Survey of ponds at Oldhouse Yard Covert

Report for the Freshwater Habitats Trust

Martin Hammond

martinhammondecology@gmail.com

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1. Introduction

Oldhouse Yard Covert forms part of the Forestry Commission holding adjoining Frost Common and Cranberry Rough in the Breckland of West Norfolk (national grid reference TL 94 93). It comprises broadleaved and conifer plantations with a central, cattle-grazed area of wet grassland.

The whole area contains many pingos/palsa-scars, which are natural ponds formed by frozen groundwater under tundra-like conditions in the late glacial period. Pingos are of special importance for their extraordinary invertebrate communities, which include many sedentary (or 'relict') species restricted to ancient ponds along with other rare or scarce fen species.

Many pingos have become surrounded by woodland or scrub in recent decades, resulting in a loss of vegetation structure and probably an increased rate of accumulation of organic sediment. The Forestry Commission and Norfolk Wildlife Trust plan to open-up some densely-shaded pingos with the aim of restoring their ecological quality.

This survey was undertaken to provide baseline data on ponds at Oldhouse Yard Covert which have been identified as priorities for management. Eight ponds were surveyed on 28th & 29th April 2016 using the Freshwater Habitat Trust's National Pond Survey (NPS) methodology (Pond Action, 1998). For monitoring purposes, the NPS data was analysed using PSYM software (see section 3 below).

At each pond, aquatic invertebrates were sampled for three minutes¹ using a long-handled net with a 1 mm mesh bag, with effort divided equally between each of the 'meso-habitats' present. A further minute was spent collecting invertebrates from the surface film or submerged debris. The standard NPS method requires that samples are sorted in the laboratory. However, because the Breckland pingo systems are known to support important populations of rare species, samples were sorted in a white polythene tray on the bankside, to avoid removing large numbers of individuals. Species were either identified in the field or preserved for identification at a later date. The standard NPS invertebrate groups were identified to species level (i.e. flatworms and fly larvae were recorded to family level and pea-mussels to genus).

The botanical survey involved a careful examination of each pond, using a pond net to collect submerged plants where necessary. Wetland vascular plants listed on the NPS proforma were recorded. As the survey was undertaken early in the season, a few additional species listed in the NWT pingo reports were added since these had probably been overlooked and were unlikely to have disappeared since the reports were compiled in 2014. Standard NPS environmental variables were recorded for each pond.

¹ NB: The three minutes are the active netting time, not the total time expended on the survey.

2. Water chemistry

Water samples were collected from seven of the eight ponds on April 28th and tested for pH and electrical conductivity (a measure of solute content). Samples for five of the ponds were also tested for nitrate (NO₋₃) and soluble reactive phosphate (PO₄-P). Results are shown in Table 1.

Pond number	water pH	conductivity	nitrate	phosphate	grid ref	area
		(µS/cm⁻¹)	(ppm)	(ppm)		(m²)
Pond 10	7.34	390	n/r	n/r	TL9425793219	64
Pond 13	7.28	670	n/r	n/r	TL9425993173	306
Pond 14	7.31	490	0	<0.02	TL9423193149	464
Pond 15	7.61	310	0	0	TL9429193161	300
Pond 27	6.95	360	0.2	0.02	TL9431393011	990
Pond 28	6.91	440	0.2	0.1-0.2	TL9421892929	740
Control	6.99	450	0	0.02	TL9415092912	460
Control 2	n/r	n/r	n/r	n/r	TL9413592910	300

Table 1: water chemistry data for ponds at Oldhouse Yard Covert

Water pH varied from 6.91 to 7.61 with a mean of 7.20. The ponds inside the plantation (27, 28 and the control pond) were marginally more acidic than those in the grassland. Electrical conductivity ranged from 310 to 670 μ S/cm⁻¹ with a mean of 444. These are readings which would normally be expected of base-rich, mesotrophic to eutrophic ponds.

The ponds within the wet grassland (10, 13, 14 & 15) had negligible levels of nitrate and phosphate and are probably isolated from eutrophication. Within the plantation, Ponds 27 & 28 showed elevated (but still relatively low) levels of nitrate while Pond 28 produced a higher phosphate (but still moderate) reading. These ponds are closer to the edge of the site and could potentially be impacted by arable farming in the neighbouring field, although increased accumulation of organic matter under the tree canopy could also be a factor. All four woodland ponds probably support dense surface growth of duckweeds and the floating liverwort *Riccia fluitans* in summer, indicating relatively high nutrient status.

3. PSYM assessment

The survey data was assessed using PSYM (**P**redictive **Sy**stem for **M**ultimetrics), the standard methodology for assessing the ecological quality of ponds (Environment Agency, 2002). PSYM uses six 'metrics' (measurements) representing important indicators of ecological quality. The three botanical metrics are:

- diversity of emergent and submerged plant species
- the number of uncommon species
- Trophic Ranking Score (TRS, an indication of nutrient status based on selected plant species)

The three invertebrate family-level metrics are:

- Average Score Per Taxon (ASPT, an estimation of biological water quality based on the sensitivity of different invertebrate families to organic enrichment)
- diversity of dragonfly, damselfly and alderfly families²
- diversity of water beetle families

Environmental data obtained for each pond include: surface area, altitude, grid reference, water pH, presence/absence of inflows, substrate composition, degree of shade, accessibility to livestock and cover of emergent vegetation.

The PSYM software compares the observed data with values predicted from a large reference dataset of undegraded ponds. PSYM predicts how a high quality pond with similar attributes *should* score for each metric, and compares the predictions with the survey results. The scores for each metric are combined to produce an Index of Biotic Integrity (IBI) which provides an overall indication of the ecological quality of the pond. Ponds are then categorised as Very Poor, Poor, Medium and Good.

The PSYM results for Oldhouse Yard Covert must be interpreted with two important caveats:

- The reference dataset used in PSYM is from surveys undertaken in June to August. This survey was undertaken earlier in the season (because many 'pingo' invertebrate specialities are most easily detected in spring), so the plant lists may be incomplete as a result. For example, it is difficult to separate duckweed species reliably this early in the year.
- PSYM was devised for permanent/semi-permanent ponds and is not reliable for water bodies which dry out every year. For this reason, Ponds 10, 13, 14 and 15 were not assessed. Pond 27 was classed as "usually wet" in the 2014 NWT assessment while Pond 28 was considered to be permanent. The two control ponds were categorised as permanent in the NWT report for Young's Covert.

PSYM provides a replicable methodology so the baseline results from this survey could be compared with monitoring data in subsequent years. Any future monitoring should also be undertaken in spring: re-surveying in mid- or late- summer could potentially result in better detection of wetland plants but poorer detection of aquatic invertebrates (e.g. due to low water levels or phenological factors).

PSYM results are provided in Appendix 1 and summarised briefly for the relevant ponds in section 4 below.

² As no alderflies were recorded in the survey, this metric is referred to simply as diversity of Odonata families.

4. The ponds surveyed

Ponds 10, 13, 14 and 15 are located within an area of open grassland and scattered scrub which is grazed by cattle. Ponds 27, 28 and the two control ponds are situated within coniferous and mixed plantation to the west. These are accessible to cattle but do not show much sign of grazing or trampling.

Pond 10 (TL 94257 93219)



This is a shallow, seasonal pool with extensive grass mats, occasional tufts of *Juncus* and patches of Common Spike-rush *Eleocharis palustris*. Small herbs include Common Marsh Bedstraw *Galium palustre*, Marsh Speedwell *Veronica scutellata* and Marsh Thistle *Cirsium palustre*. It produced 28 aquatic macro-invertebrate taxa. Species of conservation concern included the diving beetle *Agabus uliginosus* (Near Threatened)³ and the scavenger water beetles *Helophorus nanus* (Nationally Scarce), *H. strigifrons* (NS) and *Enochrus nigritus* (NT).

Pond 13 (TL 94259 93173)

This shallow, seasonal pingo is heavily shaded by collapsed and sprawling sallows with a large fallen birch across its southern edge. It contains patchy grass mats and one or two tussocks of Tufted Sedge *Carex elata*. Thirteen aquatic macro-invertebrate taxa were

³ Near Threatened (NT) species are not considered to be under immediate threat in Great Britain but are at risk of becoming so (see Foster, 2010). Nationally Scarce (NS) species have very localised distributions and are believed to occur in 100 or fewer ten km squares in Great Britain.

identified from the sample, the only species of conservation concern being the scavenger water beetle *Helophorus strigifrons* (NS).



Pond 14 (TL 94231 93149)

This seasonal pond abuts the eastern boundary of the plantation and has an indeterminate edge. It is heavily shaded by sprawling sallows and overhanging Hawthorn *Crataegus monogyna* though a tongue of unshaded, seasonally-flooded wet grassland extends out from the margin. Eighteen aquatic macro-invertebrate taxa were identified from the sample; none of these were species of conservation concern.

Pond 15 (TL 94291 93161)

This pond has mature sallows around its northern margin and *Juncus* tussocks around the southern edge with an extensive grass mat in the centre. It grades into a crescent-shaped depression to its east. Small patches of Pointed Spear-moss *Calliergonella cuspidata* occur amongst low herbs such as Lady's Smock *Cardamine pratensis*, Marsh Speedwell, Lesser Spearwort *Ranunculus flammula* and Common Marsh Bedstraw. Pond 15 yielded a respectable total of 30 aquatic macro-invertebrate taxa, including five species of conservation concern: the diving beetle *Rhantus frontalis* (NS) and the scavenger water beetles *Hydrochus crenatus* (NT), *Helophorus nanus* (NS), *H. strigifrons* (NS) and *Enochrus nigritus* (NT).



Pond 27 (TL 94313 93011)



This elongate pingo is heavily shaded by previously-coppiced alders. Apart from patchy grass mats at its margins (mainly Rough Meadow-grass, *Poa trivialis*), it contains little vegetation other than duckweed and Floating Crystalwort *Riccia fluitans*.

Fifteen aquatic invertebrate taxa were recorded. These were mostly water beetles, though mosquito larvae and Water Hoglice *Asellus aquaticus* were very abundant. One species of conservation concern was recorded: the diving beetle *Agabus uliginosus*.

PSYM assessment produced an Index of Biotic Integrity of 50%, placing this pond in the category of **Moderate** ecological quality. Wetland plant diversity was very poor and representation of uncommon plants was poor. Trophic Ranking Score (an indication of eutrophication) was good but this was probably influenced by the small number of plant species recorded. ASPT (a measure of biological water quality) was good and representation of water beetles at family level was moderate. However, no dragonflies, damselflies or alderflies were present in the invertebrate sampling, resulting in a null score for the OM metric.

Pond 28 (TL 94218 92929)



This pingo is less heavily shaded than Pond 27. There are some previously-coppiced Alders along the banks and several recently-felled stumps. Grass mats occur locally around the margins with small amounts of Soft Rush *Juncus effusus*, Water Forget-me-not *Myosotis scorpioides*, Common Marsh Bedstraw and other low herbs.

Twenty-two aquatic invertebrate taxa were recorded, most of these being water beetles. Although no species of conservation concern were collected, localised species included the diving beetles *Rhantus exsoletus*, *R. grapii* and *Hydroporus figuratus*, and the scavenger water beetle *Cercyon sternalis*. PSYM assessment produced an Index of Biotic Integrity of 67%, placing this pond in the category of **Moderate** ecological quality. Wetland plant diversity was poor and representation of uncommon plants was moderate. Trophic Ranking Score (an indication of eutrophication) was good. ASPT (a measure of biological water quality) and family-level representation of water beetles was good but no Odonata were recorded.

Control Pond 1 (TL 94150 92912)

This pond is on the west side of the track, opposite Pond 28. There are mature oaks and poplars at its northern end; on its eastern bank there is a large collapsed poplar and an upturned Sycamore root-plate has formed a small side-pool. There are narrow fringes of trailing grasses and low herbs including Greater Yellow-cress *Rorippa amphibia* and Gipsywort *Lycopus europaeus*. Floating Crystalwort occurs amongst duckweeds on the surface. This is probably Pond 23 on the NWT's Pingo Site Assessment form for Young's Covert, though this should be checked by cross-referencing grid references if possible.

Twenty-nine aquatic macro-invertebrate taxa were identified from the sample. There was just one species of conservation concern (the Nationally Scarce diving beetle *Rhantus frontalis*) but localised species including the scavenger water beetle *Cercyon sternalis*, the aquatic weevil *Poophagus sisymbrii* and the soldier-fly *Odontomyia tigrina*.

PSYM assessment produced an Index of Biotic Integrity of 78%, placing this pond in the category of **Good** ecological quality. Wetland plant diversity was moderate and representation of uncommon plants was good. Trophic Ranking Score was good. ASPT (a measure of biological water quality) and family-level representation of water beetles was good but no Odonata were recorded.

Control Pond 2 (TL 94135 92910)

This sinuous hollow is to the NW of Control Pond 1. It is on the west side of the track, opposite Pond 28. It was selected as a natural-looking pingo containing the characteristic tussocks of Tufted Sedge. There are extensive grass mats and Wood Small-reed *Calamagrostis epigejos* fringes one side of the pond. Duckweeds (*Lemna minor* and/or *L. minuta*) and Floating Crystalwort form patches on the surface.

Thirty-four aquatic macro-invertebrate taxa were recorded, making this the most speciesrich of the eight ponds surveyed. Five species of conservation concern included the scavenger water beetles *Hydrochus crenatus* (NT), *Helophorus strigifrons* (NS), *Enochrus nigritus* (NT) and *Helochares punctatus* (NS) and the caddis-fly *Trichostegia minor* (NS).

PSYM assessment produced an Index of Biotic Integrity of 83%, placing this pond in the category of **Good** ecological quality. Wetland plant diversity and representation of uncommon plants was good. Trophic Ranking Score (an indication of eutrophication) was moderate. ASPT (a measure of biological water quality) and family-level representation of

water beetles were good but representation of dragonflies, damselflies and alderflies was poor.



5. Results

5.1 Invertebrates

A list of aquatic macro-invertebrates recorded during this survey is provided in Appendix 2. More detailed data have been provided in spreadsheet format. A total of 76 taxa were recorded. The list is dominated by water beetles (45 species or 59% of taxa) and caddis-flies characteristic of seasonal ponds rich in organic detritus were also well represented. Taxa more typical of permanent ponds with submerged vegetation were either absent (e.g. leeches) or poorly represented (e.g. dragonflies and open-water gastropods and bugs). In the most shaded ponds, macro-invertebrate biomass is dominated by mosquito larvae (Culicidae) with marsh beetle larvae (Scirtidae) and seasonal-pool gastropods also being locally-abundant.

The site did not yield any of the rarest relict-fen species found on classic Breckland palsascar/pingo fens such as Thompson Common (e.g. the water beetles *Hydroporus elongatulus*, *H. glabriusculus*, *H. scalesianus*, *Hydrochus brevis*, *H. ignicollis* or *Hydraena palustris*). In this respect Oldhouse Yard Covert seems notably poorer than the nearby Frost Common pingos surveyed by Geoff Nobes. Further survey effort might well reveal additional species of conservation concern but the lack of extensive mossy and tussocky draw-down zones limits habitat quality. Nonetheless, the list includes several rare or scarce fen specialists, demonstrating that this is a high quality wetland and certainly worthy of targeted conservation measures to enhance habitat quality.

5.2 Plants

A total of 32 wetland plants (as listed on the PSYM/NPS pro-forma) were recorded: a list is provided in Appendix 3 and lists for each pond are included in the PSYM pro-formas. This list is modest, reflecting the limited botanical diversity of these ponds. In carrying out the PSYM evaluation, a few extra species were added based on the notes from the NWT's 2014 surveys. Tufted Sedge is very characteristic of Breckland pingos and was recorded from three of the ponds whilst the widespread but declining Lesser Spearwort and Marsh Speedwell are also species of conservation concern. Duckweed vegetation will probably be extensive in summer on at least three of the woodland ponds, and this includes the local floating liverwort *Riccia fluitans* (Floating Crystalwort).

5.3 Species of conservation concern

Agabus uliginosus (Dytiscidae), a diving beetle (Near Threatened)

This mid-sized diving beetle is associated with seasonal pools in fens, unimproved grassland and old woodland. It is classified as Near Threatened due to the vulnerability of its habitats and evidence of localised contractions in range (Foster, 2010). The *dispar* form, in which the females have matt-textured wing cases, is present here as in other populations in eastern and northern Britain. It was recorded from Pond 10 and Pond 27: in the latter, it was found in a small area with trailing terrestrial grasses at the west end of the pond.

Rhantus frontalis (Dytiscidae), a diving beetle (Nationally Scarce)

Rhantus frontalis is a mid-sized diving beetle with a very patchy British distribution centred on eastern Scotland, East Anglia, the Thames and North Kent Marshes, the Somerset Levels and Anglesey (Foster & Friday, 2011). It was found in Pond 15 and Control Pond 1.

Hydrochus crenatus (Hydrochidae), a scavenger water beetle (Near Threatened)

A small, slender hydrophilid, virtually confined to fenland habitats in East Anglia and the counties around the Wash. Despite its very restricted distribution, *H. crenatus* can occur in secondary habitats including clay pits and the reedy margins of arable ditches. It is the most frequent *Hydrochus* in Breckland and is probably fairly mobile. Pond 15 and Control Pond 2 produced specimens.

Helophorus nanus (Helophoridae), a scavenger water beetle (Nationally Scarce)

A small scavenger water beetle closely associated with seasonal, grassy pools in wet grassland or floodplain swamps. *Helophorus nanus* was present in numbers in the grazed Ponds 10 and 15. This is not a classic 'pingo' species but is a good indicator of cattle-grazed pools in summer-dry fens.

Helophorus strigifrons (Helophoridae), a scavenger water beetle (Nationally Scarce)

This species often occurs with *H. nanus* and is equally typical of summer-dry fens though it persists in more shaded habitats. It has a widely scattered national distribution. Helophorus strigifrons was found in Ponds 10, 13, 15 and Control Pond 2.

Helochares punctatus (Hydrophilidae), a scavenger water beetle (Nationally Scarce)

Although listed as Nationally Scarce by Foster (2010), *H. punctatus* is a localised rather than rare beetle, mostly associated with acidic bog-pools at low to moderate elevations but sometimes occurring in base-rich ponds. It was recorded from Control Pond 2.

Enochrus nigritus (Hydrophilidae), a scavenger water beetle (Near Threatened)

Occurring in "mesotrophic and base-rich fen, most often in relict sites", *E. nigritus* is known in England from scattered sites between Hampshire and Cheshire, and also on Anglesey (Foster *et al*, 2014). This is one of the 'less fussy' pingo-fen specialities, known from some degraded as well as high-quality sites. Specimens were collected from Ponds 10, 15 and Control Pond 2.

Trichostegia minor (Phryganeidae), a caddis-fly (Nationally Scarce)

This is a small Phryganeid, occurring with various Limnephilid caddis species in partiallyshaded fen pools. Larvae were found in Control Pond 2 and this species has also been collected from pingos at Thompson and Stow Bedon Commons. It has been recorded from 98 hectads in Great Britain from 1980 onwards (Wallace, in prep.) so it only narrowly qualifies for Nationally Scarce status.

Carex elata, Tufted Sedge (Near Threatened in England)⁴

This tussock-forming sedge is associated with fluctuating water margins in base-rich fens. Its British distribution is centred on the belt of former fenland extending from East Anglia to the Vale of York with outlying centres in the Lake District, the Cheshire Plain and Anglesey. Its range (Extent of Occupancy) in England contracted by 29% during the second half of the 20th century. A few plants occur in Ponds 13 and 15; it is more abundant in Control Pond 2.

Ranunculus flammula, Lesser Spearwort (Vulnerable in England)

Although still widespread and locally common, Lesser Spearwort underwent a 32% decline in distribution in England during the latter half of the last century (Stroh *et al*, 2014). It was found in Ponds 14 and 15.

Veronica scutellata, Marsh Speedwell (Near Threatened in England)

A moderately declining species of water-margins on poorer soils, which was recorded from Ponds 10 and 15.

⁴ Plant status is based on the England Red List (Stroh *et al.*, 2014)

6. Implications for conservation management

The results of this survey corroborate findings from Thompson and Stow Bedon Commons which show that deeply-shaded pingos with poor vegetation structure tend to support impoverished plant and invertebrate communities. There seems to be little evidence that Breckland pingos support a distinct fen-carr invertebrate fauna dependent on deep shade, although a number of uncommon shade-tolerant species do occur. In the present survey, the only shade-tolerant species of conservation concern was the diving beetle *Agabus uliginosus* in Pond 27 but this is equally adaptable to exposed conditions.

On balance, management to reduce overhanging shade in order to allow aquatic or emergent vegetation to develop will usually be highly beneficial, though this need not necessitate complete opening-up of ponds.

One potential drawback of opening-up woodland ponds at Oldhouse Yard Covert could be increased growth of surface-covering duckweeds (*Lemna* species) and the floating liverwort *Riccia fluitans*. These can become dominant in nitrogen-rich ponds surrounded by woodland, especially if conditions are too sheltered to allow the wind to break-up floating vegetation. Duckweed-dominated ponds are a natural habitat but may be perceived as aesthetically unappealing and the surface vegetation can suppress submerged and semi-aquatic plants, reducing habitat diversity.

The grassland ponds (10, 13, 14 & 15) are well-grazed by cattle. Pond 15 has varied and complex vegetation structure, including low emergent herbs with fragmentary moss carpets. This is a particularly rich habitat for invertebrates in pingo/palsa-scar fens and should always be protected. In this case, collapsed/sprawling sallow boughs around the northern side of the pond protect patches of this vegetation from trampling. Given that only about a quarter of this pond is directly overhung by bushes, there would probably be little benefit from removal the sallows. On balance, it would be more advisable to try to maintain this pond in its current condition.

Wood Small-reed is evidently an invasive native species in terrestrial habitats on this site but does not pose a problem for pond restoration. In Control Pond 2, which probably had unusually high water levels at the time of the survey, submerged stems of *Calamagrostis* provided a productive habitat for water-margin invertebrates.

7. References

Environment Agency (2002). *A guide to monitoring the ecological quality of ponds and canals using PSYM.* Version 2. Environment Agency Midlands Region: Solihull.

Foster, G.N. (2010). A review of the scarce and threatened Coleoptera of Great Britain, Part 3: water beetles of Great Britain. Joint Nature Conservation Committee: Peterborough.

Foster, G.N. & Friday, L.E. (2011). *Keys to adults of the water beetles of Britain and Ireland (Part 1).* Handbooks for the Identification of British Insects, **4** (5). Royal Entomological Society: London.

Pond Action (1998). *A guide to the methods of the National Pond Survey*. Pond Action: Oxford.

Stroh, P.A., Leach, S.J., August, T.A., Walker, K.J., Pearman, D.A., Rumsey, F.J., Harrower, C.A., Fay, M.F., Martin, J.P., Pankhurst, T., Preston, C.D. & Taylor, I. (2014). *A vascular plant Red List for England*. Botanical Society of Britain and Ireland: Bristol.

Wallace, I. (in prep.) *A review of the status of the caddis flies (Trichoptera) of Great Britain*. Draft of Species Status No. 27, prepared for Natural England.

APPENDIX 1:

PSYM RESULTS

Site details				
Site name	Oldhouse	Oldhouse Yard	Oldhouse Yard	Oldhouse Yard
	Yard Covert	Covert Pond 28	Covert/Control	Covert/Control
Survey date	Pond 27 28-Apr-16	29-Apr-16	28-Apr-16	29-Apr-16
Grid reference (e.g.	TI 0/2 020	23-Api-10 TI 9/2929	TI 0/1020	23-Api-10 TI 0/1020
SP123456 or higher	12 942 929	12942929	12941929	12941929
precision)				
Plant metrics				
No. of submerged +	5	8	10	14
marginal plant species (not				
Number of uncommon	1	2	2	6
plant species	1	2	5	0
Trophic Ranking Score (TRS)	9	9	9	9.3
Invertebrates metrics				
ASPT	4.6	5.111111111	5	5.666666667
Odonata + Megaloptera (OM) families	0	0	0	1
Coleoptera families	2	3	3	3
Environmental variables				
Altitude (m)	38	38	38	38
Easting	5942	5942	5941	5941
Northing	2929	2929	2929	2929
Shade (%)	80	60	35	20
Inflow (0/1)	0	0	0	0
Grazing (%)	0	0	0	0
рН	6.95	6.91	6.99	7
Emergent plant cover (%)	12	10	5	60
Base clay (1-3)	3	3	3	3
Base sand, gravel, cobbles (1-3)	1	1	1	1
Base peat (1-3)	1	1	1	1
Base rock (1-3)	1	1	1	1
Area (m ²)	990	740	460	300
Results				
Submerged + marginal plant species				
Predicted (SM)	21.9	20.6	18.6	17.0
Actual (SM)	5	8	10	14
EQI (SM)	0.23	0.39	0.54	0.82
IBI (SM)	0	1	2	3

Uncommon plant species				
Predicted (U)	3.9	3.7	3.3	2.9
Actual (U)	1	2	3	6
EQI (U)	0.26	0.55	0.92	2.04
IBI (U)	1	2	3	3
Trophic Ranking Score (TRS)				
Predicted (TRS)	8.79	8.77	8.74	8.72
Actual (TRS)	9.00	9.00	9.00	9.30
EQI (TRS)	1.02	1.03	1.03	1.07
IBI (TRS)	3	3	3	2
ASPT				
Predicted (ASPT)	5.11	5.11	5.11	5.11
Actual (ASPT)	4.60	5.11	5.00	5.67
EQI (ASPT)	0.90	1.00	0.98	1.11
IBI (ASPT)	3	3	3	3
Odonata + Megaloptera (OM) families				
Predicted (OM)	3.47	3.44	3.33	3.40
Actual (OM)	0	0	0	1
EQI (OM)	0.00	0.00	0.00	0.29
IBI (OM)	0	0	0	1
Coleoptera families				
Predicted (CO)	3.75	3.76	3.75	3.75
Actual (CO)	2	3	3	3
EQI (CO)	0.53	0.80	0.80	0.80
IBI (CO)	2	3	3	3
Sum of Individual Metrics	9	12	14	15
Index of Biotic Integrity (%)	50%	67%	78%	83%
PSYM quality category (IBI >75%=Good, 51-75%= Moderate, 25-50%=Poor, <25%=V Poor)	Moderate	Moderate	Good	Good
Is this a Driarity Dand?	Na	No	Vec	Vec
(Good quality category)	INO	NO	Tes	res

APPENDIX 2:

AQUATIC MACRO-INVERTEBRATES RECORDED DURING THE SURVEY

Taxon	Family	Order	English name	GB status⁵
indet flatworm	Planariidae	Turbellaria	a flatworm	
Galba truncatula	Lymnaeidae	Gastropoda	Dwarf Pond Snail	
Radix balthica	Lymnaeidae	Gastropoda	Wandering Snail	
Stagnicola palustris agg.	Lymnaeidae	Gastropoda	Marsh Pond Snail	
Anisus leucostoma	Planorbidae	Gastropoda	White-lipped Ramshorn snail	
Pisidium sp.	Sphaeriidae	Bivalvia	a pea-mussel	
Crangonyx pseudogracilis	Crangonyctidae	Amphipoda	an amphipod shrimp	
Asellus aquaticus	Asellidae	Isopoda	Water Hoglouse	
Aeshna cyanea	Aeshnidae	Odonata	Southern Hawker larva	
Cloeon dipterum	Baetidae	Ephemeroptera	Pond Olive larvae	
Corixa punctata	Corixidae	Hemiptera	a lesser water-boatman	
Hesperocorixa moesta	Corixidae	Hemiptera	a lesser water-boatman	
Hesperocorixa sahlbergi	Corixidae	Hemiptera	a lesser water-boatman	
Gerris lacustris	Gerridae	Hemiptera	Common Pond-skater	
Gerris odontogaster	Gerridae	Hemiptera	Toothed Pondskater	
Hydrometra stagnorum	Hydrometridae	Hemiptera	Water-measurer	
Ilyocoris cimicoides	Naucoridae	Hemiptera	Saucer Bug	
Nepa cinerea	Nepidae	Hemiptera	Water Scorpion	
Notonecta glauca	Notonectidae	Hemiptera	Common Backswimmer	
Gyrinus substriatus	Gyrinidae	Coleoptera	Common Whirligig	
Haliplus ruficollis	Haliplidae	Coleoptera	an algivorous water beetle	
Noterus clavicornis	Noteridae	Coleoptera	a burrowing water beetle	
Acilius sulcatus	Dytiscidae	Coleoptera	a diving beetle	
Agabus bipustulatus	Dytiscidae	Coleoptera	a diving beetle	
Agabus sturmii	Dytiscidae	Coleoptera	a diving beetle	
Agabus uliginosus	Dytiscidae	Coleoptera	a diving beetle	NT
Colymbetes fuscus	Dytiscidae	Coleoptera	a diving beetle	
Dytiscus (not semisulcatus)	Dytiscidae	Coleoptera	a great diving beetle	
Dytiscus semisulcatus	Dytiscidae	Coleoptera	a great diving beetle	
Hydroporus angustatus	Dytiscidae	Coleoptera	a diving beetle	
Hydroporus erythrocephalus	Dytiscidae	Coleoptera	a diving beetle	
Hydroporus figuratus	Dytiscidae	Coleoptera	a diving beetle	
Hydroporus gyllenhalii	Dytiscidae	Coleoptera	a diving beetle	
Hydroporus palustris	Dytiscidae	Coleoptera	a diving beetle	
Hydroporus pubescens	Dytiscidae	Coleoptera	a diving beetle	
Hydroporus striola	Dytiscidae	Coleoptera	a diving beetle	

⁵ NT – Near Threatened, NS – Nationally Scarce. Designations based on Foster (2010) for water beetles and Wallace (in prep) for caddis-flies.

Hydroporus tristis	Dytiscidae	Coleoptera	a diving beetle	
Hydroporus umbrosus	Dytiscidae	Coleoptera	a diving beetle	
Hygrotus inaequalis	Dytiscidae	Coleoptera	a diving beetle	
Hyphydrus ovatus	Dytiscidae	Coleoptera	a diving beetle	
llybius ater	Dytiscidae	Coleoptera	a diving beetle	
Ilybius chalconatus/montanus	Dytiscidae	Coleoptera	a diving beetle	
Laccophilus minutus	Dytiscidae	Coleoptera	a diving beetle	
Rhantus exsoletus	Dytiscidae	Coleoptera	a diving beetle	
Rhantus frontalis	Dytiscidae	Coleoptera	a diving beetle	NS
Rhantus grapii	Dytiscidae	Coleoptera	a diving beetle	
Rhantus suturalis	Dytiscidae	Coleoptera	a diving beetle	
Helophorus nanus	Helophoridae	Coleoptera	a scavenger water beetle	NS
Helophorus obscurus	Helophoridae	Coleoptera	a scavenger water beetle	
Helophorus strigifrons	Helophoridae	Coleoptera	a scavenger water beetle	NS
Hydrochus crenatus	Hydrochidae	Coleoptera	a scavenger water beetle	
Anacaena limbata	Hydrophilidae	Coleoptera	a scavenger water beetle	
Anacaena lutescens	Hydrophilidae	Coleoptera	a scavenger water beetle	
Cercyon sternalis	Hydrophilidae	Coleoptera	a scavenger water beetle	
Cymbiodyta marginellus	Hydrophilidae	Coleoptera	a scavenger water beetle	
Enochrus nigritus	Hydrophilidae	Coleoptera	a scavenger water beetle	NT
Enochrus ochropterus	Hydrophilidae	Coleoptera	a scavenger water beetle	
Helochares lividus	Hydrophilidae	Coleoptera	a scavenger water beetle	
Helochares punctatus	Hydrophilidae	Coleoptera	a scavenger water beetle	NS
Hydrobius fuscipes	Hydrophilidae	Coleoptera	a scavenger water beetle	
Hydraena riparia	Hydraenidae	Coleoptera	a moss beetle	
Ochthebius minimus	Hydraenidae	Coleoptera	a moss beetle	
Dryops sp.	Dryopidae	Coleoptera	a long-toed water beetle	
Contacyphon larvae	Scirtidae	Coleoptera	marsh beetle larvae	
Poophagus sisymbrii	Curculionidae	Coleoptera	an aquatic weevil	
Limnephilus (other)	Limnephilidae	Trichoptera	a caddis-fly	
Limnephilus ?marmoratus	Limnephilidae	Trichoptera	a caddis-fly	
Limnephilus flavicornis	Limnephilidae	Trichoptera	a caddis-fly	
Limnephilus rhombicus	Limnephilidae	Trichoptera	a caddis-fly	
Limnephilus stigma	Limnephilidae	Trichoptera	a caddis-fly	
Limnephilus vittatus	Limnephilidae	Trichoptera	a caddis-fly	
Trichostegia minor	Phryganeidae	Trichoptera	a caddis-fly	NS
Chironomidae larvae	Chironomidae	Diptera	non-biting midge larvae	
Culicidae larvae	Culicidae	Diptera	mosquito larvae	
Dixidae larvae	Dixidae	Diptera	meniscus midge larvae	
Odontomyia tigrina	Stratiomyidae	Diptera	a soldier-fly	

APPENDIX 3:

WETLAND PLANTS RECORDED DURING THE SURVEY

Species	English name	status ⁶
Agrostis stolonifera	Creeping bent	LC
Alisma plantago-aquatica	Common Water-plantain	LC
Alopecurus geniculatus	Marsh Foxtail	LC
Calamagrostis epigejos	Wood Small-reed	LC
Calliergonella cuspidata	Pointed Spear-moss	LC
Callitriche sp.	a water-starwort	-
Cardamine pratensis	Lady's Smock	LC
Carex elata	Tufted Sedge	NT
Carex panicea	Carnation Sedge	LC
Carex pseudocyperus	Hop Sedge	LC
Cirsium palustre	Marsh Thistle	LC
Deschampsia cespitosa	Tufted Hair-grass	LC
Eleocharis palustris	Common Spike-rush	LC
Epilobium spp.	willowherbs	LC
Equisetum palustre	Marsh Horsetail	LC
Galium palustre ssp. palustre	Common Marsh Bedstraw	LC
Glyceria fluitans	Flote-grass	LC
Iris pseudacorus	Yellow Flag	LC
Juncus conglomeratus	Compact Rush	LC
Juncus effusus	Soft Rush	LC
Juncus inflexus	Hard Rush	LC
Juncus subnodulosus	Blunt-flowered Rush	LC
Lemna minor	Common Duckweed	LC
Lemna minuta	Least Duckweed	LC
Lycopus europaeus	Gipsywort	LC
Lythrum salicaria	Purple Loosestrife	LC
Mentha aquatica	Water Mint	LC
Myosotis scorpioides	Water Forget-me-not	LC
Ranunculus flammula	Lesser Spearwort	VU
Riccia fluitans	Floating Crystalwort	LC
Rorippa amphibia	Greater Yellowcress	LC
Veronica scutellata	Marsh Speedwell	NT

⁶ VU = Vulnerable (England Red List: Stroh *et al*, 2014); NT = Near Threatened (England Red List); NS = Nationally Scarce (Leach & Rusbridge, 2006; Preston, 2006); LC = Least Concern