

## THE FRESHWATER MACROFAUNA AND WATER QUALITY OF THE RIVER MEDINA, ISLE OF WIGHT

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### Abstract

The freshwater macrofauna of Island rivers is relatively under-recorded and poorly understood. The Medina is the Island's second longest river and over many centuries its course has been highly modified by water mills, the railway and more recently through flood alleviation schemes. Intensive farming practices and discharges of wastewater and urban and agricultural run-off have resulted in pollution and poor water quality for many decades. Parts of the river also suffer from iron-ochre deposits that may also suppress species diversity.

A survey of the Medina in 1992-96 revealed that the variety of aquatic insects and other invertebrates was unremarkable, but that there were 'hot spots' of higher diversity, indicating that the river had greater potential. Over the past 30 years there has been more extreme weather, notably warmer summers, milder winters, and periods of sustained and heavy rainfall. There have also been attempts to improve habitats and water quality generally in rivers throughout the UK and Europe.

In 2022-3, the river was resurveyed, using a similar method, that involved 'kick-sampling' at nine stations between St Catherine's Down and Coppins Bridge, Newport and at a single site on the Merstone Stream, a tributary of the Medina. Across both surveys, a total of 107 species of invertebrate and eight fish were recorded; importantly however, the most recent survey revealed the presence of more pollution-sensitive species including caddisflies and nymphs of Britain's largest mayfly *Ephemera danica*. Biological indices of water quality, Biological Monitoring Working Party (BMWP) and Average Score per Taxon (ASPT) scores, had increased noticeably at sites downstream of Chillerton, however there was no improvement in the upper catchment.

Overall, the study has shown that the Medina has not been reaching its full ecological potential because of poor water quality, and yet recovery is possible. This bucks the general trend of decreasing terrestrial diversity in some areas. However, this is no time for complacency.

### Keywords:

Water quality, biological monitoring, kick-sampling, Isle of Wight rivers, iron-ochre, Merstone Stream, invertebrates, fish, birds

### Introduction

The diversity of macrofauna in the Island's rivers has long been a topic of discussion. In the past century, Morey (1909) and later Blair (1950) commented that the number of records of some groups of aquatic insects and other invertebrates were disappointingly low but argued that this was most likely because there were few interested observers. Blair also attributed low diversity to a "comparative lack of running streams and large sheets of water". At a workshop on Isle of Wight rivers and streams held at the Medina Valley Centre in 1994, it was suggested that compared to similar mainland rivers, aquatic diversity was suppressed due to relatively high levels of iron-ochre, pollution and poor river management, limited opportunities for recruitment from mainland rivers and a restricted gene pool (Pope, 1994).

In the past decades there has been an increased survey effort and additional information and records have been forthcoming (Herbert, 1991; Cooksley & Herbert, 2008; NBN, 2024). To fully understand the condition of riverine habitats, it is important to broaden the scale of survey and investigate the wider catchment.

Although the estuarine fauna and flora have been described (Withers, 1979; Herbert 1995, 2001; Mallinson and Herbert, 2003), and the flora of the river corridor has been surveyed (Kettell et al., 1979; Chatters, 1985; Environment Agency (EA) 1996)

there have been no published surveys of the freshwater fauna of the River Medina. However, because macroinvertebrates and fish are useful indicators of water quality, the EA and its predecessors have monitored the fauna at specific locations as part of statutory river surveillance programmes (EA, 2024a). From November 1994 to June 1996, we undertook, winter, spring, and summer surveys of the macrofauna of the Medina at ten stations between the source on St Catherine's Down and the tidal limit at Coppins Bridge, including the Merstone Stream tributary (Herbert & Riley, 1998 unpublished report). This information was supplemented by regular surveys of the river at Shide Weir from 1991-1995 (Herbert & Riley 1996). The study concluded that, in common with many of the Island's streams at that time, the invertebrate macrofauna of the Medina was not very diverse and the abundance of organisms was generally disappointing. However, there were local 'hot spots' in relatively undisturbed riffles and pools that yielded higher species richness, indicating that the river had much greater potential.

The past three decades have been characterised by more extreme weather, notably warmer summers, milder winters, and periods of sustained and heavy rainfall. There have also been attempts to improve habitats and water quality generally in rivers throughout the UK and Europe following the implementation of the EU Wastewater Treatment

Directive (1991), EU Water Framework Directive (2000) and other broadscale measures, including Catchment Sensitive Farming launched in 2005, that encouraged the creation of buffer strips between arable fields and rivers to reduce soil erosion and chemicals leaching in to the water. In October 2002, Southern Water's *Seaclean Wight* scheme became operational that transferred wastewater from across the island via a network of pipelines and pumping stations to a new sewage works at Sandown.

It was therefore decided to repeat the earlier survey as a comparison to assess how the macrofauna in the river has changed since the mid-1990s.

### **The Medina and its catchment area**

The Medina is the Island's second longest river. It rises from springs on the slopes of St Catherine's Down, above the village of Chale Green, and flows 17 km north through the middle of the Isle of Wight to Newport where it becomes tidal (Fig 1). The upper stage of the main river, and its main tributary the Merstone Stream, flow across the Cretaceous rocks of the Lower Greensand Group: Ferruginous Sands, Sandrock and Monk's Bay Sandstone. In periods of heavy rain, iron-rich sand and silt are washed into the river, causing the distinctive ochre colour of the alluvium in the channel. The main river also crosses the Selborne Group, made up of the clays of the Gault Formation and sands of the Upper Greensand, part of the ridge that runs west to east across the centre of the Island.

Shortly after the confluence of the Medina and Merstone Stream, the river cuts across the Chalk Group, through a gap near Shide where the central ridge is at its narrowest. The estuarine lower stage of the river crosses a sequence of Palaeogene sands and clays, before entering the Solent at its mouth at Cowes, a further 7 km to the north.

The river has a total catchment area of 36.5 km<sup>2</sup> (EA 2024b) and is fed by four main tributaries: the Appleford Drain, the Merstone Stream, an un-named stream that has its confluence with the Medina at Pan Mill Meadows in Newport and the Lukely Brook. At Upper Shide, the mean flow discharge is 0.29 m<sup>3</sup> s<sup>-1</sup>; however, compared to chalk streams such as the Lukely Brook, flows fluctuate more on the Medina, due to the underlying greensand soils and run-off (Windrush, 2009). River flows may also vary as a result of water abstraction from boreholes within the Medina catchment. These include transfers into the Merstone Stream and the Medina at Blackwater. Water may also be moved via the Medina-Yar Augmentation scheme that moves water directly from the Medina at Blackwater and groundwater from catchment boreholes to Sandown, where it is utilised to maintain levels in the East Yar (EA, 2019).

Adjacent land-use between Chale and Shide is mainly rural, with arable farming and ley pasture on the sandy soils. Between Chale Green and Cridmore the river flows through a relatively extensive marshy area known as 'The Wilderness' that includes Cridmore Bog Site of Special Scientific Interest, which is one of the last remaining peat bogs on the Island. Downstream of Shide, the river flows beside busy roads through the town of Newport with adjacent residential areas and superstores. There are

five wastewater treatment works between Chale and Blackwater (Southern Water, 2020) where effluent may enter the Medina and Merstone Stream, and there are stormwater discharges into the river from drains close to the growing residential town of Newport.

The river course and channel have been heavily modified over hundreds of years. The construction of water mills resulted in the straightening of some channels and often the formation of large mill ponds, which must have significantly affected fish passage and the dispersal and connectivity of invertebrate and fish populations. A water mill at Gatcombe and four mills at Shide are mentioned in the Domesday Book and it appears that other mills at Gatcombe were present at various times. Gatcombe Mill, Blackwater Mill and the Upper Shide Mill, Lower Shide Mill, Pan Mill and Ford Mill in Newport remained operational well into the 20<sup>th</sup> Century. The railway line connecting Newport and Sandown, built in the 1870s, straightened the river's natural meandering course, and it became divided between Blackwater and Newport. Following heavy rain and severe flooding of Newport in 1960 and 1961, flood alleviation measures were implemented between Blackwater and Coppins Bridge including additional canalisation and the construction of weirs (Solomon & Beach, 2009). This further reduced natural riverine habitat and potential fish passage. Over the past decade, measures to restore habitats in the lower catchment have been attempted by the Newport Rivers Group, including pollarding and coppicing of bankside trees to increase sunlight over the channel, the construction of fish passes for brown/sea trout and eels, and in-stream improvements to restore riffles, pools and bankside vegetation.

Chemical water quality has fluctuated with organic pollutants, including pesticides, metals, and excess nitrate and phosphate arising from agricultural run-off entering the river from the middle and southern part of the catchment. After heavy rainfall, the river in Newport looks very brown-orange due to high levels of iron-rich sediment and soil running off fields from higher up in the catchment. The EA have classified the Medina as a Heavily Modified Water Body (HMWB) of 'Moderate' quality under the EU Water Framework Directive.

### **Methods**

Between November 1994 and June 1996, samples of river macrofauna were taken from nine stations along the main river between the source on St. Catherine's Down above the village of Chale Green, and the tidal limit at Coppins Bridge in Newport (Fig 1.) An additional site on the Merstone Stream (Site 5), a tributary of the Medina, was also sampled near Blackwater. Access which was suitable and safe was the main criterion for selecting sites, together with an appropriate sample separation distance downstream and variety of habitats. Using a standard 1mm mesh pond net, a three-minute kick-sample was obtained at each site and the contents of the net emptied into a plastic bucket for sorting and identification back in the laboratory. Identification was taken to species level where possible although some worms, fly larvae and mites were not identified

on every occasion.

River depth and width were determined using a metre rule and tape measure. Flow rate was measured with an MJP flow meter, or by timing a float over a known distance. Dissolved oxygen, water temperature and conductivity were determined using portable meters (pHOX Systems 62 and YSI). Observations were made of riverbank and aquatic flora, and adjacent land use. Data collected from Shide Weir near Newport was supplemented by more frequent observations made 1991-1995 by field study students from the Medina Valley Centre under the authors' supervision.

At each site, a biological assessment of water quality was made based on the presence of taxa known to be sensitive and tolerant to organic pollution. Using the BMWP scoring system (Hawkes, 1997), species are assigned a value between 1 and 10 according to their tolerance to levels of pollutants and dissolved oxygen, with 10 being given to the most sensitive taxa. A 'site BMWP score' is the sum of all species scores in the sample; in simple terms, the higher the total score, the cleaner and more oxygenated the water. In addition, the average score per taxon (ASPT) was also determined as this is more independent of type and size of river and a more reliable metric for comparing different sites. This is found by dividing the BMWP score by the number of contributing taxa. Taxonomic nomenclature is from UK Centre for Ecology and Hydrology (2011).

In November 2022, March and June 2023, the survey was repeated using the same methods, although the earlier monitoring site immediately below the slope at Shide Weir (Site 8) had become inaccessible, so an additional site 50 m further upstream (Site 7a) was sampled instead.

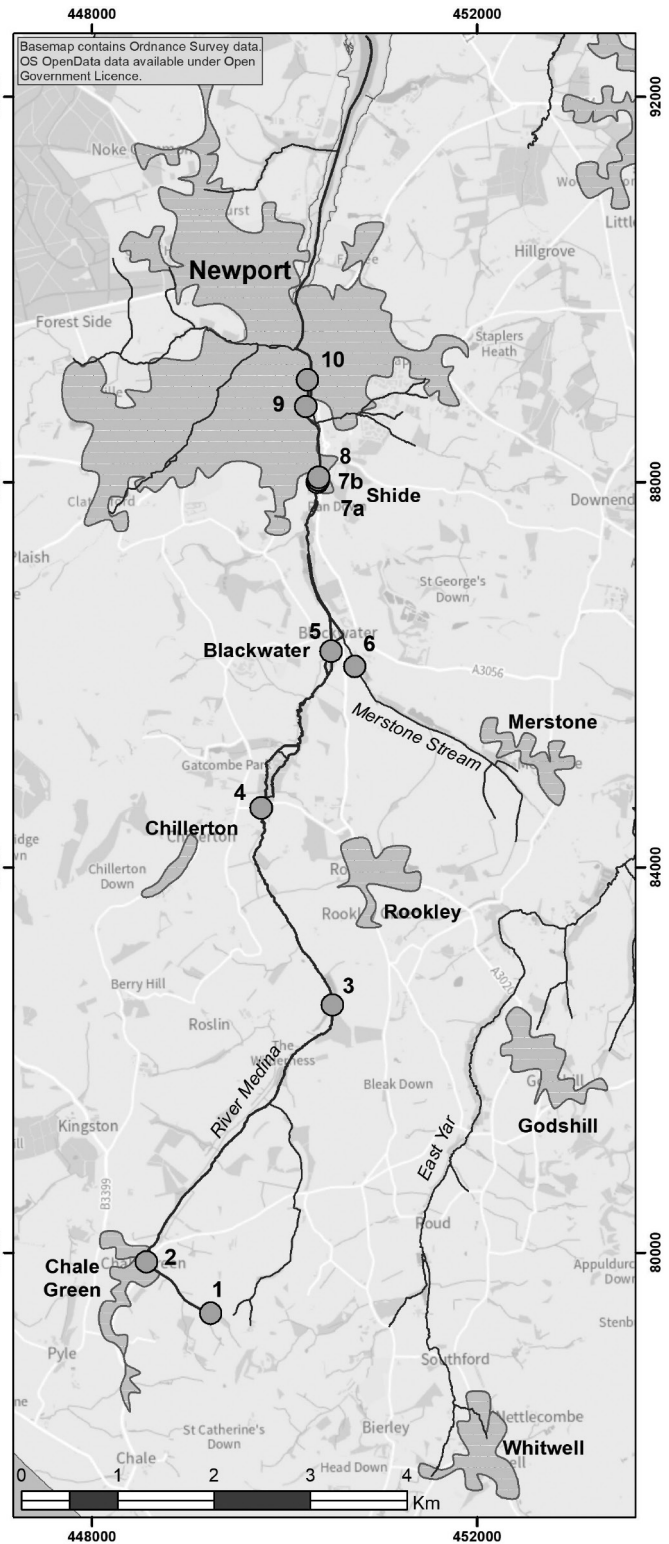
## Results

### General observations

Over the two survey periods, a total of 107 species of aquatic invertebrates, eight fish and five waterbirds were recorded in the Medina and Merstone Stream. Over the two main surveys in the 1990s, 54 species taxa across 43 families were recorded, excluding eight water mites which were not systematically identified at all sites. An additional 21 species were recorded anecdotally at the two locations surveyed regularly at Shide Weir from 1991-1995.

In the single 2022-23 survey period, 67 species, excluding three water mites, were identified across 46 families. Species diversity generally increased downstream, though dipped again below Shide as the river became more exposed to urban run-off. A greater variety of species were found in winter and spring samples prior to the emergence of insect nymphs and larvae; however, adult water beetles and bugs were more frequent in summer samples.

Four species of flatworms (Planariidae), oligochaete worms and six species of leech (Hirudinea) were found. Arthropods included ten species of water mite (Hydracarina) of which five were new to the Island (*Hydrodroma torrenticola*; *Hygrobatas calliger*, *H. fluviatilis*, *H. setosus* and *H. longipalpis*). The amphipod crustacean, *Gammarus pulex* (Fig. 2), was



**Fig. 1:** Catchment of the River Medina showing sampling stations. See text for site details and description.



**Fig.2:** Pair of freshwater shrimp, *Gammarus pulex*. Merstone Stream 14th July 2023

Photo: Keith Marston

almost ubiquitous in samples; *G. zaddachii* was only recorded north of Shide Weir close to the tidal limit, which is characteristic of the species. The amphipod *Crangonyx pseudogracilis* was just found at Cridmore. This species and the New Zealand mud snail, *Potamopyrgus antipodorum*, were the only non-native invertebrate species found in the river.

A wide variety of insect larvae and nymphs typical of British rivers including caddisflies, mayflies, stoneflies and true flies were recorded along the length of the river, with more found downstream of Chillerton Bridge. Common across most sites was the swimming mayfly *Baetis rhodani/atlanticus*. *B. atlanticus* was described as new to the British mayfly fauna in 2018 (Macadam *et al.* 2018). Morphological differences with *B. rhodani* are very slight and because there is a possibility these have been overlooked, the two species have not been separated. Caddisflies new or uncommon to the island included *Hydroptila sparsa* and *Lepidostoma hirtum*, both at Shide, and *Rhyacophila fasciata* grp. Nymphs of the mayfly *Seratella ignita* (Fig. 3) were found in both survey periods downstream of Chillerton. The larger burrowing nymphs of *Ephemera danica*, known from the East Yar, were first



**Fig. 3:** Mayfly nymphs **Above:** *Seratella ignita*, (body length 6.5mm) Blackwater Mill Farm 30<sup>th</sup> June 2023  
**Below:** *Ephemera danica* (body length 30mm) Shide, 26<sup>th</sup> March 2024. Photos: Keith Marston

seen in the Medina in 2022-23 at Shide (Fig. 3). Stoneflies were represented only by the family Nemouridae, of which *Nemoura avicularis* was found for the first time in 2022, although the species has been sampled previously in the East Yar.

In the 1990s, water bugs such as the lesser water boatmen (Corixidae) and greater water boatman *Notonecta glauca* were commonly seen in slow flowing reaches of the river, particularly above Shide Weir.



**Fig. 4:** Three-spined Stickleback *Gasterosteus aculeatus* Merstone Stream 30<sup>th</sup> June 2023

Photo: Keith Marston



**Fig. 5:** Stone loach *Barbatula barbatula*, Blackwater Mill Farm 30<sup>th</sup> June 2023

Photo: Keith Marston

Members of the beetle family Helophoridae were mostly found in the upper parts of the catchment near Chale Green whereas riffle water beetles (Elminthidae) were found mainly at stations downstream of Chillerton. Molluscs included the almost ubiquitous *P. antipodorum*, pea shells (Sphaeriidae spp.), the occasional pond snail (*Lymnaea peregra*), and where the river ran swiftly, the river limpet *Ancylus fluviatilis*.

Three-spined Stickleback (*Gasterosteus aculeatus*) (Fig. 4) was the most frequently observed fish and Stone Loach (*Barbatula barbatula*) (Fig.5) and Miller's Thumb (*Cottus gobio*) were occasionally found in the river. Mallard and Moorhen were the most commonly seen waterfowl and observed mostly in the lower reaches of the river.

A full list of species recorded is given in Appendix 1. Selected physical and chemical data collected over the two survey periods is presented in Appendix 2.

### Site descriptions

#### Site 1 St. Catherine's Down (SZ 492794)

The sampling site is about 90m above sea level and is approximately 60m below the river's source, as marked on the Ordnance Survey (OS) map. The channel water width varied between 0.4-0.9 m, and water depth was generally between 3-10 cm, although in June 1995, it was dry. The riverbed is predominantly clay with some gravel and larger stones. There are overhanging oak, willow, blackthorn and hawthorn trees, and the banks are covered with brambles and nettles. A small bridge crossing the stream at this point enabled access for sampling. In the 1990s, the adjacent land use was

predominantly pasture and sheep grazing, with some of the grass cut for making silage and hay, and this was mostly unchanged in 2022-23. In the 1990s survey the New Zealand mud snail *P. antipodarum* were highly abundant, as was the freshwater shrimp *G. pulex* and chironomids, but less so in 2022-23. Small beetles (Helophoridae spp. Helodidae, Hydrophillidae, Elminthidae) were also conspicuous. This was the only site on the Medina where nymphs of the stonefly *Nemoura cinerea* were recorded.

#### Site 2 Chale Green (SZ 486798)

This sampling site is beside arable fields within a few metres of a road which adjoins the B3399 in the village of Chale Green. The channel water width here varied between 0.9-2.3 m, and water depth between 5-23 cm, although in June 1995 it was dry. The riverbed consists of silt and sand over remains of concrete structures. On the riverbanks there were grasses, nettles, brambles and the occasional blackthorn bush. In the 1990s, there was often an oily film on the surface of the stream and the water and sediments smelled of petrol.

The benthic invertebrate community was dominated by *P. antipodarum* and *G. pulex*. Beetle larvae (Helophoridae and Helodidae) were often frequent and caddisfly larvae of the family Limnephilidae were also found.

#### Site 3 Cridmore (SZ 505825)

Just above this sampling site is an extensive marshy area known as The Wilderness. The channel water width here varied between 2.2-3.4m, and water depth between 5-51 cm. The riverbed is silty sand and the water was always brown-orange in colour due to colloidal iron hydroxide or 'iron-ochre'. A small concrete ford crosses the river and there are some overhanging willows and oaks. There are also stands of *Phragmites australis* lining the riverbank. In June 1995, there were small clumps of water starwort (*Calitriche* sp.) present by the ford. Surrounding the river is grazing land and at Cridmore Farm, large new reservoirs have been constructed.

Species diversity in the 2022-23 survey was about half that of the 1990s when the community was variable but included flatworms *Polycelis* spp. oligochaete worms, freshwater shrimps, coleoptera



**Fig. 6:** Early instar nymph of the water scorpion, *Nepa cinerea*, Cridmore 26<sup>th</sup> June 2023. Photo: Keith Marston

and water boatman *Sigara nigrolineata* and *S. venusta*. In 2023, the stonefly *Nemoura avicularis* was found for the first time. Water beetles *Agabus bipustulatus* and *A. paludodius* (Dytiscidae) were found here together with scavenger beetles (*Helophorus* sp.). An early instar of the water scorpion (*Nepa cinerea*) (Fig. 6) was sampled in June 2023.

#### Site 4 Chillerton Bridge (SZ 497846)

Above the bridge on Highwood Lane, the river is straight and narrow and runs through a large open field. In November 1994, this was sown with winter cereals, and in the following years left as sheep pasture and cut for silage. In June 2023, the east bank was pasture and on the west bank, maize had been planted (Fig. 7). The site is completely open with no scrub or trees lining the banks. The channel water width here varied between 2.2-3.6m, and water depth between 25-55 cm. The riverbed is sandy silt along over a concrete base with occasional shoals of fine gravel mixed with large stones in the middle.

By 2022, the channel immediately upstream of the bridge had been canalised with a concrete riverbed and a gauging station constructed. The water is generally clearer than further upstream, and in the 1990s clumps of water-starworts (*Calitriche* sp.) were frequent along this stretch. In the silty margins, Tubificidae were abundant with Diptera larvae Chironomidae, *Pedicia* and *Dicranota*. Larvae of the alderfly *Sialis lutraria* were also found, and nymphs of the mayfly *Baetis rhodani/atlanticus* were common in most samples.



**Fig.7:** View south (upstream) from the bridge at Highwood Lane, Chillerton. 8<sup>th</sup> November 2022.

Photo: Keith Marston

#### Site 5 Blackwater Mill Farm (SZ 505863)

This is a relatively undisturbed section of the river where the water runs swiftly through several small meanders, creating riffles and pools (Fig. 8). The channel water width here varied between 2-4.5 m, and water depth between 7-23 cm. The riverbed mainly consists of coarse gravel and cobbles. There are livery stables adjacent to the river where horses graze in paddocks. On the riverbanks there are mature willows and alders, and upstream of the sampling site is Gatcombe withy bed, an extensive area of wet woodland and marshes. Growing on the steep outer banks of the meanders there are large

patches of liverworts (Bryophyta). This site has a rich diversity of macroinvertebrates with seven families of caddisflies recorded in 2022-23. During the winter and spring, the benthic community is dominated by larvae of the caseless caddisfly *Hydropsyche siltalai*, but following emergence they are virtually absent from the June samples. Nymphs of the mayfly *Baetis rhodani/atlanticus* and amphipod *G. pulex* are also abundant. Other species commonly found in clean fast flowing water included river limpet *A. fluviatilis*, blackfly

larvae *Simulium ornatum*, mayfly nymph *S. ignita*, and damselfly *Calopteryx splendens* (Fig.9).

**Site 6 Merstone Stream (SZ 507862)**

The river at the sampling site runs through woodland next to a domestic garden and was shaded by alders, ash and sycamore trees. The channel water width here varied between 1.6-2.4 m, and water depth between 7-30 cm. The riverbed is mainly cobbles and shingle with a covering of silt. This tributary of the Medina was included in the sampling programme because of water quality concerns in the 1990s. The catchment of the Merstone stream includes intensive agriculture and the river was always a bright orange in colour, due to iron-ochre suspension and deposits on the stream bed (Fig. 10). Moreover, there were iron-rich sediments oozing out of the soil banks lining the channel. In 2022-23 iron-ochre deposits were still visible but less obvious than in the earlier survey.

The variety and abundance of invertebrate fauna



**Fig. 8:** Blackwater Mill Farm 30<sup>th</sup> June 2023.  
Photo: Keith Marston



**Fig. 10:** Merstone Stream 30<sup>th</sup> June 2023.  
Photo: Keith Marston



**Fig.9:** Beautiful demoiselle damselfly *Calopteryx splendens* **Above:** Nymph at Highwood Lane, Chillerton 8<sup>th</sup> November 2022. **Below:**Adult male upstream of Blackwater Mill Farm 12<sup>th</sup> May 2020.  
Photos: Keith Marston



**Fig. 11:** Larvae of cased caddisflies **Above:** *Lepidostoma hirtum* **Below:** Limnephilidae sp. Merstone Stream 30<sup>th</sup> June 2023. Photo: Keith Marston

found here was generally poor compared to sites on the main river of the Medina.

#### **Site 7a Shide Riffles (SZ 503880)**

This site, on the southern outskirts of Newport, was only visited in the 2002-23 survey. It is about 50m upstream of Shide Weir and although the course of the river has been straightened and engineered, this site is characterised by a small fast flowing meander and gravel riffles, that may have been created relatively recently as part of in-stream improvements (Fig. 12).



**Fig. 12:** Shide Riffles, 26<sup>th</sup> March 2024.

Photo: Keith Marston

The channel water width here varied between 4.6-5.3 m, and water depth between 15-30 cm. The riverbed consists mainly of gravel with silt on the channel edges. The site is heavily shaded by alder and white willow trees and is diverse with amphipod *G. pulex*, caddisflies *R. dorsalis*, *Sericostoma personatum*, *L. hirtum*, *Mystacides azurea*, *Adicella reducta*, *Silo pallipes* and nymphs of the mayfly *Ephemera danica*, *Seratella ignita* and *Baetis rhodani/atlanticus*.

#### **Site 7b Shide, above weir (SZ 503880)**

The 6.5m wide channel was straightened and the river level was lowered here in 1968 to reduce the risk of flooding. A small weir was constructed, above which the river became slow flowing and the water on average was about 50cm deep with a sandy-silt riverbed. To reduce siltation upstream of the weir and to facilitate high winter discharges after heavy rain, the weir boards were removed in November 1994 and in March and November 1995. The river is shaded with alder and willow and to the east is the busy St George's Way. On the west side is a small car park for visitors to the Christmas tree nursery. In the 1990s, both this site and Site 8 were sampled regularly by field study students from the Medina Valley Centre.

Prior to permanent removal of the weir-boards in about 2004, the river had a pond-like community with water boatman (*Sigara* spp.), greater water boatman *Notonecta glauca*, whirling beetles (*Gyrinus* sp.) and diving beetles, Dytiscidae spp. and in June 1996, dense congregations of the ostracod *Herpetocypris reptans* were observed. Fish, including 3-spined stickleback (*Gasterosteus aculeatus*) and stone loach (*Barbatula barbatula*)

were caught frequently along with occasional eels (*Anguilla anguilla*). In 2022-23, the river was generally swiftly flowing with maximum depth varying between 35-50cm and water width 6.1-6.3m over the survey period. The pond-like community was no longer evident but species typical of fast flowing riffles were present including nymphs of the mayfly *E. danica* and *S. ignita* and larvae of cased caddisflies *L. hirtum*, *M. azurea*, *S. personatum* and *Silo pallipes*.

#### **Station 8 Shide, below weir (SZ 503880)**

This site was not sampled in 2022-23 as access to the riverbank had been restricted by the growth of dense scrub. Prior to their removal, water flowed over the wooden weir boards and swiftly down a rough concrete slope to a canalised concrete channel 5.8m wide. The slope was colonised with the moss *Amblystegium riparium* (Hedw.) and green algae (*Cladophora* sp.) attached to pebbles and larger stones on the concrete riverbed. Water depth varied between 10-16 cm and a thin layer of silt accumulated on the riverbed a few metres further downstream of the weir where flow rate was reduced. In the mid-1990s, the riverbed below the weir was raised slightly to enable the installation of a new flow-gauge. This increased the depth of water below the weir to between 30-40cm and reduced the flow rate.

Recorded here in the 1990s were *Sigara* spp. (lesser water boatmen) which must have been washed over the weir boards, but the 'below weir' community was distinctly different and dominated by species characteristic of higher flow rates, such as nymphs of the mayfly *Baetis rhodani/atlanticus* and larvae of the caseless caddisfly *Hydropsyche siltalai*. In the spring, the caseless caddis *Tinodes waeneri* was frequently recorded and the cased caddis *Goera pilosa* was occasional.

#### **Site 9 St Georges Approach Bridge (SZ 502888)**

This shaded site below the road bridge has been canalised, is 9.5m wide and located just above two stepped weirs with a total head of 1.4m (Fig. 13) Maximum water depth varied between 11-27cm and the substrate above the concrete bed is mixed silt sand and gravel.



**Fig. 13:** St Georges Approach Bridge 11<sup>th</sup> April 1996. The sampling site is above the weir and beneath the bridge. The scrub on the east bank has now matured.

Photo: Anne Marston

In the 1990s, on the riverbed just above the weir, there was some water-starwort (*Callitriche* sp.) and a clump of water crowfoot (*Ranunculus* sp.), but this was not seen in 2022-23. Of note is the variety of water mites which have been recorded which must feed on the invertebrates and fish. Although some species sensitive to poor water quality were recorded here in the 1990s, such as the mayfly *S. ignita*, this site was found to be significantly more diverse in 2022-23 with larvae of caddisflies *S. personatum*, *L. hirtum*, *M. azurea*, *Adicella reducta*, *S. pallipes* and nymphs of the mayfly *E. danica*. The shrimp *Gammarus zaddachi* which is commonly recorded elsewhere as estuarine conditions are approached, was recorded in 2022-2023 but not seen in the 1990s surveys.

#### Site 10 Coppins Bridge (SZ 502891)

Just prior to the main roundabout in the centre of Newport the river flows within a concrete channel between gardens and a small amenity area (Fig.14). Water width ranged between 6.7 -7.7m and maximum depth varied between 17-38cm. The riverbed consists of gravel and some larger cobbles covered by a thin layer of silt.



**Fig. 14:** Coppins Bridge, 29<sup>th</sup> March 2024  
Photo: Keith marston

The presence of the green algae *Ulva* sp. and *Cladophora* sp. on the riverbed and edges of the channel and the abundance of the amphipod *Gammarus zaddachi* could be indicative of occasional saline incursion. Species richness was lower here compared to Shide at the edge of the town, which could be due to urban run-off and occasionally raised salinity. The amphipod, *Niphargus aquilex*, observed in the 1990s, is often found in drains and may well have entered the river through storm water discharges. Flounder and Common Goby found here are typically estuarine fish but are known to penetrate far beyond tidal limits. In June 2023, a single larva of the uncommon caddisfly *Rhyacophila fasciata* grp was recorded here.

#### Discussion

The results of surveys in the 1990s, showed that the Medina was characterised by a low diversity and low abundance of freshwater macroinvertebrate fauna. It was thought this was primarily due to the heavily modified and engineered channel, the absence or rarity of floating and emergent vegetation, an

inferior variety of bankside habitats, iron-rich sediments and low flows, and to a variety of pollutants and low oxygen levels.

Except for the reach between Gatcombe and Blackwater Mill, the river remains heavily modified and engineered, yet, at many sites, there have been quite significant changes in the macrofauna assemblages over the past three decades. At Shide Weir the removal of the weir boards, now permanent, has resulted in significantly higher flow rates immediately upstream. Fauna characteristic of slow flowing, almost pond-like conditions has been replaced by species commonly found in fast-flowing riffles such as mayfly nymphs and caddisfly larvae.

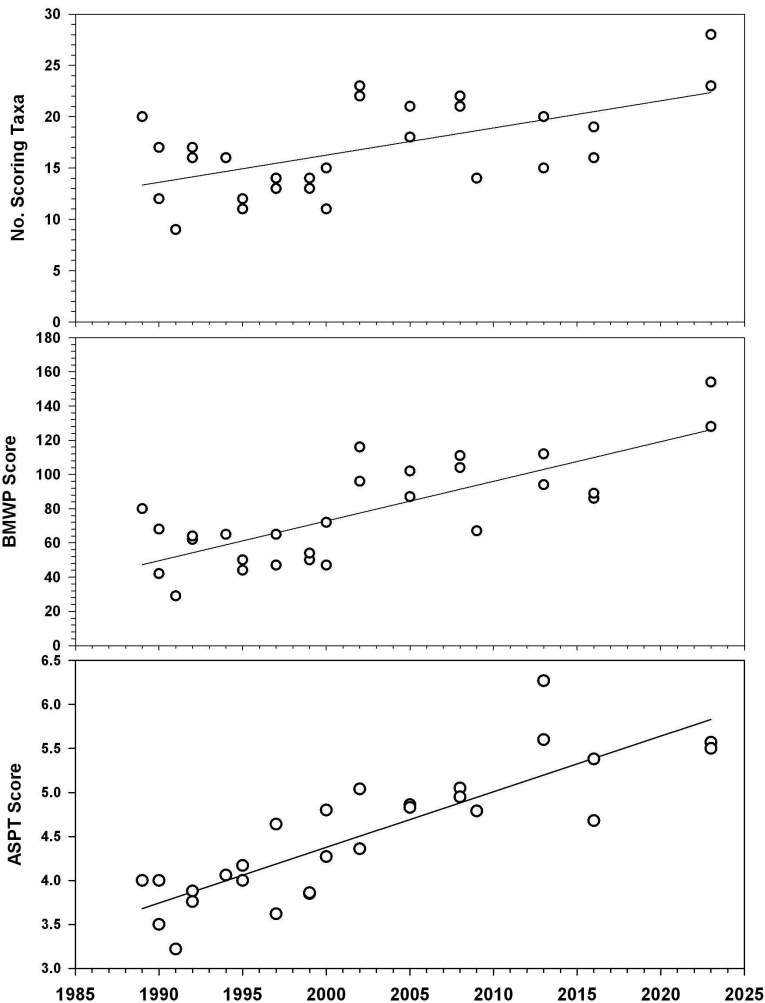
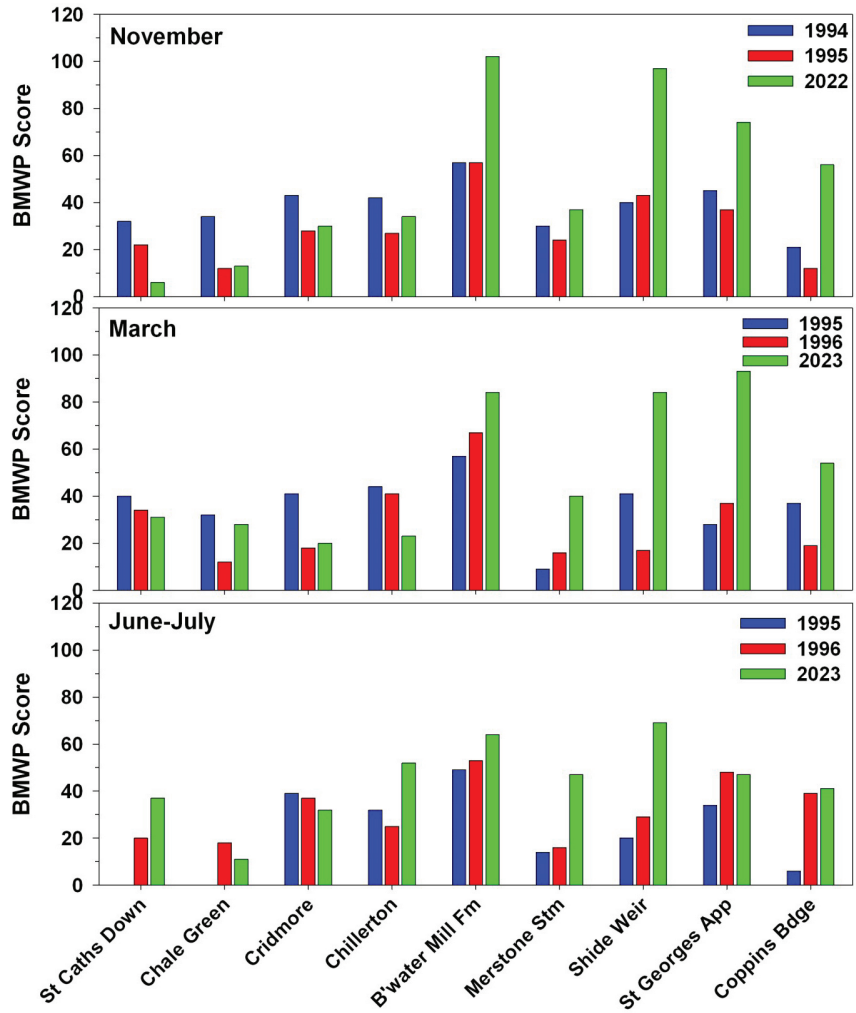
Most striking has been an increase in the number of invertebrate families that are sensitive to poor water quality at sites downstream of the bridge at Highwood Lane, Chillerton, and including the Merstone Stream. This suggests that the long-term water quality of this section of the river has improved. Compared to the 1990s, site BMWP scores in the lower section of the river were significantly higher in 2022-3 at nearly all sites in all seasons (Fig. 15). Although this might partially reflect more oxygenated water due to higher flow conditions at Shide Weir, and other habitat enhancements, a similar improvement was observed further upstream at Blackwater Mill Farm and on the Merstone Stream where the river course and flow characteristics have generally remained unchanged. Between Shide and St Georges Approach bridge, pollution sensitive caddisfly families Leptoceridae, Lepidostomatidae, Sericostomatidae and Goeridae have become more widespread, and the presence of the mayfly *E. danica* boosted BMWP scores. For some of these taxa, abundance could be quite high, especially for caddis *M. azurea* and *S. personatum*.

Sites above Chillerton in the upper part of the catchment showed no such improvements, suggesting that the macrofauna here remains exposed to poorer water quality and habitat. Where the river flows through The Wilderness and Cridmore the fauna may be suppressed by iron-ochre. However, surrounding these wetland habitats is intensive arable farming, so there remains the possibility of pollution from run-off and groundwater contamination.

A general comparison of abundance across all taxa is limited as two surveys were carried out in the 1990s and only one survey season in 2022- 2023. However, some insect groups were lower in numbers in the recent survey, notably water bugs (Hemiptera) water beetles of family Dytiscidae, midges (Chironomidae) and blackflies (Simuliidae). This could be partially due to the removal of weir boards at Shide and the loss of slow-flowing habitat that is favoured by some of these species. However, the widespread decline in insect abundance across the UK is a serious concern (Ball *et al.* 2022; Mancini *et al.* 2023). A revised score system (Wallace Hawkes Paisley Trigg index), now employed by the EA (Paisley *et al.* 2014) incorporates changes to some BMWP scores that are dependent on species abundance, so future monitoring may become more sensitive to variations in the faunal assemblages.

An analysis of data collected by the EA (and

**Fig. 15:** BMWP scores calculated for November, March and June/July at all sampling sites for each survey period. Samples from standard 3-min kick-sample. Higher BMWP scores are generally indicative of better water quality.



**Fig. 16:** Biological metrics of water quality obtained for the River Medina at Shide Weir 1989-2023. The linear regression equations show a statistically significant increase in the number of scoring taxa, BMWP and ASPT scores over this period.

**Top:** Number of Scoring Taxa (linear regression: df 1,26 F 13.3 p=0.001  $R^2_{Adj}$  =0.31);

**Middle:** BMWP score (linear regression df 1/26 F 38.6 p<0.001  $R^2_{Adj}$  =0.58);

**Bottom:** ASPT score (linear regression df 1/26 F 66.99 p<0.001  $R^2_{Adj}$  =0.71).

Data extracted from Environment Agency (2024a) Site ID 43254, OS Grid Reference SZ5034788019.

predecessors) at Shide Weir from 1989-2023 supports the assertion that water quality of the lower Medina has generally improved. The significant trend of increasing BMWP and ASPT scores over the past three decades (Figs. 15 & 16) suggest that environmental conditions now offer a more favourable habitat for a wider range of taxa. EA measurements of dissolved oxygen at the monitoring site at Shide Weir have risen and stabilised over the past three decades, and levels of ammonia have fallen. These encouraging data for the Medina are mirrored by recent larger scale time-series analyses of UK and European river macroinvertebrate surveillance data over the same period (Pharaoh *et al.* 2023; Qu *et al.* 2023; Hasse *et al.* 2023).

We also know that there has been an almost concurrent decline in many chemicals of serious concern in English rivers (Whelan *et al.* 2022) and improvements in urban water courses since the introduction of the EU Urban Wastewater Directive (1991). So, the rise in BMWP scores is likely to be due to a general reduction in pollution levels and/or particular pollutant(s) that were previously widespread but now at much lower levels. We may not fully understand the lag time between chemical improvement and the arrival of pollution sensitive taxa, which are likely to vary significantly, and it is possible that the trends reflect quality improvements over a longer time period - perhaps since the 1970s. Yet, a closer examination of the data from the Medina shows that several pollution sensitive taxa started to appear more commonly in EA samples at Shide Weir from the late 1990s and early 2000s and our more recent data has confirmed their continued presence, and some newcomers (Table 1).

All taxa in Table 1 have been recorded in other Island rivers and streams prior to these dates, with the exception of the caddisfly *L. hirtum* which appears to be a recent colonist - possibly from the mainland, where it is widespread. So, we can assume that most new families in the Medina have spread from other Island rivers. For example, the mayfly *Ephemera danica* has been known from the East Yar since the 1980s; it was first recorded in the Lukely Brook at Plaish in 2006 and in EA samples from other parts of the Lukely in 2017.

Yet some sensitive taxa have been lost from Shide Weir over the period, for example larvae of the caddisfly *Goera pilosa* (Family Goeridae) was occasionally recorded in the mid-1990s but was not observed in 2022-23. However, *S. nigricornis*, also of Family Goreridae, has colonised the site, so there may have been a species interaction or other habitat

changes.

There has been a general climatic warming trend in the past 30 years, with some exceptionally hot summers and mild winters. Some species may be responding positively to this, in addition to cleaner water. However, for others, e.g. the mayfly *E. danica*, continued warming could result in changes to shorter life cycles (Everall *et al.* 2015; Macadam *et al.* 2022) that may affect the species fecundity.

No full assessment of fish in the Medina has been made in this study, as the kick sampling method is not appropriate for all species. However, in addition to species listed from our surveys in Appendix 1, electric fishing by the EA at sites north of Blackwater have yielded Brook Lamprey (*Lampetra planeri*), Common Wild Carp (*Cyprinus carpio*), and Brown (sea) Trout (*Salmo trutta*) (EA 2024a).

Waterfowl and other avifauna have not been systematically surveyed along the freshwater section of the river, however the estuary is a site in the British Trust for Ornithology's Wetland Bird Survey.

### Iron-Ochre

No discussion of the Medina would be complete without reference to its rusty orange-brown colour, which is a particular feature after heavy rainfall! This is mostly due to the erosion of iron-rich water, soils and sediments in the upper catchment that enter the river because of intensive farming practices. Particular sections of the river also suffer from flocculated iron hydroxide or iron-ochre. This can occur when waterlogged anaerobic soils, such as those present at The Wilderness and Cridmore Bog, containing a high organic content and appreciable amounts of iron sulphides are drained and iron-rich water then flows directly into the river, as these habitats may have formerly acted as a 'sponge' (Pope, 1994). Oxidation of these sulphides by sulphur bacteria (*Thiobacillus*), results in the formation of iron sulphate, which when exposed to more neutral and alkaline conditions is further oxidised to insoluble hydrated ferric oxide,  $Fe(OH)_3$ , which precipitates as an orange coloured deposit (Gibson, 1996).

The precise biological effects of 'iron-ochre' are unknown, although for some species, interference with respiratory and feeding mechanisms is likely (see stonefly nymph *N. avicularis* Fig. 17).

Smothering of burrows may also suppress the fauna and reduce algal growth on the stream bed which will inhibit grazing herbivorous species. Reduced pH values, which occur during the initial oxidation processes, may also fall outside the tolerance limits of some species and slightly acidic conditions (pH 6.5) were detected in the Merstone Stream in the

**Table 1:** First appearance of some pollution sensitive taxa in samples from Shide Weir on the River Medina post-1996. EA time-series is 1989-2015.

Species	Family	BMWP score	First records in samples	Source
<i>Sericostoma personatum</i>	Sericostomatidae	10	1997	EA
<i>Silo nigricornis</i>	Goreridae	10	2000	EA
<i>Lepidostoma hirtum</i>	Lepidostomatidae	10	2008	EA
<i>Rhyacophila dorsalis</i>	Rhyacophidae	7	2022	This study
<i>Ephemera danica</i>	Ephemeridae	10	2022	This study



**Fig. 17:** Nymphs of the stonefly *Nemoura avicularis*  
**Above:** from Cridmore, 4<sup>th</sup> March 2023, covered in deposits of iron ochre **Below:** From Chillerton 12<sup>th</sup> March 2023, free of iron-ochre Photos: Roger Herbert

1990s. In the more recent surveys, some iron-ochre remained visible at Merstone, and the river still looks very brown after rain, yet BMWP scores are now generally much higher than previously.

### Conclusions

This study has shown that the Medina has not been reaching its ecological potential because of poor water quality, and yet recovery is possible. This will only be sustained if river habitat and catchment management continues to be enhanced and maintained. Further improvements are necessary, particularly in the upper course of the river, which may result in yet higher species diversity along the whole length of the river. If detailed assessments of other rivers are forthcoming, they may provide new insights into the colonisation and dispersal of the Island's aquatic macrofauna.

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## APPENDIX 1

Survey 1 is November 1994-June 1996. Survey 2 is November 2022-March 2023.

Values refer to Maximum count in 3 min kick sample with 1mm pond net.

1 = 1-9 individuals (ind), 2 = 10-99 ind, 3 = 100-999 ind. p = present in *ad hoc* samples

See Methods for further details.

SITE (See Fig. 1)	1		2		3		4		5		6		7a		7b		8		9		10	
	1	2	1	2	1	2	1	2	1	2	1	2	2	1	2	1	2	1	1	2	1	2
<b>SPECIES</b>																						
<b>PLATYHELMINTHES (Flatworms)</b>																						
<i>Planariidae</i>																						
<i>Polycelis nigra/tenuis</i>					1				1	1		1		1		p		1	1			
<i>Polycelis felina</i>					1		1		1	1		1	1	2	1	2	2			1	1	
<i>Dugesiiidae</i>																						
<i>Dugesia tigrina</i>									1						p			1				1
<i>Dendrocoelidae</i>																						
<i>Dendrocoelum lacteum</i>										2						p						
<b>NEMATOMORPHA (Horsehair worms)</b>																						
Nematomorpha sp.																p		p				
<b>MOLLUSCA (Snails)</b>																						
<i>Hydrobiidae</i>																						
<i>Potamopyrgus antipodarum</i>	4	1	3	2	1		1	2	2	1			3	2	3	3	3	3	3	2	3	
<i>Lymnaeidae</i>																						
<i>Lymnaea (Radix) peregra</i>															p		1	1	1			
<i>Planorbidae</i>																						
<i>Ancylus fluviatilis</i>									2	1						1	2		1			
<i>Bathyomphalus contortus</i>																p						
<i>Gyraulus albus</i>																	p					
<i>Planorbidae</i> sp.													1									
<i>Sphaeriidae</i>																						
<i>Pisidium milium</i>																p						
<i>Pisidium subtruncatum</i>																p						
<i>Pisidium</i> sp.		1		1						1						p		p				
<i>Sphaerium corneum</i>																p		p				
<i>Sphaeridae</i> sp.	1	1	1		1		1		1							1	1					
<b>ANNELIDA (Oligochaeta - Worms)</b>																						
<i>Lumbriculidae</i>																						
<i>Lumbriculus variegatus</i>	1						1									p		p				
<i>Naididae</i>																						
<i>Stylaria lacustris</i>	1	1															p					1
<i>Tubificidae</i>																						
<i>Potamothenrix hammoniensis</i>																p						
<i>Psammoryclides barbatus</i>									1													
<i>Tubifex tubifex</i>																p		p				
<i>Tubificidae</i> spp.	3	1	2	1	1	1	3	1	2	1	1	2	1	2	1	2	1	1	1	1	1	1
<i>Lumbriculidae</i>																	p					
<i>Eiseniella tetraedra</i>	1		1		1												p					
<i>Lumbriculidae</i> sp.									1	1		1	1			1	p					1
Oligochaeta indet.	2		1		2		2		2		1			2	1	1	2			2		
<b>ANNELIDA (Hirudinea - Leeches)</b>																						
<i>Piscicolidae</i>																						
<i>Piscicola geometra</i>													1	1								1

APPENDIX 1 (continued)

SITE (See Fig. 1)	1		2		3		4		5		6		7a	7b		8	9		10		
SURVEY	1	2	1	2	1	2	1	2	1	2	1	2	2	1	2	1	1	2	1	2	
<b>ANNELIDA (Hirudinea - Leeches)</b>																					
<i>Glossiphoniidae</i>																					
<i>Glossiphonia complanata</i>																					
					1		1		1			1	1	1	1	p	1	1	1		
<i>Helobdella stagnalis</i>																					
									1				1		1	p				1	
<i>Hemiclepsis marginata</i>																					
									1							p					
<i>Theromyzon tessulatum</i>																					
									1					1		1					
<i>Erpobdellidae</i>																					
<i>Erpobdella octoculata</i>																					
						1			3	1		1	1	1	1	1	1	1	1	1	
<b>ARTHROPODA (Hydracarina - Mites)</b>																					
<i>Hydrodroma torrenticola (despiciens)</i>																					
																		1			
<i>Hygrobatas calliger</i>																					
																				1	
<i>Hygrobatas fluviatilis</i>																					
																p				1	
<i>Hygrobatas longipalpis</i>																					
								1				1			p						
<i>Hygrobatas setosus</i>																					
												1							1		
<i>Hygrobatas nigromaculatus</i>																					
					1													1		1	
<i>Lebertia inaequalis</i>																					
					1		1		1										1		
<i>Lebertia porosa</i>																					
					1										p			1			
<i>Sperchon denticulatus gr.</i>																					
																			1		
<i>Sperchon hibernicus</i>																					
																		1			
<i>Sperchon setiger</i>																					
																		1			
<i>Hydracarina spp.</i>																					
					2		2	1	2	1			1	2	1	3	3	3	3	1	
<b>ARTHROPODA (Crustacea)</b>																					
<b>Cladocera</b>																					
<i>Cladocera sp.</i>																					
					1										p						
<b>Ostracoda</b>																					
<i>Herpetocypsis reptans</i>																					
														1	1	p					
<i>Ostracoda indet.</i>																					
					1				2	1	1	1	1	4	2	2	2	2	2	1	
<b>Isopoda</b>																					
<i>Asellidae</i>																					
<i>Asellus aquaticus</i>																					
1				2	1		2		2	1		2	2	1	2	1	1	2	1	2	
<i>Proasellus meridianus</i>																					
				2							3	1									
<b>Amphipoda</b>																					
<i>Crangonyctidae</i>																					
<i>Crangonyx pseudogracilis</i>																					
				1		1															
<i>Gammaridae</i>																					
<i>Gammarus pulex</i>																					
3	1	2	2	2	2	2	1	2	3	2	3	3	2	3	3	2					
<i>Gammarus zaddachii</i>																					
																			2	2	3
<i>Niphargidae</i>																					
<i>Niphargus aquilex</i>																					
																				1	
<b>ARTHROPODA (Insecta)</b>																					
<b>Ephemeroptera (Mayflies)</b>																					
<i>Baetidae</i>																					
<i>Baetis rhodani/atlanticus</i>																					
					2	1	3	2	1	1	1	2	1	2	2	2	2	2	1	1	
<i>Cloeon dipterum</i>																					
				1											p						
<i>Ephemeridae</i>																					
<i>Ephemera danica</i>																					
													1		2				1		

APPENDIX 1 (continued)

SITE (See Fig. 1)	1		2		3		4		5		6		7a	7b		8		9		10	
	1	2	1	2	1	2	1	2	1	2	1	2	2	1	2	1	1	2	1	2	
EphemereIIDae																					
<i>Seratella ignita</i>							1	1	1				2		2	1	1	1	1	1	1
Caenidae																					
<i>Caenis luctuosa</i>																p					
<b>Plecoptera (Stoneflies)</b>																					
Nemouridae																					
<i>Amphinemura sulcicollis</i>															p						
<i>Nemoura avicularis</i>					1		1														
<i>Nemoura cinerea</i>	1	2									2										
<i>Nemoura</i> sp.																1					
<i>Nemurella pictetii</i>															p		p				
<b>Odonata (Dragonflies)</b>																					
Libellulidae																					
<i>Libellula depressa</i>																	p				
Calopterygidae																					
<i>Calopteryx splendens</i>							1								1	p		1			
<b>Hemiptera (Water Bugs)</b>																					
Veliidae																					
<i>Velia</i> sp.	1						1	1				1					1				
Nepidae																					
<i>Nepa cinerea</i>					1										p						
Notonectidae																					
<i>Notonecta glauca</i>																p					
Pleidae																					
<i>Plea minutissima</i>																p					
Corixidae																					
<i>Sigara dorsalis</i>																p	1				
<i>Sigara falleni</i>																	p				
<i>Sigara nigrolineata</i>					1																
<i>Sigara venusta</i>							1									p	1				
<i>Sigara</i> sp.					2		2		1							3					
<b>Coleoptera (Beetles)</b>																					
Halplidae																					
<i>Halplus lineatocolis</i>																	1				
Dytiscidae																					
<i>Agabus bipustulatus</i>							1														
<i>Agabus paludosus</i>					1																
<i>Hydroporus erythrocephalus</i>		1																			
<i>Nebrioporus elegans</i>																	p				
<i>Stictotarsus duodecimpustulatus</i>											1						p				
Dytiscidae indet.	1		1		1		1								1		p			1	
Gyrinidae																					
<i>Gyrinus</i> sp.	1															p	p				
Helophoridae																					
<i>Helophorus brevipalpis</i>		1			1																
<i>Helophorus</i> sp.	1	1	2		1	1															

APPENDIX 1 (continued)

SITE (See Fig. 1)	1		2		3		4		5		6		7a	7b	8		9		10	
	1	2	1	2	1	2	1	2	1	2	1	2	2	1	2	1	1	2	1	2
<b>Coleoptera (Beetles) continued</b>																				
<i>Helodidae</i>																				
<i>Elodes</i> sp.	2		2																	
<i>Hydrophilidae</i>																				
<i>Anacaena globulus</i>		1																		
<i>Elminthidae</i>																				
<i>Elmis aena</i>		1					1	1	1				1	1	p		1			1
<i>Oulimnius</i> sp.														p		p				
<i>Limnius volkmari</i>													1	1						
<b>Megaloptera (Alderflies)</b>																				
<i>Sialidae</i>																				
<i>Sialis lutaria</i>					1		1				1			p	1					
<b>Trichoptera (Caddisflies)</b>																				
<i>Rhyacophilidae</i>																				
<i>Rhyacophila dorsalis</i>									1			1								
<i>Rhyacophila fasciata</i> grp																				1
<i>Hydroptilidae</i>																				
<i>Hydroptila sparsa</i>																p				
<i>Psychomyiidae</i>																				
<i>Lype reducta</i>						1														
<i>Tinodes waeneri</i>																1				
<i>Polycentropodidae</i>																				
<i>Plectrocnemia conspersa</i>						1				1										
<i>Polycentropodidae</i> sp.																1				
<i>Hydropsychidae</i>																				
<i>Hydropsyche siltalai</i>								1	3	2	1		1	1	1	2	3	1	2	1
<i>Lepidostomatidae</i>																				
<i>Lepidostoma hirtum</i>										1		1	1	2			2			
<i>Limnephilidae</i>																				
<i>Glyphotaelius pellucidus</i>				1																
<i>Halesus radiatus</i>			1			1	1			1				1	1	p				
<i>Limnephilus lunatus</i>														p		p				
<i>Limnephilus marmoratus</i>								1								p				
<i>Limnephilus</i> sp.			1		1				1		1			p						
<i>Micropterna lateralis</i>								1			1									
<i>Micropterna sequax</i>	1		1																	
<i>Limnephilidae</i> indet.		1		1	1		1			1		1	1							
<i>Stenophylax</i> sp.				1																
<i>Goeridae</i>																				
<i>Goera pilosa</i>									1							p				
<i>Goeridae</i> indet.																				1
<i>Silo pallipes</i>										1			2	1				1		
<i>Sericostomatidae</i>																				
<i>Sericostoma personatum</i>									1	1		1	2	1			2	p		2
<i>Leptoceridae</i>																				
<i>Adicella reducta</i>													1					1		
<i>Mystacides azurea</i>													1	2	p		2			
<i>Trichoptera</i> indet																				

APPENDIX 1 (continued)

SITE (See Fig. 1)	1		2		3		4		5		6		7a	7b		8		9		10	
	1	2	1	2	1	2	1	2	1	2	1	2	2	1	2	1	1	2	1	2	
<b>Diptera (Two-winged flies)</b>																					
<u>Tipulidae</u>																					
<i>Tipula</i> sp.			1		1		1		1							p	1				
Tipulidae sp.										1				1							
<u>Limoniidae</u>																					
<i>Elaeophila</i> sp.														p							
<u>Pediciidae</u>																					
<i>Dicranota</i> sp.	1	1	1		1	1	1	1	1	1	1	1	1		1	1	1				1
<i>Pedicia</i> sp.	1				2		1			1	1	1				1	1				
<u>Psychodidae</u>																					
Psychodidae sp.		1																			
<u>Ptychopteridae</u>																					
<i>Ptychoptera</i> sp.															1	p					
<u>Dixidae</u>																					
<i>Dixa</i> sp.							1							p		p					
<u>Culicidae</u>																					
Culicidae sp.				2						1					1						
<u>Simuliidae</u>																					
<i>Simulium ornatum</i> grp.					1		1		3		1		1	1		p					
<i>Simulium</i> sp.		2				1		1	2	1		1	1		1						
<u>Chironomidae</u>																					
<i>Prodiamesa olivacea</i>			1		1		1		1							1					
Chironomidae spp.	3	1	2	1	2	2	3	2	2	1	2	1	1	3	2	2	4	2	3	2	
<u>Muscidae</u>											1										
<i>Lymnophora</i> sp.									1												
Muscidae indet.										2											
<b>VERTEBRATA</b>																					
<b>Pisces (Fish)</b>																					
<i>Anguilla anguilla</i> (Eel)											1					p					
<i>Gasterosteus aculeatus</i> (3-Spined stickleback)							1	1				1		1	p		1				1
<i>Cottus gobio</i> (Bullhead)								1					1		p						
Cyprinidae sp. (Carp)															p						
<i>Barbatula barbatula</i> (Stone loach)					1					1		1		p		1					
<i>Leuciscus leuciscus</i> (Dace)																p					
<i>Platichthys flesus</i> (Flounder)																				1	p
<i>Pomatoschistus microps</i> (Common goby)																				p	
<b>Aves (Birds)</b>																					
Grey Wagtail														p		p		1			
Grey Heron								1													
Kingfisher														p		p		1			
Moorhen										1				p	1	p		1			1
Mallard							1		1					p		p		1			1

## APPENDIX 2

Physical and chemical data from the 1994-96 surveys was usually obtained over two consecutive days; however data from 2022-23 was collected over two to three weeks. See Fig.1 and text for site details. n/d = not determined.

### Water Temperature °C

Site	Nov-94	Mar-95	Jun-95	Nov-95	Mar-96	Jun-96	Nov-22	Mar-23	Jun-23
1	11.0	6.8	DRY	11.3	4.3	13.5	12.4	4.5	14.9
2	9.8	6.8	DRY	11.3	4.0	13.5	12.2	4.4	15.5
3	10.3	6.9	13.6	11.3	n/d	14.0	12.4	6.0	14.8
4	10.6	8.6	13.7	11.7	n/d	14.0	12.8	7.9	13.3
5	10.4	7.7	13.2	11.5	n/d	14.0	12.8	7.8	14.0
6	10.7	8.1	14.7	10.6	n/d	13.5	13.0	7.6	12.8
7	10.2	8.4	15.4	11.8	5.8	15.0	n/d	n/d	n/d
8	10.3	8.6	15.1	11.8	5.9	15.0	10.8	10.4	14.7
9	10.4	8.6	15.0	11.9	6.3	15.0	10.9	10.5	13.8
10	n/d	8.6	14.8	12.1	6.2	15.3	10.9	10.6	15.3

### Water Conductivity µS

Site	Nov-94	Mar-95	Jun-95	Nov-95	Mar-96	Jun-96	Nov-22	Mar-23	Jun-23
1	525	460	DRY	620	530	650	590	521	641
2	520	460	DRY	610	530	570	742	500	638
3	450	450	435	540	520	460	542	401	421
4	500	500	490	550	510	440	436	409	496
5	485	480	530	530	480	460	440	396	471
6	540	465	450	620	490	430	462	373	423
7	500	480	510	540	510	470	451	473	539
8	490	490	480	540	510	470	n/d	n/d	n/d
9	520	480	540	560	530	490	460	486	633
10	495	490	490	560	560	490	569	487	603

### Oxygen % Saturation

Site	Nov-94	Mar-95	Jun-95	Nov-95	Mar-96	Jun-96	Nov-22	Mar-23	Jun-23
1	98	100	DRY	91	90.0	n/d	80	100	79
2	95	100	DRY	63	97	n/d	66	87	69
3	88	100	76	83	98	n/d	73	92	83
4	88	100	76	83	98	n/d	83	92	92
5	90	n/d	92	93	96	n/d	96	98	93
6	85	101	84	84	86	n/d	78	88	69
7	98	100	91	97	101	n/d	92	97	98
8	99	100	95	101	101	n/d	n/d	n/d	n/d
9	98	101	97	96	100	n/d	95	96	94
10	99	102	95	97	96	n/d	100	100	100

### Flow Rate ms<sup>-1</sup>

Site	Nov-94	Mar-95	Jun-95	Nov-95	Mar-96	Jun-96	Nov-22	Mar-23	Jun-23
1	0.33	0.42	DRY	0.1	0.14	0.02	0.1	0.20	<0.1
2	0.27	0.22	DRY	<0.1	0.08	0.17	0.02	0.02	<0.1
3	0.33	1.1	0.25	0.55	0.2	0.14	0.2	0.28	0.36
4	0.95	0.87	0.23	0.53	0.21	0.11	1.4	0.58	0.28
5	1.04	1.2	1.25	1.47	1.0	0.67	1.4	0.47	0.16
6	0.32	2.37	0.69	1.06	0.38	0.33	1.28	0.67	0.44
7	0.54	0.85	<0.1	0.57	<0.1	<0.1	0.63	0.21	0.1
8	0.5	3.4	0.65	0.54	0.5	0.36	n/d	n/d	n/d
9	0.8	1.39	0.5	0.73	0.8	0.36	0.52	0.16	0.1
10	0.44	0.83	0.1	0.35	0.25	0.17	1.27	0.48	0.27