Trialling the constructed wetlands monitoring method with citizen scientists

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ACKNOWLEDGEMENTS

We are grateful to the mayor of London for funding this trial and the partners and volunteers who worked with us on the project.

SUPPORTED BY

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1. PROJECT BACKGROUND

Constructed wetlands are increasingly being used as a Nature Based Solutions (NBS) for improving the management of surface water in towns and cities that, in addition to building flood resilience and removing pollutants, can benefit biodiversity and improve urban environments for wellbeing. However, there is often a trade-off between these benefits, for example the biodiversity of a constructed wetland will be compromised by excessive pollution loadings (Zhang *et al.,* 2020). In addition, it is essential that constructed wetlands, are maintained to sustain these benefits (Ellis *et al.,* 2003).

To understand how constructed wetlands are performing and inform their maintenance it is important they are monitored on an ongoing basis. Engaging local voluntary groups in this monitoring as citizen scientists can be a beneficial way of providing this information to site managers whilst also encouraging more environmental stewardship and understanding.

In the UK, using freshwater macroinvertebrates as indicators of waterbody health was first developed as The Biological Monitoring Working Party (BMWP) method in the 1970s (Hawkes, 1998). Standard assessment methodologies for measuring water quality and ecosystem health using invertebrates now exist for ponds, lakes, rivers and streams. The Riverfly Partnership's 'Riverfly Monitoring Initiative' (RMI) is a citizen science version of the BMWP that has been used regularly at ~1600 river sites by more than 2000 volunteers annually (Brooks *et al*., 2019). However, no citizen science methods exist to systematically monitor the invertebrates living within the complex, often polluted conditions of constructed urban wetland systems.

The Constructed Wetland Monitoring Method (CWMM) and creation of guidance material stems from **Phase 1: ZSL's investigation of the impacts of Headstone Manor Park wetlands** (ZSL, 2023). This investigation showed that the Headstone Manor Park wetland experienced a 'die off' event that was potentially caused by a combination of drought, the extreme high temperatures recorded in summer 2022, excessive incoming pollution loads and the immaturity of the wetland system. During the die off event, the water quality processing abilities of an aerobic wetland stopped as it became anoxic. Following this in-depth investigation, a project (**Phase 2**) was undertaken in 2024 to develop and pilot a citizen science methodology, adapted from the Riverfly Partnership's RMI method. This safely supported evidence gathering on the basic functioning and biodiversity value of a constructed wetland that can be used alongside other data sets to inform maintenance and design of future urban constructed wetlands.

The piloted method proved effective in engaging citizen scientists with the systematic monitoring of the wetland at Headstone Manor Park. Over eight months the invertebrate monitoring demonstrated the system was functioning and worked as a warning system for potential problems with the function of the wetland such as die off.

In this phase of the project (**Phase 3**), ZSL worked with partners Thames21, Citizen Crane, Friends of Chinbrook Meadows and Friends of Headstone Manor Park, and local volunteers, to trial the method further. If we are to maximise the benefits of NBS within London's green infrastructure for nature recovery and climate resilience, and evidence their potential and limitations, it is essential we support communities to work alongside NGOs, academics and other stakeholders to systematically gather and share data on them.

Aim of this report

To share the findings of trialling the CWMM on a variety of wetlands in London and support the spread of systematic community-based monitoring of NBS.

2. METHOD

In addition to Headstone Manor Park, two sites were selected for a wider roll out of the method tested through Phase 1 and Phase 2, Newton Park and Chinbrook Meadows (see Appendix 1 for more information on these wetlands). A description of the CWMM can be found in Appendix 2 and short film on the method on the ZSL website here London's Rivers | ZSL. Headstone Manor Park, Chinbrook Meadows and Newton Park wetlands were monitored by trained volunteers for 7 months from August 2024 to February 2025. As well as using the CWMM, Handheld Hanna Checkers (ammonia (NH_3-N) medium range and phosphate (PO_4) low range were used by volunteers to monitor water quality each month before their wetland invertebrate sample was collected. Volunteers followed the methods and safety precaution procedures provided by Hanna Instruments. Methods involved: 1) collecting water samples from the inlet and outlet at pre-defined locations, 2) preparation of the vials provided with the water samples and the reagents, 3) resetting the checker, 4) adding the reagents, and finally, 4) reading the phosphate/ammonia levels displayed on the screen. Water quality data was added to the data recording sheets. Volunteers kept reagents in a cool, dry place to prevent damage from temperature and humidity fluctuations and vials were rinsed after each test to ensure accurate future readings and limit contamination. Volunteers conducted all water quality sampling outdoors to ensure good ventilation while wearing gloves and adhering to the Hanna Instruments safety guidance. Full methods that were followed by volunteers are available here: HI715 Ammonia Medium Range and HI-713 Phosphate Low Range. Water quality, CWMM data and site photographs were shared over Padlet and using GoogleSheets. A ZSL project officer was on hand to answer questions and support volunteers through the project both in person and via the chat function on the Padlet pages.

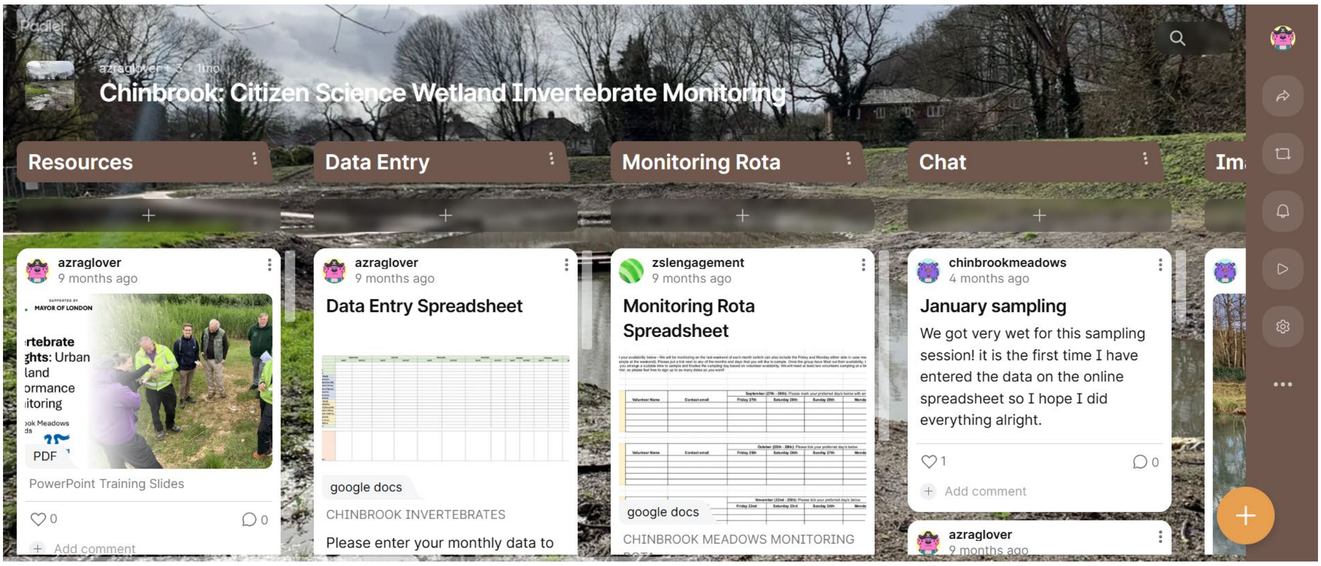

Figure 2.1: Screenshot of the Chinbrook Meadows Wetland Monitoring Padlet page used by volunteers to access resources such as training materials, data entry spreadsheets, the monitoring rota, chat/discussion threads and a space to upload monthly images.

TRAINING

Twenty-four volunteers attended two ZSL led training sessions in August 2024 - one at Newton Park wetlands, another at Chinbrook Meadows. Trainings were split into two parts, a half day, in classroom learning session which presented volunteers with the project theory, background, target taxa, monitoring techniques and health and safety followed by an afternoon of practice sampling and invertebrate identification at the wetlands. A refresher session with volunteers at Headstone Manor Park wetlands was carried out on the 6th of September 2024 with four volunteers. To provide a detailed understanding of the wetland sites and set monitoring into context a local Environment Agency officer presented local water quality trends and information on the key environmental pressures in the area at the Newton Park training and Thames21 staff did the same at Chinbrook Meadows.

Figure 2.2: (Left) Image taken of volunteers undertaking the in-classroom part of the training for monitoring Newton Park Wetlands, (Right) Demonstration of the methods at the Chinbrook Meadows wetlands training.

3. RESULTS

3.1 AVERAGE AND MONTHLY WETLAND INVERTEBRATE SCORES ACROSS SITES.

Table 3.1: Wetland invertebrate scores compared across Newton Park, Headstone Manor Park and Chinbrook Meadow wetlands for the 7-month monitoring period.

	Month	Aug	Sep	Oct	Nov	Dec	Jan	Feb	MEAN	RANGE
CHINBROOK MEADOWS	Inlet	7	5	6	7	7	7	4	6.1	3
	Outlet	10	5	2	4	9	6	6	6.0	8
NEWTON PARK	Inlet	4	5	4	5	3	5	4	4.3	2
	Outlet	10	7	6	6	4	5	7	6.4	6
HEADSTONE MANOR PARK	Inlet	n/a	3	3	2	2	n/a	4	2.8	2
	Outlet	n/a	3	5	3	3	n/a	5	3.8	2

Headstone Manor Park wetlands consistently recorded the lowest mean invertebrate scores and diversity in comparison to the other monitoring sites, both at the inlet and the outlet sampling points. Highest mean wetland invertebrate scores were recorded at the outlet of Newton Park wetlands which averaged a score of 6.4, closely followed by the inlet and outlet at Chinbrook Meadows (scoring 6.1 and 6.0). There was little variation between average monthly scores at both the inlet and outlet of Chinbrook Meadows. The highest difference in mean scores was seen at Newton Park with an average of 4.3 at the inlet and 6.4 at the outlet. The highest range in monthly wetland invertebrate scores was at the Chinbrook Meadows outlet, which varied between a high of 10 in August to a low of 2 in October.

3.2 COMPARISONS OF THE INLET AND OUTLET WETLAND INVERTEBRATE SCORES AT INDIVIDUAL SITES.

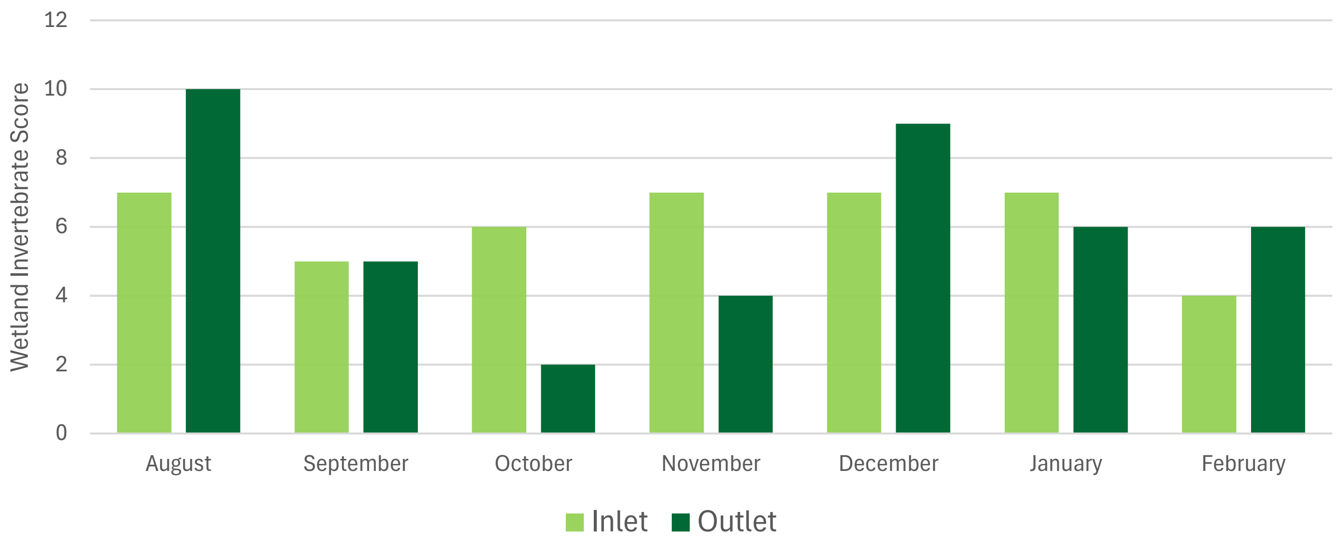

Figure 3.2.1: Chinbrook Meadows Wetland invertebrate scores at inlet and outlet sampling locations.

Chinbrook Meadows inlet scores exceed outlet scores in October, November and January while outlet scores were higher in August, December and February. The highest variation between inlet and outlet scores was achieved in October with a difference if 4 points. The highest inlet score (5) was recorded in August, November, December and January, while the highest outlet score (10) was recorded in August.

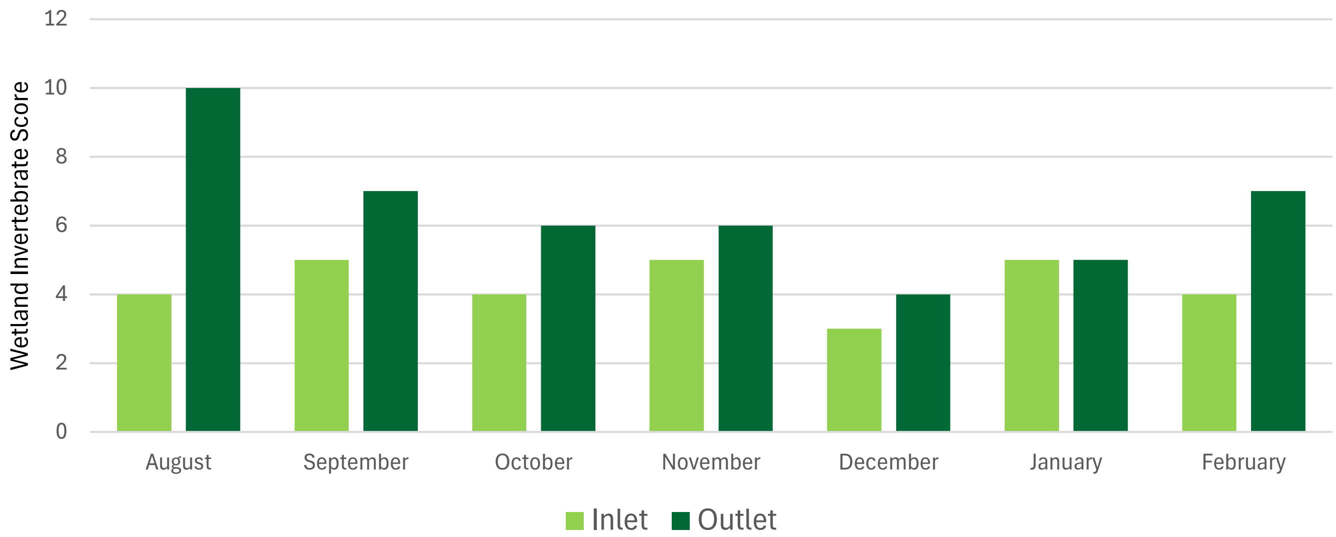

Figure 3.2.2: Newton Park Wetland invertebrate scores at inlet and outlet sampling locations.

Scores were consistently higher at the Newton Park wetland outlet, except during January when scores were equal at both the inlet and the outlet. The largest variation between inlet and outlet scores was seen in August with the inlet achieving a wetland invertebrate score of 4 while the outlet achieved a score of 10. Inlet and outlet scores were lowest in December. The highest inlet score (5) was recorded in September, November and January. The highest outlet score (10) was recoded in August.

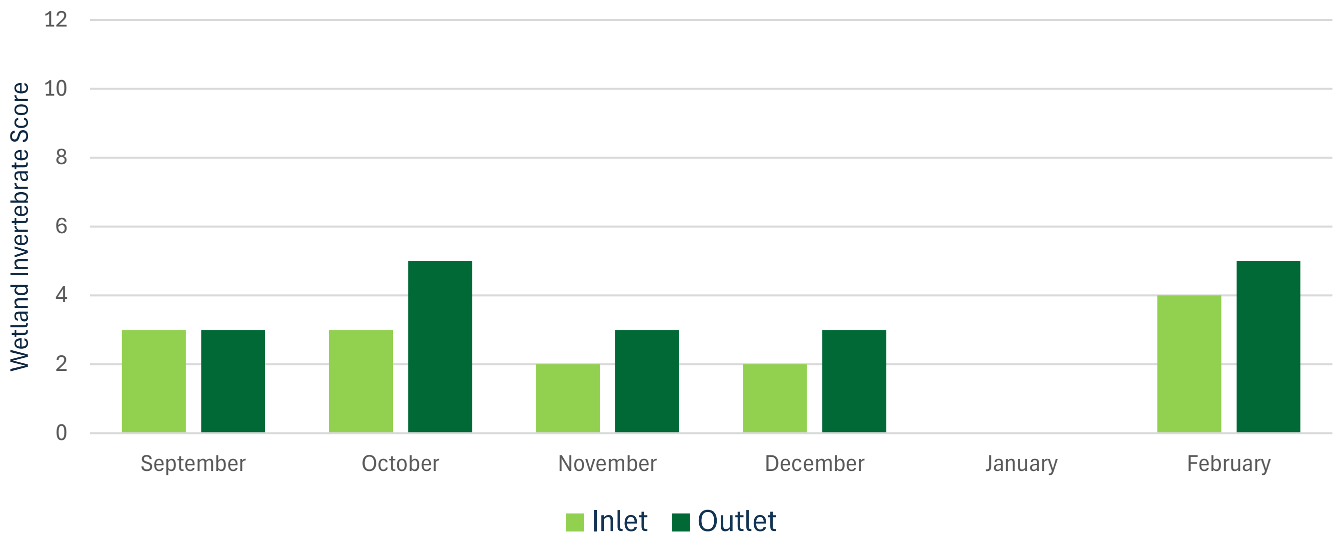

Figure 3.2.3: Headstone Manor Park Wetland invertebrate scores at inlet and outlet sampling locations.

Scores were consistently higher at the Headstone Manor Park wetland outlet, except in September when scores were equal. The highest variation between inlet and outlet scores was seen in October with the inlet achieving a wetland invertebrate score of 3 while the outlet achieved a score of 5. Inlet scores were lowest in November and December and lowest outlet scores were recorded in September, November and December. Highest scores for both the inlet (4) and outlet (5) were recorded in February. Due to frozen weather conditions, no samples were collected in January.

3.3 INDIVIDUAL TAXA BREAKDOWN

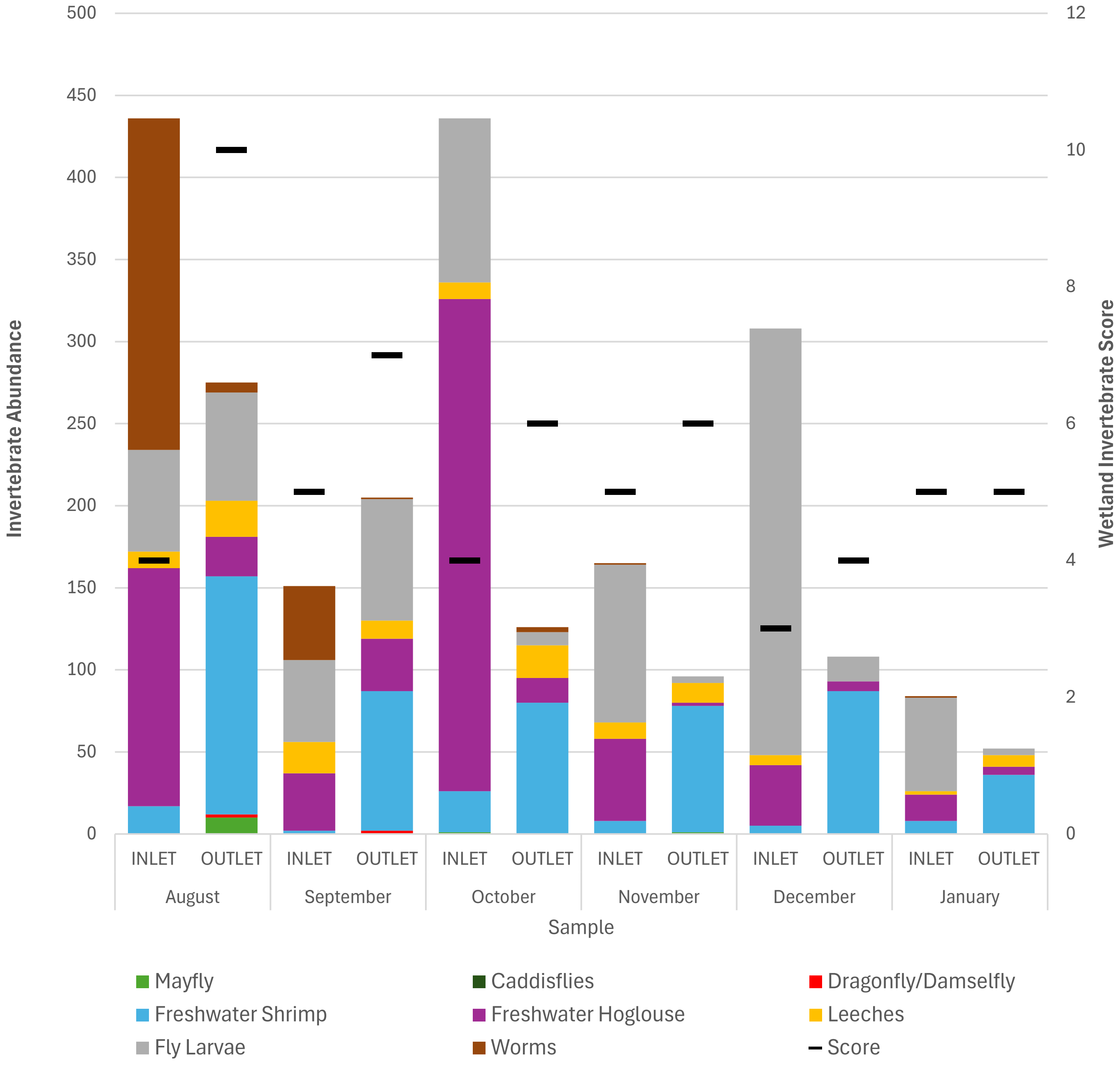

Figure 3.3.1: Newton Park invertebrate abundance vs Wetland invertebrate score.

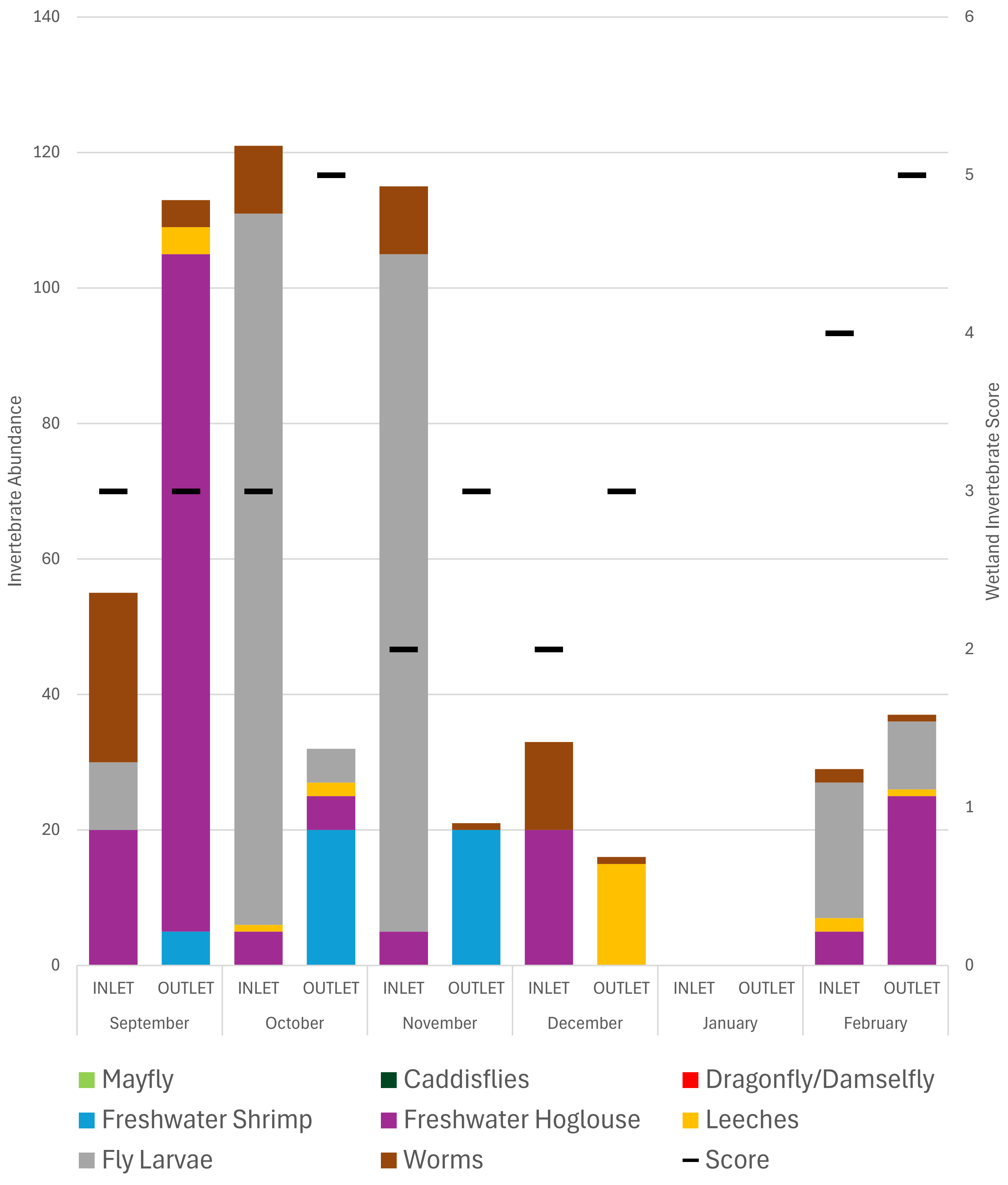

Figure 3.3.2: Headstone Manor Park invertebrate abundance vs Wetland invertebrate scores.

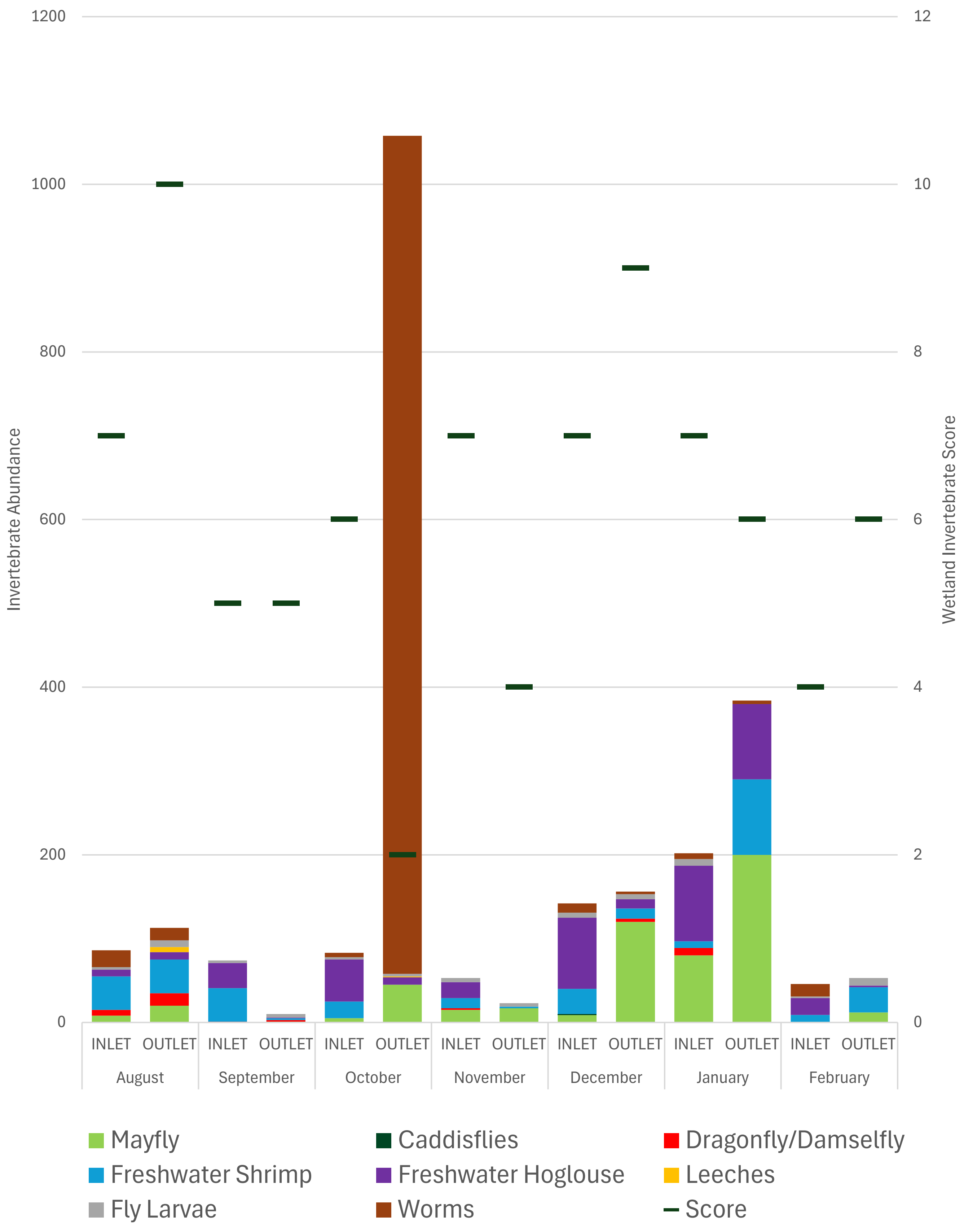

Figure 3.3.3: Chinbrook Meadows invertebrate abundance vs Wetland invertebrate scores.

Across the three wetlands, highest scoring samples contained the highest diversity of invertebrate groups while lowest wetland invertebrate score samples were predominantly dominated by fewer taxa that were more pollution tolerant e.g. freshwater hoglice, worms, leeches and fly larvae. Although these pollution tolerant groups/taxa were often still present in higher scoring samples, they were recorded in lower abundances and present in conjunction with other more pollution sensitive species, such as mayflies and dragonflies/damselflies.

3.4 WATER QUALITY DATA AT WETLAND MONITORING SITES

Data from the water quality sampling can be seen below.

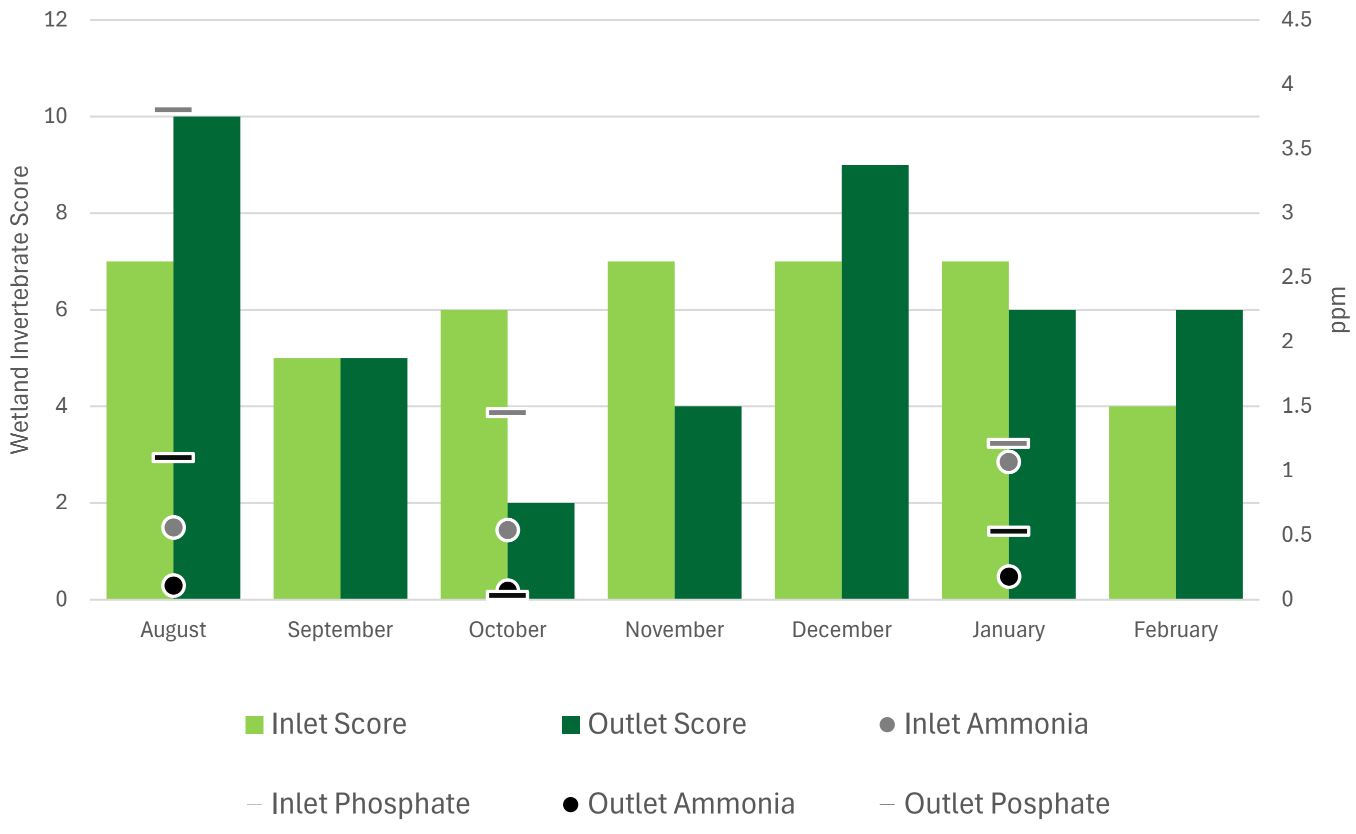

Figure 3.4.1: Chinbrook Meadows monthly wetland inlet and outlet ammonia (NH3-N) and phosphate (PO4) concentrations (ppm).

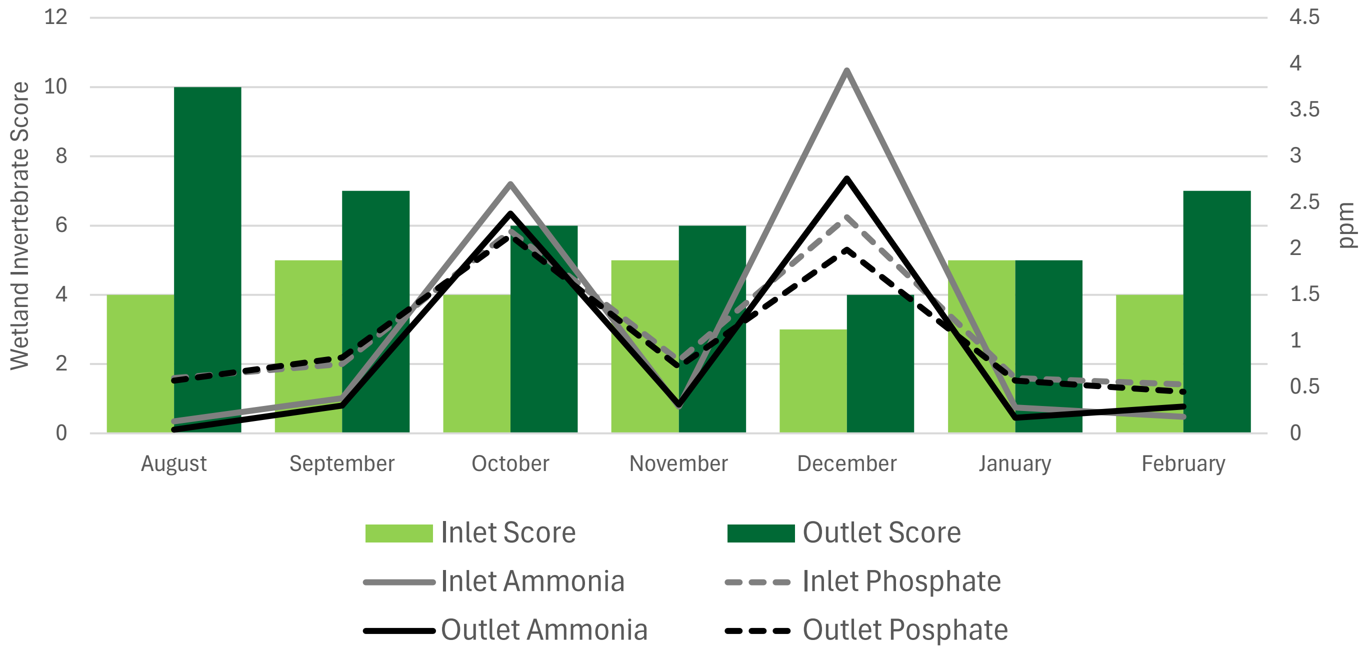

Figure 3.4.2: Newton Park monthly wetland inlet and outlet ammonia (NH3-N) and phosphate (PO4) concentrations (ppm).

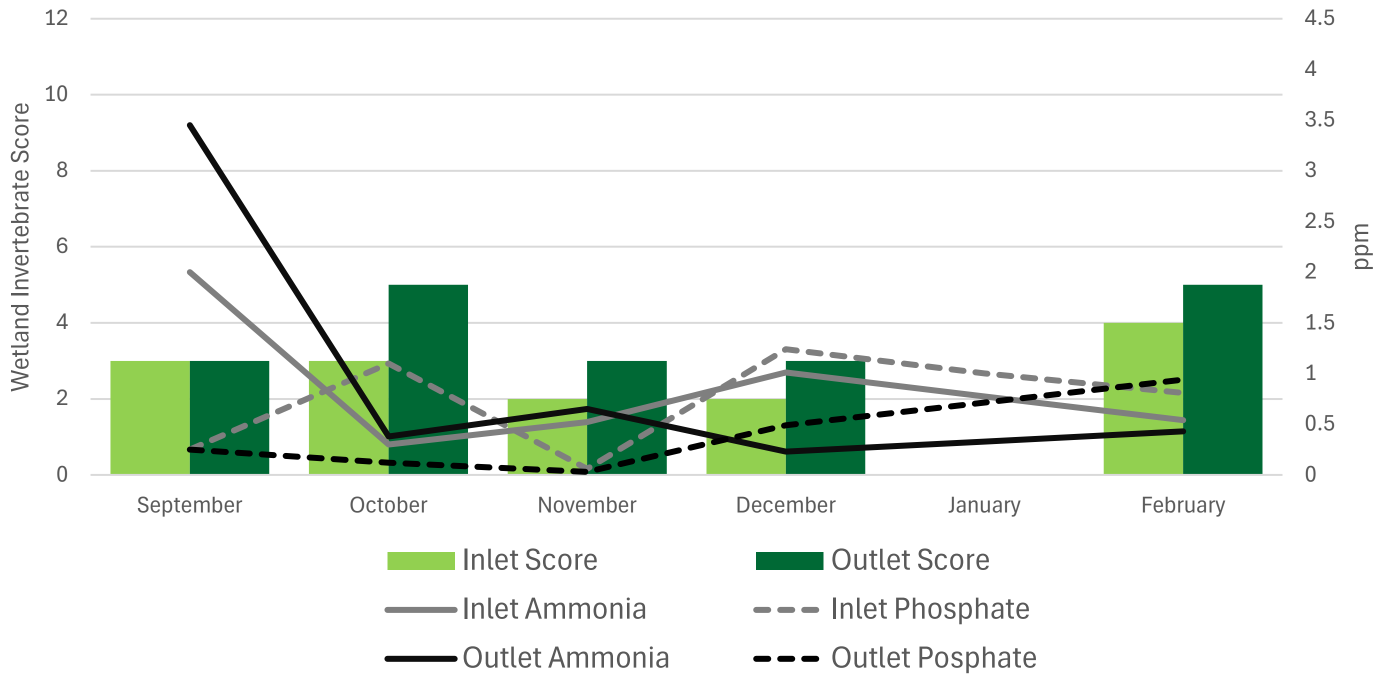

Figure 3.4.3: Headstone Manor Park monthly wetland inlet and outlet ammonia (NH3-N) and phosphate (PO4) concentrations (ppm).

In general, across the three wetlands, concentrations of both phosphate and ammonia were higher at the inlets than the outlets, except at Headstone Manor Park where between September and November concentrations of ammonia were higher at the outlet than the inlet, followed by higher inlet concentrations between November and February.

4. DISCUSSION:

4.1 HEALTH AND SAFETY

The safety of volunteers is the primary consideration for any community science project. A thorough risk assessment was undertaken by ZSL staff at each site before volunteers were asked to conduct sampling. No health and safety issues or near misses were recorded at any of the sites by the volunteers. Safety reminders were circulated before each sampling session to alert volunteers if potentially dangerous sampling conditions were likely to occur, e.g. heavy rainfall, high water levels, very cold temperatures. Volunteers were sent reminders to abort or reschedule their sampling if conditions were unsafe, and at Chinbrook Meadows for example, some of the Hanna checker sampling was not carried out to avoid extended time periods sampling in undesirable cold and rainy conditions and one sample was rescheduled to avoid high wind conditions.

4.2 EFFECTIVENESS OF THE WETLAND INVERTEBRATE MONITORING METHODS IN TRACKING THE PERFORMANCE OF CONSTRUCTED URBAN WETLAND SYSTEMS

A weighted scoring system was created in the CWMM so that normally functioning aerobic wetlands will show higher scores at the outlet than the inlet as water quality improves through the wetland. The consistently higher outlet scores compared to the inlet at Newton Park and Headstone Manor Park confirms that these wetlands were functioning aerobically with a greater proportion and abundance of pollution sensitive taxa living in the outlet cell compared to the inlet. Fluctuations of scores compared between the inlet an outlet at Chinbrook could be indicative of the age of the system. As the wetland construction and planting of Chinbrook wetlands was only completed in August when monitoring began, there is potential that the system was not yet mature enough to efficiently slow flows and trap polluted sediments. Similar results were seen at Headstone Manor Park, in the first two years post-construction. In contrast, the improvement in scores between the inlet and outlet cells at Newton Park and Headstone Manor Park are consistent with expectations of more mature, effectively functioning constructed wetland systems – with the more pollution sensitive taxa being found in the outlet cells.

Overall, the taxa/groups of invertebrates chosen during Phase 1 and 2 at Headstone worked well when rolled out to Newton Park and Chinbrook Meadows. Chinbrook Meadows was the only site that recorded the occurrence of a caddisfly which was found in the December sample. No mayfly were recorded at Headstone Manor Park, and this group was only recorded in August at the outlet of Newton Park. Mayfly were consistently recorded in relatively high abundances at Chinbrook Meadows except in September (inlet and outlet) and February (inlet). This indicated that the invertebrate groups chosen for scoring based on Phase 1 and Phase 2 were present at the other wetlands sites and were effective in tracking inlet vs outlet performance.

As part of this investigation some invertebrates were grouped quite broadly and in turn, some invertebrate preferences and tolerances were generalised (e.g. some mayfly species are more pollution tolerant than others). However, due to the nature of this monitoring being citizen scientist led - a balance between what we can record in a limited amount of time, following a one-day training and without the use of microscopes was needed. However, as seen from the data of this investigation, the broad groups combined with the weighted scoring still provide an interesting and effective insight into the function of the wetlands monitored.

4.3 POTENTIAL FOR USING INVERTEBRATE DIVERSITY AS AN INDICATOR INSTEAD OF THE WETLAND INVERTEBRATE SCORING METHODS

During the development of the CWMM ZSL staff spoke with Steve Brooks (chair of the Riverfly Partnership) about possible alternative approaches to monitoring the function of constructed wetlands. It was suggested that a measure of diversity alone might be used as an indicator of function i.e. that species richness might always be greater at the outlet.

Table 4.1: Comparison of invertebrate diversity at the inlet and outlet

	Month	Aug	Sep	Oct	Nov	Dec	Jan	Feb	MEAN	RANGE
CHINBROOK MEADOWS	Inlet	6	4	5	5	6	6	4	5.1	2
	Outlet	7	5	5	3	6	4	4	4.9	4
NEWTON PARK	Inlet	5	5	5	5	4	5	4	4.7	1
	Outlet	7	6	5	5	3	4	5	5.0	4
HEADSTONE MANOR	Inlet	n/a	3	4	3	2	n/a	4	3.2	2
	Outlet	n/a	4	4	2	2	n/a	4	3.2	2

Table 4.1 shows that although in some instances diversity and wetland invertebrate score were correlated, recording the number of taxa alone as an indicator does not accurately reflect the fluctuations in wetland invertebrate communities that have been seen with the diversity score not accurately representing the pollution tolerance of invertebrate community composition. For example, at Headstone Manor Park Wetlands – in October the inlet received a score of 3 and the outlet received a 5. The diversity at the inlet and outlet scored a 4. The inlet sample recorded very high abundances of both fly larvae and freshwater hoglice (pollution tolerant species), whereas, although present in the outlet sample, these taxa were found in much lower abundances and the outlet sample was dominated instead by freshwater shrimp.

A similar example can be seen in the Chinbrook October sample where the inlet received a score of 6 and the outlet received its lowest score of 2. The diversity scores for the inlet and outlet in October at Chinbrook were both 5. Although the same number of taxa/taxa groups were found in each sample, the composition of the two samples was very different with the outlet dominated by over 1000 worms.

By using the CWMM we can obtain a more detailed understanding of the changes in community composition and fluctuations in pollution tolerant and pollution sensitive species presence/absence over time. Although recording species diversity alone would somewhat reduce volunteer effort and sampling time, the negative weighting aspect of the wetland invertebrate scoring helps to account for waves of pollution tolerant species abundance that were often recorded at sites. Such patterns in the data are likely indicative of high concentration of pollutants or other changes in factors such as flows entering the wetlands and impacting the invertebrate communities living in the different wetland cells.

4.4 ADDITIONAL MONITORING

The CWMM method provides a broad indication of the function of the constructed wetland being monitored. It is recommended as the basis of a wider monitoring strategy for a wetland that includes both event-based monitoring, using sondes, to evidence concentrations of pollutants passing through at peak flow, and ongoing spot sampling of water chemistry during normal flow conditions. Only two water quality parameters (ammonia and phosphate) were measured as part of this trial using Hanna checkers, equipment that is commonly used for citizen science monitoring. Long-term water chemistry data is needed to better understand the relationship between water chemistry and wetland invertebrate scores. In addition to ammonia and phosphate, chemicals associated with sewage pollution, we suggest dissolved oxygen or Biological Oxygen Demand as another helpful indicators of ecosystem function. In addition, metals such as copper and zinc and hydrocarbons in the sediment, particularly of the inlet cell, could indicate the impact of upstream run off. Gathering evidence on chemical concentrations in conjunction with flow will allow the calculation of pollutant loads.

In addition to water chemistry, the biodiversity value of constructed wetlands will be better evidenced by the CWMM being delivered alongside other ways of monitoring species richness such as Bioblitzs and, for example, British Trust for Ornithology bird surveys.

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APPENDICES

APPENDIX 1. WETLAND SITES BACKGROUND

A1.1 Headstone Manor Park Wetlands

Headstone Manor Park wetlands are in the London Borough of Harrow in Northwest London. The site is of critical importance to the Crane Catchment as the historic moat that surrounds the Headstone Manor feeds water into the nascent Yeading Brook West. Construction of the ~9,000 m^2 wetlands started in July 2018 and was completed in December 2021. The wetland comprises of three main cells. A sediment pond, split into two cells (Cells 1 and 2); and a reedbed pond (Cell 3).

Prior to the construction of the wetlands, the Headstone Manor moat was fed directly from a surface water sewer that drained a heavily urbanised catchment. The inflow is prone to poor water quality due to upstream sewage and polluted sediment inputs including hydrocarbons and heavy metals. The aim of the wetlands creation scheme was scheme was to construct a sedimentation pond and reed bed upstream to the northeast of the Manor, to improve the water quality within the medieval moat by intercepting and reducing sediment and pollutants from the upstream culverted catchment.

Figure A1.1: (Left) Arial image of Headstone Manor Park wetlands, (right) design drawing of the wetlands. Credit: London Borough of Harrow.

A1.2 Chinbrook Meadow Wetlands

Chinbrook Meadows, a park in Southeast London near Grove Park station, is bisected by the River Quaggy and the Southeastern railway line. Once a dairy farm, it became a public park in the early 1900s. In 2002, a community-led effort restored the Quaggy by removing 300 meters of concrete channel, improving biodiversity. However, persistent water pollution from Grove Park Ditch, including foul smells and discoloration, led to the Thames21 led wetland project.

This four cell wetland construction project aimed to; improve water quality by filtering polluted water through wetland flora, enhance biodiversity by replacing low-value grassland with a wetland, manage flooding by slowing river flow during heavy rainfall and engage the community through volunteering and educational initiatives. In autumn 2023, excavation of the wetlands took place. Throughout the winter and spring of 2023/24, a series of volunteer events helped prepare the site for reopening. Volunteers cleared litter, installed hedgerows and dead hedges, and planted over 2,600 plug plants around the ponds. Additionally, a footpath and turf were laid to improve accessibility, and a wildflower meadow was created on the earth mound. The park reopened to the public in August 2024, with a long-term maintenance and monitoring plan set in place for 2025 and beyond. Chinbrook wetlands are the youngest of the three wetlands monitored as part of this investigation having only been completed a week before the monitoring training took place.

Figure A1.2: (Left) Arial image of Chinbrook Meadow wetlands, (right) design drawing of the wetlands. Credit: Thames21.

A1.3 Newton Park Wetlands

The Newton Park Wetlands, the oldest wetland system being monitored as part of this investigation were constructed as part of the Newton Park Flood Alleviation and River Restoration Project in 2018, a project initiated to address recurrent flooding issues that affected residential properties surrounding Newton Park West, which evolved to include environmental improvements including benefits to water quality, biodiversity and habitat creation and improved amenity value. Prior to this project, the park had poor access, was run down and not used by residents. Heavy rainfall often led to the park's flooding, causing damage to nearby homes and infrastructure. In collaboration with Harrow Council and the Environment Agency, Metis Consultants conducted a comprehensive analysis to identify the causes of flooding and proposed effective mitigation strategies. This collaboration resulted in the development of Sustainable Drainage Systems (SuDS), including the construction of a four-cell wetland designed to cope with large amounts of rainfall and provide water quality improvements to the Yeading Brook East (formerly Roxbourne Brook).

Figure A1.1: (Left) Arial image of Newton Park wetlands, credit: London Borough of Harrow, (right) design drawing of the wetlands, credit: ZSL.

APPENDIX 2. MONITORING EQUIPMENT LIST

- ☐ Risk assessment and dynamic risk assessment
- ☐ Safety equipment including:
  - First aid kit
  - Buoyancy aid
  - Anti-bacterial hand sanitiser
  - Nitrile gloves
  - Telephone
- ☐ Wellington boots or waders
- ☐ Standard sampling net (1.5m handle, 25cm wide frame)
- ☐ Invertebrate sorting equipment including:
  - Large pipette/turkey baster
  - Small pipette
  - Plastic spoons
  - Hand lens
  - Large plastic bucket (x2)
  - Large white plastic tray (x2)
  - Sectioned tray (x2)
- ☐ Data recording sheets
- ☐ Clipboard or weather writer
- ☐ Identification guide
- ☐ Hanna Checkers (ammonia and phosphate)

APPENDIX 3. MONITORING METHOD

A3.1 Sample Collection

The **bank-side** sample collection is a **one-minute hand netting** of **vegetation and bed material** around the **wetland perimeter** at a suitable location as near to the wetland **inlet and outlet** as safely possible.

1. Once a safe location has been established at the wetland inlet and outlet perimeter, this will remain fixed for each month. Changes in flow, vegetation and habitat may change seasonally/over time which may impact access. If this is the case, sample as near to the fixed location as safe as possible.
2. If you are carrying out fixed point photography and water quality sampling (Hanna checkers or strip test sampling) as part of your monitoring, this should be carried out before you start sampling invertebrates.
3. To collect your invertebrate sample, gently disturb the bed substrate such as gravels or organic debris (leaves and twigs) with the base of the net using a scooping and sweeping motion. Split sampling time between any patches of different vegetation or bed substrates (e.g. submerged, floating, emergent vegetation) according to the proportion of different habitats/vegetation present.
4. During sampling, if the net collects lots of sediment or plant material, the sample can be decanted into the sampling bucket between the sampling of different habitats. The timer can be paused while doing this.

A3.2 Sample Processing

1. Before you start processing your sample, you can remove any unwanted debris or sediment. Sediment can be rinsed by holding the net over one of the large buckets and passing clean water through the sample while gently disturbing the contents to dislodge any silt, mud or sediment. This step can be repeated multiple times until the sample is clear enough to start processing. Large sticks or vegetation can also be carefully removed by rinsing into the bucket before discarding - being mindful not to lose any of the required invertebrates that may be attached.
2. Once the sample has been cleaned in the bucket it can be placed into the large white tray half-filled with clean water for processing. Depending on how much material has been collected in the net, the sample can be split into sub-samples for ease of processing. If processing as subsamples, please ensure there is enough water in the bucket for the other invertebrates while you are processing what is in the tray.
3. Using the large and small pipettes or spoons you can start sorting invertebrates into the segmented tray (along with some water in each segment) to assist with counting. Not all invertebrates need to be

transferred into the segmented tray, for example, if there is a high abundance of freshwater shrimp, it can be easier to estimate counts directly from the tray.

4. Once sorted, estimate total counts which can then be grouped into abundance categories: **1-9**, **10-99**, **100-999** and **>1000**. See table below.
5. Record site data (date, time, surveyor name, location, conditions) estimated counts, abundance categories and totals to the recording form.
6. You can note down any additional invertebrates or species of interest. For example, if you see an abundance of snails or fish, this can be added to the 'additional notes' section of the form.
7. Once all data has been recorded, carefully tip the contents of the trays back into the bucket and then carefully return into the wetland sample site.

Please note: The presence of target invertebrates may vary between wetlands, inlet and outlet, and seasonally throughout the year so, it is likely that not all target taxa will be present in every sample.

A3.3 Data Recording and Uploading

Volunteers should enter data to a shared online spreadsheet (e.g. Google Sheets, EpiCollect or preferred alternative) and upload any corresponding water quality data and site photographs. A project Padlet page can be a useful space to store this data in one place as it does not require volunteers to register with an email address and notifications can be tailored. Volunteers should be encouraged to take a photograph and safely store their paper data sheets as a backup.

APPENDIX 4. PILOT WETLAND INVERTEBRATE IDENTIFICATION GUIDE (WITH THANKS TO THE RIVERFLY PARTNERSHIP)

Identification Guide (adapted from Anglers' Riverfly Monitoring Initiative (ARMI) guide)

Mayfly (*Ephemeroptera)*

- 3 tails and 3 pairs of legs
- Feathery or small leaf like gills may be present along body, these can be held out to the side or above the body
- Antenna often visible

***Avoid confusing with:**
- damselfly larvae: both have 3 tails/gills projecting from end of body but damselfly much more robust

Caddisflies (*Trichoptera*)

Cased

- No visible antenna
- Body enclosed within a case
- Case material can vary from small stones, sand grains, plant material, twigs and shell
- 3 pairs of legs but may not always be visible. Legs may be held at the front of the case and can often be visible when moving

Caseless

- No visible antenna
- 3 pairs of legs visible, 2 posterior hooks and anal proleg with terminal brush of long seta
- Tufted gills on abdominal segment (don't confuse with legs)

***Avoid confusing with:**
Chironomid midge larvae - often found inside a case, have no legs but walk using a soft peg near their head; Beetle larvae which have no hooks on the posterior appendages

Dragonflies and Damselflies *(Odonata*)

Dragonfly *(Anisoptera)*

- 3 sets of legs
- Gills are located inside the rectum (unlike those of damselflies, which extend from the hind end like 3 leaflike tails)
- Stout body, no tails but 5 short spines at the end of the body
- Large eyes

Damselfly *(Zygoptera)*

- Three fin-like gills projecting from end of abdomen
- Body slender/elongated
- 3 sets of legs
- Large eyes
- Range in colour from green to brown
- Slow crawling/climbing movement

Freshwater Shrimp (*Gammarus*)

- Body always curved and flattened side to side
- Swims on side
- More than 3 pairs of legs plus other appendages on the underside of body

Freshwater Hoglouse (*Aseliidae*)

- Looks like a woodlouse
- Slow crawling movement
- Body dorsally flattened

Leeches (*Hirudinea*)

- No legs
- Dorsally flattened
- Sucker present at each end of the body (uses these to move in looping motion)
- Often stuck to rocks – check tray and bucket as you empty
- Variety of shapes and colours

Worms (*Oligochaeta*)

- Wiggle movement
- No legs with a long, thin, cylindrical body (15+) segments

***Avoid confusing with:**

- **terrestrial worms**: aquatic worms are a lot thinner and smaller. The head is indistinct and unlike terrestrial worms they lack a clitellum (raised band).
- **non-biting midge larvae**

Fly Larvae (Diptera)

Mosquito Larvae (*Culicidae*)

- Fast wriggling movement
- Tend to remain at the surface of the water
- Tube/siphon on end of body as well as anal segment with gills sometimes visible
- Large/bulbous head and thorax

Non-Biting Midge Larvae *(Chironomidae)*

Midge

Larvae
(*Chiro*

- Worm-like segmented shape
- Distinctly separate head which is often darker than the rest of the body
- Colouring can be tan, light green or clear, but some are red

Dronefly Larvae *(Syrphidae)*

- Long thin breathing tube (tail-like)
- Greyish, green, or pale brown in colour
- Slow moving

APPENDIX 5. DATA RECORDING FORM

Date:	
Time:	
Surveyor name/s:	
Location:	
Conditions:	
Additional Notes:	
Inlet:	**Outlet:**

Taxa	Abundance			
	1-9	10-99	100-999	1000+
Mayfly (Ephemeroptera)	1	2	3	4
Caddisflies (Trichoptera)	1	2	3	4
Dragonflies and Damselflies (Odonata) - Dragonfly (Aeshnidae) - Damselfly (Coenagrionidae)	1	2	3	4
Freshwater Shrimp (Gammarus)	1	2	3	2
Freshwater Hoglouse (Aseliidae)	1	1	0	-2
Leeches (Hirudinea)	1	1	0	-2
Fly Larvae (Diptera) - Non-Biting Midge Larvae (Chironomidae) - Mosquito larvae (Culicidae) - Drone fly larvae (Syrphidae)	1	1	0	-3
Worms (Oligochaeta)	1	1	0	-3

Taxa	**INLET**		**OUTLET**	
	Estimated Count	**Score**	**Estimated Count**	**Score**
Mayfly (*Ephemeroptera*)				
Caddisflies (*Trichoptera*)				
Dragonfly & Damselfly *(Odonata)*				
Freshwater Shrimp *(Gammarus)*				
Freshwater Hoglouse *(Aseliidae)*				
Leeches *(Hirudinea)*				
Fly Larvae (*Diptera*) • Midge Larvae *(Chironomidae)* • Mosquito Larvae *(Culicidae)* • Drone Fly Larvae *(Syrphidae)*				
Worms *(Oligochaeta)*				
	Total INLET score =		**Total OUTLET score =**	

APPENDIX 6. WETLAND INVERTEBRATE SCORING TABLE

Taxa	BMWP Score	Abundance			
		1-9	10-99	100-999	1000+
Mayflies (*Ephemeroptera*)	10 (4)	1	2	3	4
Caddisflies (*Trichoptera*)	5-10	1	2	3	4
Dragonflies and Damselflies *(Odonata)* - Dragonfly (*Aeshnidae*) - Damselfly (*Coenagrionidae*)	6-8	1	2	3	4
Freshwater Shrimp *(Gammarus)*	6	1	2	3	2
Freshwater Hoglouse *(Aseliidae)*	3	1	1	0	-2
Leeches *(Hirudinea)*	3	1	1	0	-2
Fly Larvae (*Diptera*) - Non-Biting Midge Larvae *(Chironomidae)* - Mosquito larvae *(Culicidae)* - Drone fly larvae *(Syrphidae)*	-	1	1	0	-3
Worms *(Oligochaeta)*	1	1	1	0	-3

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