pools. Both adults and larvae are aquatic but do not swim and are slow in movement, often feigning death when disturbed. The adults feed on algae. This species is very local in southwestern and eastern England, northwest Wales (Anglesey) and in Ireland. A single example was found at SM3 (this species was found at SM4 during the 2016-17 survey).

Great Silver Water Beetle *Hydrophilus piceus* **NR** is a water beetle found in drains in coastal levels, favouring those choked with vegetation such as ivy-leaved duckweed *Lemna trisulca* and fringed with common reed *Phragmites australis*. It has contracted in range in recent times with no modern records from the Midlands, Cambridgeshire Fens, Glamorgan and the London area, though it is still well established in the Broads, Somerset Levels and coastal levels of Sussex, Kent and Essex. Examples were noted at NR2 and NR9 in the Nature Reserve and several were encountered at various sample stations on the Southern Marsh.

Nationally Scarce Species

3.2.3 The following 14 Nationally Scarce species were recorded by the present survey (see Appendix 2):

Bagous subcarinatus **NS(Na)** is an uncommon weevil that is included here as the species is truly aquatic, both as a larvae and an adult. It is associated with soft hornwort *Ceratophylum submersum* in slow-flowing waters and is very local in southern England. A single example was collected from vegetation netted around the margins of SM3 though the foodplant was not apparent there. It would

be of great interest to find any areas of the foodplant on site in order to further assess the status of this rare and elusive beetle at Crossness.

Graptodytes bilineatus **NS** inhabits moss in reed-swamps that receive brackish, or otherwise base-rich water. It has been found in sites of reletively modern origin, isolated clay pits etc suggesting that it has a relatively good dispersal ability. This species has a primarily coastal distribution from the Severn to the Humber. Examples were collected from the flooded margins of SM6 and SM7.

Hydaticus seminiger **NS** is a diving beetle associated with permanent standing water amongst dense vegetation or debris in partly shaded sites, such as weed-choked ponds and ditches, avoiding brackish water. Largely confined to areas of lowland heaths and ancient fenland in England, with outlying populations on the Somerset Levels and Cheshire Plain. Examples were found at NR2, SM4 and SM6.

Hydrovatus cuspidatus **NS** is a diving beetle only added to the British list in 2006. It is associated with man-made habitats, usually in the extreme edge of thinly vegetated ditches and pools over exposed clay. It is a species of grazing fen ditches and weakly brackish pools and is known only from a handful of sites East Kent through to East Norfolk. Examples were found at NR2 and SM3.

Hygrotus parallellogrammus **NS** is a small diving beetle that is usually confined to brackish stagnant water and inhabits coastal sites and occasionally inland sites that receive a salt-water influence. The beetle is primarily eastern in its distribution and is found between Dorset and the Humber, although it is also known from the Severn area in the west. Individuals were recorded from several sample stations across the survey.

Rhantus frontalis **NS** is a medium-sized diving beetle that is typically associated with permanent, stagnant water with some vegetation but with the substratum (sand or mud) exposed. It is a lowland species with a remarkably disjunct distribution; it is widespread in Ireland but also found in southern England and East Anglia where it inhabits coastal sites and areas of remnant fen. Found in good numbers at several sample stations across the survey area.

Gyrinus paykulli **NS** is a whirlygig beetle usually found in lowland, permanent and still, base-rich water in vegetated edges, often over peat or in reedbeds. Its distribution is very scattered across the British Isles as a whole; it is widespread across central Ireland and also found in parts of eastern England, but is extremely rare in Wales and Scotland. Several examples were found at NR2.

Haliplus apicalis **NS** is a water beetle found locally in brackish waters such as coastal lagoons and drainage ditches along the eastern seabord of Britain between Sussex and Northumberland, with a very sparse scatter of records inland and on the west coast. Found along the edge of SM3.

Peltodytes caesus **NS** is a crawling water beetle found in well-vegetated ponds and drainage ditches, usually with some exposed clay, sand or silt substrate. It has a southeastern distribution with all modern records concentrated below the Wash/Severn line. This species was found in several sample stations across both the Nature Reserve and the Southern Marsh, including NR1.

Helophorus alternans **NS** is a beetle confined to exposed, lowland waters, most often temporary or brackish pools. It is found on heathland in the south of its range and is typical of acid pools in the New Forest and southwest England but also of dykes on grazing fen. These contrasting habitat demands may indicate that temperature is a key influencing factor rather than specific water type. Examples were found at several sample stations across the survey area.

Enochrus bicolor **NS** is a water beetle usually found in brackish ponds or ditches near the coast, but can also occur inland in waters that receive a saline influence. It is a local species with a coastal distribution across much of southern Britain, extending from Anglesey to northern England. This species was recorded at NR7 and SM7.

The Smaller Noterus *Noterus crassicornis* NS is a diving beetle found in well-vegetated lakes and meres, as well as quarry ponds and canals. This species is considerably more rare than our other *Noterus* species *N. clavicornis* (except in Ireland), and has a predominantly eastern and northwestern distribution in England. Examples were found at almost half the sample stations.

***Saldula pallipes* NS** is a predatory bug found on bare, wet sand, silt or gravel, usually at the margins of standing water. It is frequently found at the edge of recently flooded mineral workings as well as on river margins and in brackish habitats and is found locally throughout England and Wales as far north as southern Scotland. This species was found amongst edge vegetation at NR2 and SM3.

***Microvelia pygmaea* NS** is a very small water bug found at the vegetated and sheltered margins of lakes and canals. It is a local species that is largely confined to southeast England and East Anglia, although there is recent evidence of range expansion into central England and further west. This species was common in the survey area and found at more than half the sample stations.

3.3 'Species Quality Index' analysis of the 2018-19 species

3.3.1 Previously 'WETSCORE' analysis was used to assess the significance of water beetle communities. The Wetscore system allocated points to each species based on its conservation value in a given region. These scores were then added together and divided by the total number of species recorded in order to arrive at a Species Quality Index score (SQS). This score is then used to evaluate the overall conservation interest of the habitat for aquatic beetles. For a full explanation of Wetscore see Foster and Eyre, 1992.

3.3.2 The Wetscore scoring system has now undergone a major revision by Buglife and a new system of evaluating the invertebrate assemblages of grazing marsh ditches has now been adopted (see Palmer, Drake & Stewart, 2013). This newer system also incorporates the current invertebrate conservation statuses following review, most notably the JNCC review of the aquatic Coleoptera (Foster, 2010).

3.3.3 Under the new system the values allocated to each species have changed and have been standardised across coastal England and Wales. As before the sum of the values are divided by the total number of species recorded in order to arrive at a SQS.

3.3.4 Unlike Wetscore the newer system is able to include invertebrate groups other that Coleoptera and as a result the aquatic Heteroptera recorded during the 2019 survey have been incorporated into the current SQS. All but three of the 88 species recorded in 2018-19 are included in the SQS analysis below. The species omitted are the weevil *Bagous subcarinatus* and the saldids *Chartoscirta cincta* and *Saldula pallipes*.

3.3.5 The total species quality score for the 2018-19 survey is 146. This figure is divided by the number of species recorded (85) which results in a SQS of 1.72. This score indicates that the Crossness grazing marsh complex is a 'good' site for aquatic invertebrates.

3.3.6 As the accuracy of the analysis decreases proportionally to the reduction in the number of species included, and given our comments regarding natural variation in sampling results (see 1.4 above), we do not believe that creating separate SQS scores for the Nature Reserve and Southern Marsh would be productive or informative.

3.4 'Species Quality Index' analysis of the 2016-17 species

3.4.1 It is unfortunate that Wetscore analysis of the Nature Reserve and Southern Marsh areas at Crossness made in the previous survey did not incorporate the latest conservation status of many of the species

involved. However it is possible to re-analyse the data from the 2016-17 survey using the current system and statuses, as well as include the aquatic Heteroptera recorded.

3.4.2 This re-analysis of the 2016-17 survey results gives a revised species quality score of 129 for the combined aquatic habitats at Crossness. This figure is divided by the number of species recorded (76) which results in an SQS of 1.70.

3.5 'Salinity Index' analysis of 2016-17 and 2018-19 surveys

3.5.1 The new evaluation system also includes a Salinity Index (SI). This index assigns salinity tolerance scores to all the species encountered that can then be used to assess the water bodies and to indicate the presence or fluctuation of brackish conditions.

3.5.2 Each species is assigned a value from zero (0) to two (2) where: 0 indicates a freshwater species that is tolerant of only mildly brackish water and is not routinely found more often in brackish water than in fresh. 1 indicates a species tolerant of mildly brackish conditions and is usually found in more brackish conditions than in completely fresh. 2 indicates a species obligately dependent on mild to moderately brackish conditions and that are absent from fresh water except as 'strays'.

3.5.3 Analysis of the data across the two survey periods provides the following SI scores. The 2016-17 survey scored 10 points, divided by the number of species (76), giving a SI of 0.13. The 2018-19 survey scored 8 points, divided by the number of species (85), giving a SI of 0.09.

3.5.4 Both survey periods encountered 8 species that scored 1 point on the salinity index. The 2016-17 score was 'boosted' by examples of *Helophorus fulgidicollis* found at SM6 which scored 2 points.

3.5.5 The Salinity Index scores across both surveys are within the normal tolerance expected of coastal grazing marsh habitats and show no apparent trend over the two survey periods.

3.5.6 It may be significant that several species showing some tolerance for brackish water were found in the flooded waterbodies to the north of the Southern Marsh (SM6, SM7, SM11 and SM12) where the natural drainage through the marsh currently appears to be retarded and this 'damming' effect may be contributing to a build up in salinity from road run-off.

3.6 Summary of the analysis

3.6.1 A summary of the data obtained across both survey periods is provided in Table 3 (below) and further discussed in section 4.

Table 3. Summary of the data obtained 2016-17 & 2018-19

SUMMARY OF DATA - BOTH SURVEYS	2016-17	2018-19
Total number of species recorded	78	88
Number of species of conservation status recorded	16	17
Number of Nationally Rare (NR) species recorded	2	3
Number of Nationally Scarce (NS) species recorded	14	14
Number of species used to calculate the SQS	76	85
Species Quality Score (SQS)	1.70	1.72
Species Quality Score (SQS) for sample station NR1	1.44	1.38
Salinity Index (SI) score	0.13	0.09

4 Discussion and recommendations

4.1.1 Once again the Crossness Nature Reserve and the South Marsh complex of waterbodies produced an aquatic invertebrate species list of high quality with the 2018-19 survey returning an SQS of 1.72. This score continues to indicate a site of high value and is a slight improvement of the SQS of 1.70 that was achieved by the previous survey (after re-analysis of those results).

4.1.2 Though there were marked differences in the results from certain sample stations, analysis of the overall species lists and SQS values show a remarkable similarity between the two surveys (see Table 3, above) which would indicate very good habitat conditions and invertebrate populations across the entire site.

4.1.3 If the Species Quality Index analysis is applied to the main sample station of concern following the pollution event (NR1), the 2016-17 survey returns an SQS of 1.44 while the 2018-19 survey gives an SQS of 1.38. Even allowing for the small sample size at NR1 (16 species in each survey) it shows a remarkable similarity between the surveys that would further support our conclusion that the pollution event has had minimal long term effects (see 2.3 above).

4.1.4 Finally it should be pointed out that no attempt was made during the 2018-19 survey to expand the species list for the Nature Reserve or Southern Marsh and that the surveyors primary concern was to replicate as closely as possible the 2016-17 survey in order to produce the most comparable results. It is our opinion that further targeted survey work may well increase the species list and SQS of the Crossness Marsh complex.

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APPENDIX 1: TERRESTRIAL INVERTEBRATE SPECIES RECORDED

National status codes are explained in Appendix 2.

Group / Species	English name	National status	Associations / Ecology
COLEOPTERA	**BEETLES**		
Curculionidae	**Weevils**		
Bagous subcarinatus		**NS(Na)**	Associated with soft hornwort *Ceratophylum submersum* in slow-flowing waters. Very local and uncommon in southern England
Dytiscidae	**Diving beetles**		
Agabus bipustulatus			A strong flier that is ubiquitous in stagnant water, even horse troughs and water butts. Widespread and common throughout
Agabus sturmii			Abundant in ponds and riverside situations where there is detritus. Widespread and common throughout
Colymbetes fuscus			Common in well-vegetated stagnant water throughout lowland Britain and Ireland - coastal in highland areas
Dytiscus marginalis			In a wide range of stagnant and slow running waters, including intensively polluted ones. Common and widespread throughout
Graphoderus cinereus		**NR**	In well-vegetated stagnant waters in lowland pools and fenlands drainage dykes – mainly coastal in the south-east
Graptodytes bilineatus		**NS**	In reedswamps with some moss, receiving brackish or otherwise base-rich water. Mostly coastal as far north as the Humber
Graptodytes pictus			In permanent ponds, lakes, canals and other slow-moving water with plenty of vegetation. Widespread throughout
Hydaticus seminiger		**NS**	Associated with permanent standing water in debris in partly shaded sites or amongst dense vegetation in open situations
Hydroglyphus geminus			In still lowland waters that have a disturbed and exposed substratum of clay, often in newly created and temporary habitats. Widespread and common in England and Wales
Hydroporus angustatus			Associated with permanently flooded fens, usually in mesotrophic but also enriched sites. Common throughout
Hydroporus memnonius			In shallow puddles and ditches, particularly amongst leafy detritus. Common across Britain, though two colour variations occur with virtually no overlap. The variety with a matt female occurs across England and Wales
Hydroporus palustris			Common in almost any still or slow-flowing water. Virtually ubiquitous in Britain
Hydroporus planus			In temporary, grassy ponds but, as it flies freely, is found in a wide variety of other water bodies. Virtually ubiquitous in Britain
Hydrovatus cuspidatus		**NS**	Associated with man-made habitats, usually at the extreme edges of thinly vegetated pools and ditches. Uncommon in the southeast, with few records from Kent to Norfolk
Hygrotus confluens			Confined to newly created and highly disturbed ponds in polluted, industrial, fouled and also brackish sites. Common throughout
Hygrotus impressopunctatus			In rich fen in lowland lakes, ponds and ditches, usually amongst Sphagnum. Common and widespread
Hygrotus inaequalis			In a wide range of permanent habitants, often in very shallow water. Common and widespread throughout
Hygrotus parallellogrammus		**NS**	Usually confined to brackish stagnant water in coastal sites from the Isle of Wight to the Humber
Hyphydrus ovatus	Cherrystone Beetle		In deep and richly vegetated permanent lakes, ponds, ditches, canals and occasionally river backwaters. Widepread
Ilybius ater			In stagnant water over vegetated mud or peat, typically in the very edge of ponds. Common and widespread throughout
Ilybius quadriguttatus			In permanent, densely vegetated ponds, ditches and canals. Widespread across England and Wales
Laccophilus minutus			A common species of lowland ponds, lakes and ditches, rarely found in slow running water. Widespread throughout
Liopterus haemorrhoidalis	Piles Beetle		Found in richly vegetated lowland ponds and ditches, usually with mosses and often cool, shaded or spring-fed. Widespread throughout England and Wales

Group / Species	English name	National status	Associations / Ecology
Rhantus frontalis		**NS**	In lowland pools amongst vegetation, often over partly exposed substrata, especially sand. Widespread but uncommon with a coastal distribution in southern England
Rhantus suturalis			Usually in lowland stagnant waters, often recently created and polluted. Widespread and common
Gyrinidae	**Whirligig beetles**		
Gyrinus caspius			Found on fen drains and pools, often in brackish water. Mainly coastal, but inland in Scotland
Gyrinus paykulli		**NS**	In lowland, permanent and still, base-rich water in vegetated edges, often over peat or in reedbeds. Uncommon and with a very scattered distribution across the British Isles
Haliplidae	**Crawling water beetles**		
Haliplus apicalis		**NS**	Found in brackish waters such as coastal lagoons, puddles and drainage ditches. Uncommon along the eastern seaboard from Sussex to Northumberland
Haliplus flavicollis			A widely distributed species of base-rich waters such as lakes, reservoirs, brick-pits and drains
Haliplus immaculatus			Associated with man-made stagnant water habiatats in the lowlands, even polluted sites and balancing pools. Widespread
Haliplus lineatocollis			In a wide range of habitat types, usually the commonest *Haliplus* in running water. Widespread throughout
Haliplus ruficollis			The commonest species of Haliplus - found in all types of water. Common and widesprerad throughout
Peltodytes caesus		**NS**	Confined to lowland rich fen pools and ditches from the Welsh and English fens and also the lowlands west of London
Helophoridae			
Helophorus aequalis			Summer adults are found in almost any habitat, but breeding is confined to stagnant freshwater amongst grass. Very common
Helophorus alternans		**NS**	In brackish water in the south-east and in heathland ponds in Hampshire. Uncommon from Essex to Anglesey
Helophorus brevipalpis			Ubiquitous in almost any aquatic habitat - breeds in exposed muddy edges of pools and streams
Helophorus minutus			A more or less ubiquitous water beetle found in grassy-edged pools, lakes and slow rivers
Heteroceridae	**Mud beetles**		
Augyles hispidulus		**NS**	Prefers the man-made sand and gravel pits where it feeds on detritus at the waters edge. Aside from a single Suffolk site this species is confined to the Lydd / Dungeness area
Heterocerus marginatus			Found in mud beside fresh water ponds, marshes and streams. Widespread across England, Wales and southern Scotland
Heterocerus obsoletus		**NS**	Found on the exposed sediments of brackish and fresh water pools and ditches. Mainly coastal in the south and east
Hydraenidae			
Hydraena testacea			On moss and reed *Phragmites* litter by muddy streams or stagnant ditches. Common and widespread
Limnebius nitidis			In mud beside rivers, ditches and pond. Widespread across the British Isles
Ochthebius minimus			In canals, ditches, lakes, ponds and pools in both brackish and fresh water. Common and widespread throughout
Hydrochidae			
Hydrochus ignicollis		**NR**	In mossy edges and Phragmites litter beside stagnant, often temporary fen pools. Very local in southwest and eastern England
Hydrophilidae			
Anacaena bipustulata			Associated with lowland, slow-running water, especially on exposed clayey substratum. Widespread in southeast England
Anacaena globulus			In mud and decaying vegetation at water's edge. Ubiquitous in almost all non-saline habitats throughout Britain
Anacaena limbata			In mud and decaying vegetation at the edge of well-vegetated, eutrophic, still waters. Common in lowland England and Wales
Berosus affinis			In well-vegetated pools and ditches on grazing levels . Modern records are from south of a line from The Wash to south Wales

Group / Species	English name	National status	Associations / Ecology
Berosus signaticollis			Amongst thin vegetation in newly created still water habitats, also occasionally in brackish water. Widespread in the southeast, though local or very local elsewhere
Cercyon sternalis			In a wide range of lowland freshwater habitats, also sometimes brackish water, associated with tussocks. Widespread but local in south-eastern England and Wales
Cercyon ustulatus			Associated with muddy banks of streams and ponds amongst litter, also beside water in cow dung. Widespread in England
Coelostoma orbiculare			Typically found on moss in floating rafts of vegetation but also at the edges of ponds and ditches, usually with moss or rotting vegetation. Frequent and widespread across Britiain
Cymbiodyta marginellus			Found in lowland fens but also common in ephemeral pools. Widespread as far north as southern Scotland
Enochrus bicolor		**NS**	In grazing marsh ditches and pools, usually in brackish water at the coast. Widespread in southeast England, local elsewhere
Enochrus melanocephalus			In lowland, thinly vegetated, often polluted or brackish, standing water. Widespread in central and southeast England, very local elsewhere
Enochrus testaceus			In fens and richly vegetated ponds, lakes and ditches - often found in submerged weed and marginal litter. Widespread
Helochares lividus			In vegetated lowland freshwaters, often in areas with a brackish influence. Common in south and east Britain
Hydrobius fuscipes			A more or less ubiquitous water beetle that fovours still and slow-flowing water with abundant vegetation
Hydrophilus piceus	Great Silver Water Beetle	**NR**	In permanent, richly vegetated ponds and in dykes on grazing fen, where there is abundant prey (aquatic molluscs). In decline but with strongholds in the Somerset Levels, Broads and on grazing marshes in the south-east
Laccobius bipunctatus			In muddy shallows at the edges ofponds, canals and running water in open situations. Common and widespread
Hygrobiidae			
Hygrobia hermanni	Screech Beetle		Confined to still water, usually over mud in ponds and ditches . Frequent across lowland England and Wales
Noteridae	**Burrowing water beetles**		
Noterus clavicornis	The Larger Noterus		Common in permanent, base-rich, lowland ponds in England, Ireland and Wales
Noterus crassicornis	The Smaller Noterus	**NS**	In permanent, base-rich lakes, ponds and grazing level ditches. Widepsread in south-east, east and north England and Wales
HEMIPTERA: HETEROPTERA			
Corixidae	**Water boatmen**		
Callicorixa praeusta			In still or slow-flowing water at low altitudes - it is found in ponds, reed swamps, stagnant reaches of rivers, tarns and dykes, prefering some degree of organic pollution. Widespread
Corixa panzeri			In ditches, pools, lake margins and slow rivers where the water is clear, neutral to alkaline or slightly saline and with extensive weed growth. Widely distributed throughout
Corixa punctata			In a wide range of still or slow-flowing water bodies. It is a strong flier and ready coloniser. Common throughout
Cymatia coleoptrata			Occurs among thick aquatic vegetation in still or gently-flowing clear water. Common in the Midlands and south-east, though rare elsewhere and absent from Scotland
Hesperocorixa linnaei			In a wide range of still, sometimes slightly saline, waters, generally with extensive emergent vegetation. Widespread
Hesperocorixa sahlbergi			Associated with densely vegetated or heavily shaded pools with a bottom of mud or dead leaves. Common and widespread
Paracorixa concinna			In a range of still, lowland water bodies and is known to breed in saline water. It is a ready migrant and can be a rapid coloniser of newly formed pools. Widespread but rarely common
Sigara dorsalis			Prefers open, clear lakes and flowing water that is neutral or alkaline with a small amount of organic matter in solution. Widespread and common throughout
Sigara falleni			In still and slow-flowing waters, usually where there is extensive bare substrate and the water is base-rich. Very common and widespread

Group / Species	English name	National status	Associations / Ecology
			throughout
Sigara fossarum			In still or slow flowing water usually with muddy substrata. Widespread and particularly common in east and central England
Sigara iactans			A recent arrival in Britain (2004) now established in the southeast in a range of habitats with a preference for sparsely vegetated sites with little organic matter
Sigara lateralis			Associated with brackish pools and ditches, heavily polluted ponds, temporary and newly created pools with little vegetation. Widespread and common, becoming local further north
Sigara nigrolineata			In small weedy ponds in the lowlands and of small dystrophic pools in the uplands, but also found in a range of other water bodies. Widespread throughout
Sigara stagnalis			In pools and ditches on saltmarsh pools, preferring brackish water. Prodominantly coastal in England and Wales
Gerridae			
Gerris lacustris	Common Pondskater		On most still or slow-flowing waters. Widespread throughout Britain
Gerris odontogaster	Toothed Pondskater		On the surface of various types of still or gently-flowing water. Widely distributed and common throughout Britain,
Hydrometridae			
Hydrometra stagnorum	Water Measurer		Found at vegetated margins of all types of water body, providing there are vertical emergent plant stems available as egg-laying sites. Common and widespread throughout
Naucoridae			
Ilyocoris cimicoides	Saucer Bug		A predaceous species of still water, living on or near the bottom, often amongst dense vegetation. Widespread in the southern half of Britain
Nepidae			
Nepa cinerea	Water Scorpion		A predacious species of clean well-vegetated ponds and other still or gently flowing waters. Widespread
Ranatra linearis	Water Stick Insect		A predaceous species found in ponds and canals with emergent vegetation. Widespread in southern England and Wales
Notonectidae			
Notonecta glauca	Common Backswimmer		In still or slow-flowing lowland waters where there is some vegetation. Common and widespread throughout
Notonecta viridis			Particularly common in brackish pools, ditches and slow rivers where there is some vegetation, but increasingly frequent in non-brackish pools, and apparently spreading. Widespread
Pleidae			
Plea minutissima			A predator, living amongst dense weed in ponds and ditches, or at the margins of larger pools and lakes or slow rivers. Widespread across lowland England and Wales
Saldidae	**Shore bugs**		
Chartoscirta cincta			Found amongst vegetation at the margins of all types of water bodies including marshes. Common and widespread
Saldula pallipes		**NS**	On bare, wet sand, silt or gravel, usually at the margins of standing water and in brackish habitats. Local throughout England and Wales and as far north as southern Scotland
Veliidae			
Microvelia pygmaea		**NS**	In still or slowly flowing water, among emergent vegetation or where there is dense overhanging vegetation. Local in the southeast
Microvelia reticulata			A surface bug found in many types of still water amongst marginal vegetation. Common and widespread throughout

APPENDIX 2: INVERTEBRATE STATUS CODES

The new IUCN status codes

Many British invertebrate species have been assigned a formal status code. These codes are paramount in the definition of noteworthy species and accordingly, it is necessary to explain them here.

Natural England has recently instigated a new programme of invertebrate status reviews, in which species are assessed according to universally accepted criteria set by the International Union for the Conservation of Nature (IUCN) (IUCN 2012a, 2012b, 2014). In contrast to previous status assessments, which focussed largely on absolute rarity, the IUCN approach places each species into a threat category that also takes historic population trends into account. Species qualifying for a threat status (Critically Endangered, Endangered or Vulnerable) are those that are not only rare, but also have a history of decline or extreme population fluctuations. Species not assigned to a threat category are categorised as Near Threatened, Least Concern, Data Deficient or Not Applicable.

As of 2016, a total of almost 4000 species have been reviewed in accordance with IUCN guidelines. All of these belong to groups that have readily available identification keys, active recorders and a history of recording. Progress with the IUCN invertebrate status review programme has recently been afforded a very useful summary (Webb & Brown, 2016).

A key to the IUCN status codes is given below and summarised in Fig. 1.

REGIONALLY EXTINCT (RE)
A taxon is Extinct when there is no reasonable doubt that the last individual has died.
CRITICALLY ENDANGERED (CR)
A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered (see Table 1). Critically Endangered species that are likely to be Extinct, but for which confirmation is still required are reported as Critically Endangered (Possibly Extinct), abbreviated as CR(PE).
ENDANGERED (EN)
A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered (see Table 1).
VULNERABLE (VU)
A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable (see Table 1).
NEAR THREATENED (NT)
A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.
LEAST CONCERN (LC)
A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.
DATA DEFICIENT (DD)
A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate.
NOT EVALUATED (NE)
A taxon is Not Evaluated when it is has not yet been evaluated against the criteria.
NOT APPLICABLE (NA)
This category is typically used for introduced non-native species whether this results from accidental or deliberate importation. It may also be used for recent colonists (or attempted colonists) responding to the changing conditions available in Britain as a result of human activity and/or climate change. The IUCN regard 1500 as the cut-off date after which a species is classed as 'non-native'.

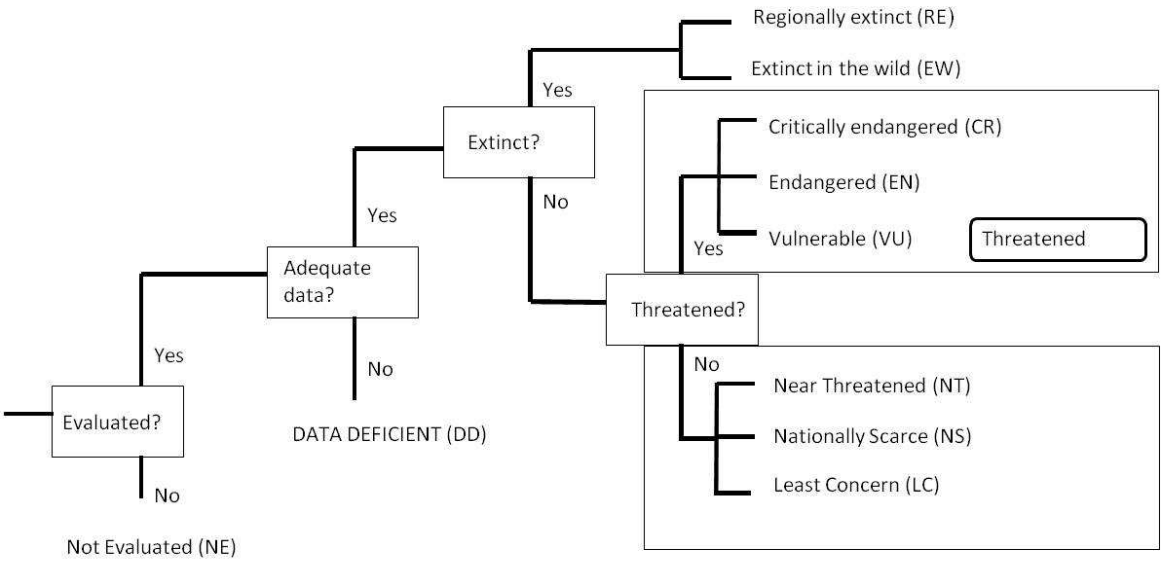

Fig. 1. Hierarchical relationships of the categories

Taxa listed as Critically Endangered, Endangered or Vulnerable are defined as Threatened (Red List) species. For each of these threat categories there is a set of five main criteria A-E, with a number of sub-criteria within A, B and C (and an additional sub-criterion in D for the Vulnerable category), and one of which qualifies a taxon for listing at that level of threat. The qualifying thresholds within the criteria A-E differ between threat categories and are summarised in Table 1.

Table 1. Summary of the thresholds for the IUCN Criteria

Criterion	Main thresholds *Critically Endangered*	*Endangered*	*Vulnerable*
A. Rapid decline	>80% over 10 years or 3 generations in past or future	>50% over 10 years or 3 generations in past or future	>30% over 10 years or 3 generations in past or future
B. Small range + fragmented, declining or fluctuating	Extent of occurrence <100 km^2 or area of occupancy <10 km^2 + two of the following: - severely fragmented or only a single location - continuing decline - extreme fluctuations	Extent of occurrence <5,000 km^2 or area of occupancy <500 km^2 + two of the following: - severely fragmented or no more than 5 locations - continuing decline - extreme fluctuations	Extent of occurrence 20,000 km^2 or area of occupancy <2,000 km^2 + two of the following: - severely fragmented or no more than 10 locations - continuing decline - extreme fluctuations
C. Small population and declining	<250 mature individuals, population declining	<2,500 mature individuals, population declining	<10,000 mature individuals, population declining
D. Very small population	<50 mature individuals	<250 mature individuals	D1. <1,000 mature individuals
D2. Very small area of occupancy			D2. <20 km^2 or 5 or fewer locations
E. Quantifiable probability of extinction	>50% within 10 years or three generations	>20% within 20 years or five generations	>10% within 100 years

Current GB rarity codes (IUCN assessed species)

The IUCN reviews also provide an assessment of rarity, based purely on the number of hectads (10km x 10km squares) in which any given species occurs. Two categories are defined:

Nationally Rare (NR)
Species recorded from between 1 and 15 hectads within a given date class when there is reasonable confidence that exhaustive recording would not find them in more hectads.

Nationally Scarce (NS)
Species recorded from between 16 and 100 hectads within a given date class when there is reasonable confidence that exhaustive recording would not find them in more hectads.

Broadly speaking, the Nationally Rare category is equivalent to the Red Data Book categories used by Shirt (1987) and Bratton (1991), namely: Endangered (RDB1), Vulnerable (RDB2), Rare (RDB3) and Insufficiently Known (RDBK). The Nationally Scarce category is directly equivalent to the combined Nationally Notable A (Na) and Nationally Notable B (Nb) categories introduced by the Nature Conservancy Council (Ball, 1986).

Current GB rarity codes (Non-IUCN assessed species)

For species not yet evaluated against the IUCN criteria, the most recent conservation status assessment is given, as specified by the Red Data Book categories (Shirt, 1987; Bratton, 1991) and Nationally Notable categories (Ball, 1986):

RDB1 (Endangered)
Taxa in danger of extinction and whose survival is unlikely if the causal factors continue operating. These include:

- Species known from only a single locality since 1970.
- Species restricted to habitats that are especially vulnerable.
- Species which have shown a rapid and continuous decline in the last 20 years and are now estimated to exist in 5 or fewer localities.
- Species believed extinct but which would need protection if re-discovered.

RDB2 (Vulnerable)
Taxa believed likely to move into the Endangered category in the near future if the causal factors continue operating. These include:

- Species declining throughout their range.
- Species in vulnerable habitats.
- Species whose populations are low.

RDB3 (Rare)
Taxa with small populations that are not at present endangered or vulnerable but which are at risk. These include:

- Species that are estimated to occur in 15 or fewer localities.

RDBK (Insufficiently known)
Taxa suspected to fall within the RDB categories but which are insufficiently known to enable placement.

RDBi (Indeterminate)
Taxa believed to qualify as either RDB1, RDB2 or RDB3 but which cannot be reliably placed into any category.

pRDB (Provisional)
The prefix 'p' before any Red Data Book category implies that the grading is provisional., pending the publication of a future edition of the Red Data Book.

Nationally Scarce species are those falling within the Nationally Notable categories introduced by Ball (1986). They are species that are estimated to occur within the range of 16 to 100 ten-kilometre squares of the British National Grid system since 1970. Notable species are subdivided as follows:

NS (Na)
Species estimated to occur within the range of 16 to 30 10-kilometre squares of the National Grid System, or for less well-recorded groups, within seven or fewer vice counties.

NS (Nb)
Species estimated to occur within the range 31 to 100 10-kilometre squares of the National Grid System, or for less well-recorded groups, between eight and 20 vice counties.

NS (N)
Species estimated to occur in 16 to 100 10 km squares in Great Britain. The subdividing of this category into Nationally Scarce A and Nationally Scarce B has not been attempted for some species because of either the degree of recording that has been carried out in the group to which the species belongs, or because there is some other reason why it is not possible to be so exact.

Recent provisional status assessments
Certain poorly recorded Dipteran groups have been subject to recent status assessment which is not based on comparisons of hectad data over two time periods (Falk et. al, 2016). This review uses IUCN status terminology with the added prefix 'p' (e.g. pVulnerable and pNationally Scarce) to indicate that these are provisional assessments based on data which would be insufficient for a formal IUCN status review. The category 'Data Deficient' (DD) is included.