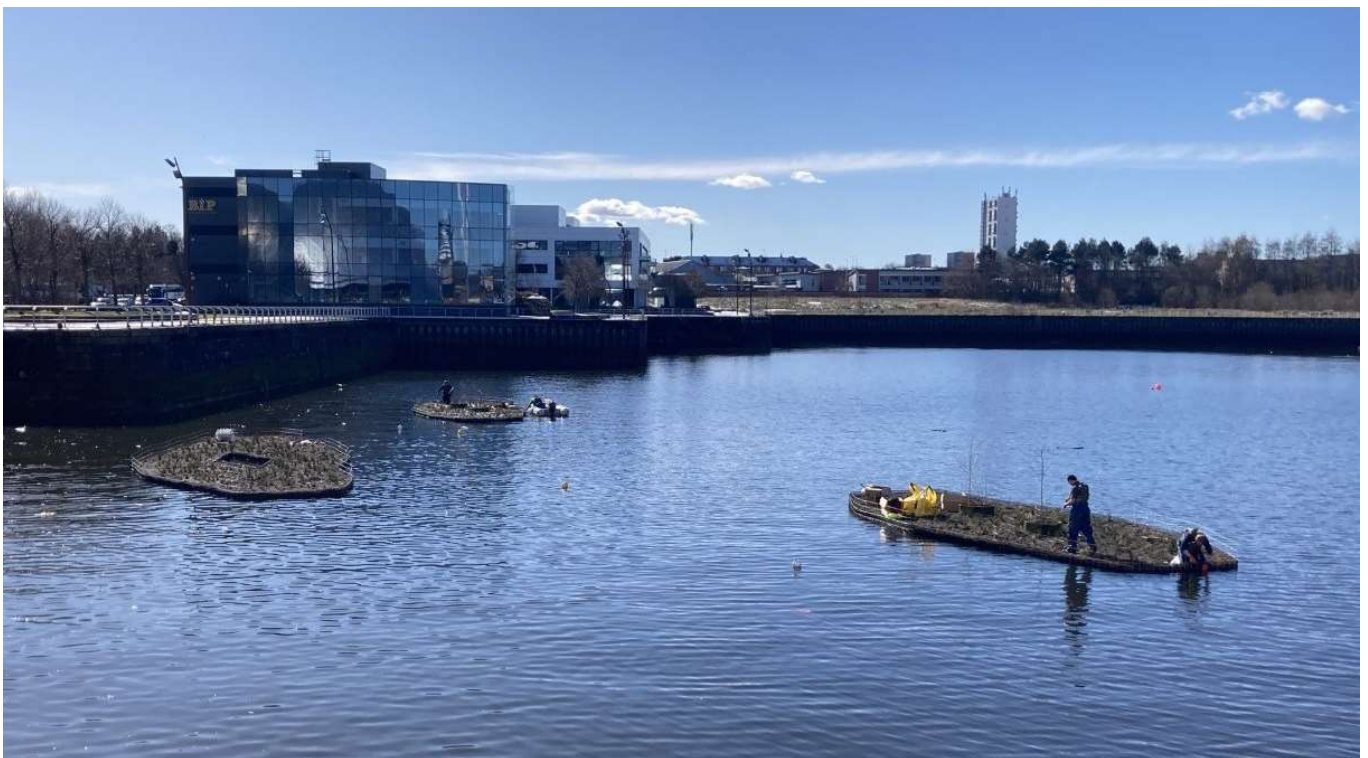




University
of Glasgow

Glasgow's Floating Estuarine Wetlands Long-Term Ecosystem Services and Function Monitoring and Evaluation Plan

March 2023



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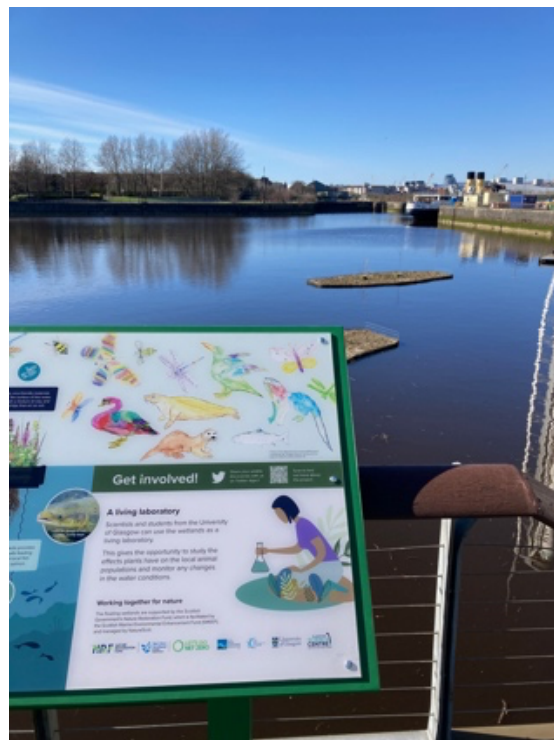
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Pictured: Base of wetlands structure pre-install into the Clyde.



Pictured: Installed Wetlands and infographic board provided by Glasgow Science Centre.

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Appendix A. Long-term Monitoring Methods: Supporting Services

Appendix B. Regulatory Services Long-term Monitoring Plan: Water Quality and sediment

Appendix C: Social and Cultural Ecosystem Services Method Statements

1. Introduction

1.1 Report Purpose

This is a comprehensive long-term monitoring plan that follows an Ecosystem Service Framework to identify and monitor the on-going impacts of the floating wetlands installation in the Canting Basin of the River Clyde, Glasgow. This plan follows the results of a recently undertaken study/report (Woolfenden et al. 2023) that an interdisciplinary team of researchers from the University of Glasgow designed and carried out with support from Glasgow Science Centre and Biomatrix. The site for Glasgow Floating Wetlands was historically used for access to graving docks, general cargo trade and was a Canting Basin (to allow large ships to turn).

This report thus outlines the recommended ecosystem services to monitor alongside the most appropriate methodologies to employ to ensure the generation of high quality and robust results (Figure 1).

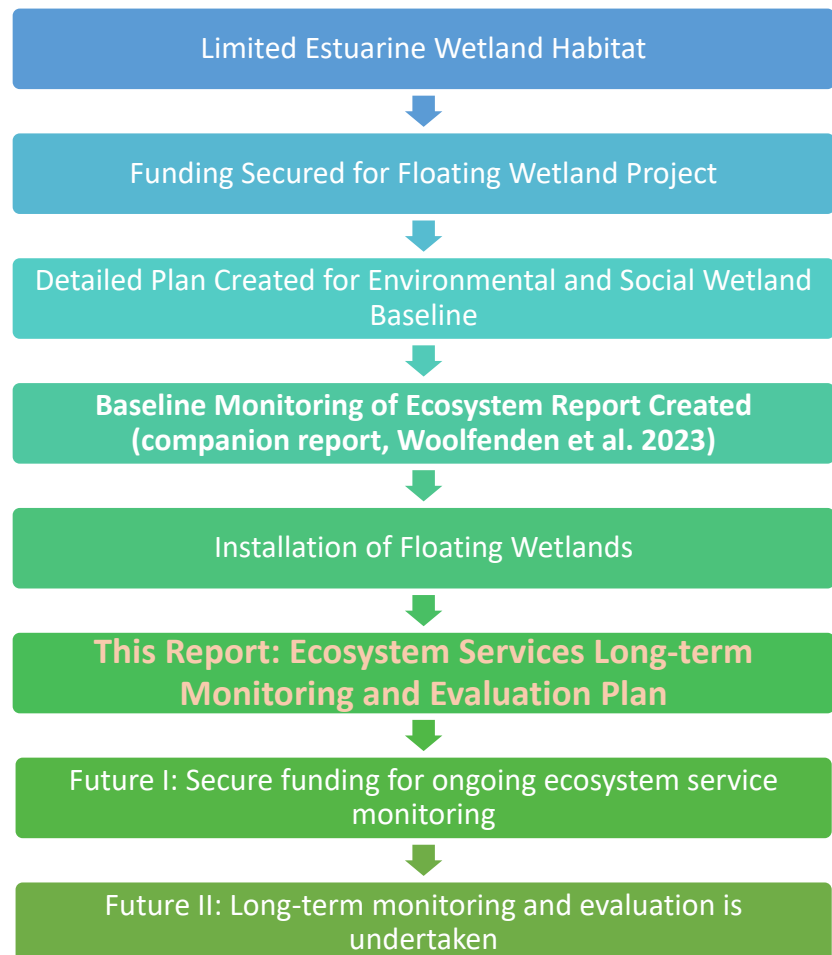


Figure 1. Flow diagram of how this report fits into the long-term monitoring and evaluation plan.

1.2 Why add nature in cities?

Urban ecosystems are much lesser studied than natural ecological systems, where estuarine and coastal components of urban ecosystems are lesser studied still. For example, until the second edition of the large reference book – the Routledge Handbook on Urban Ecosystems was published in 2020, there was no chapter on urban estuaries and coasts (Naylor et al. 2020). “Cities can be hostile environments for native vegetation because urban environments are typically highly modified. Climate change amplifies many of these effects and adds to planning complexity” (Oke et al., 2021). As human populations rapidly urbanise and urban ecosystems continue to degrade, there is an urgent need to green the greyest parts of our urban infrastructure (Naylor et al. 2017) for biodiversity and climate change adaptation, and to mitigate the “extinction of experience” with nature faced by ever-increasing numbers of people living in urban areas (Gaston et al, 2018). Nature-based

solutions are, for example, flood resilience measures that incorporate natural ecosystem characteristics in their design, such as restored or recreated urban saltmarshes. Effective urban nature-based solutions (NbS) shift the emphasis from seeing them as providing ‘nature for people’ to one that has a goal of reconnecting people and nature at its core (Welden et al. 2021). Creating spaces within the fabric of our cities and towns in which multiple species can survive and thrive, particularly blue spaces, is thus increasingly important for a range of ecological, social and climate change resilience reasons. This is the first project of its kind being implemented in Glasgow and will potentially be the starting point for many other projects devoted to ‘greening the grey’ in the city. This is timely as the recent ClimateXChange report on Tidal Flooding in the Clyde (Trehwella et al. 2022) recommended use of ‘green grey’ measures and the forthcoming statutory Clyde Marine

Plan will require consideration of these measures where other more natural, nature-based measures such as saltmarsh recreation are not technically, socially or economically feasible as climate change resilience and/or ecosystem service enhancements in urban areas.

Ecosystem Services

Marine environments provide many ecosystem benefits across all subsets including social, cultural, regulatory, provisioning and supportive services. Figure 2 provides representation of

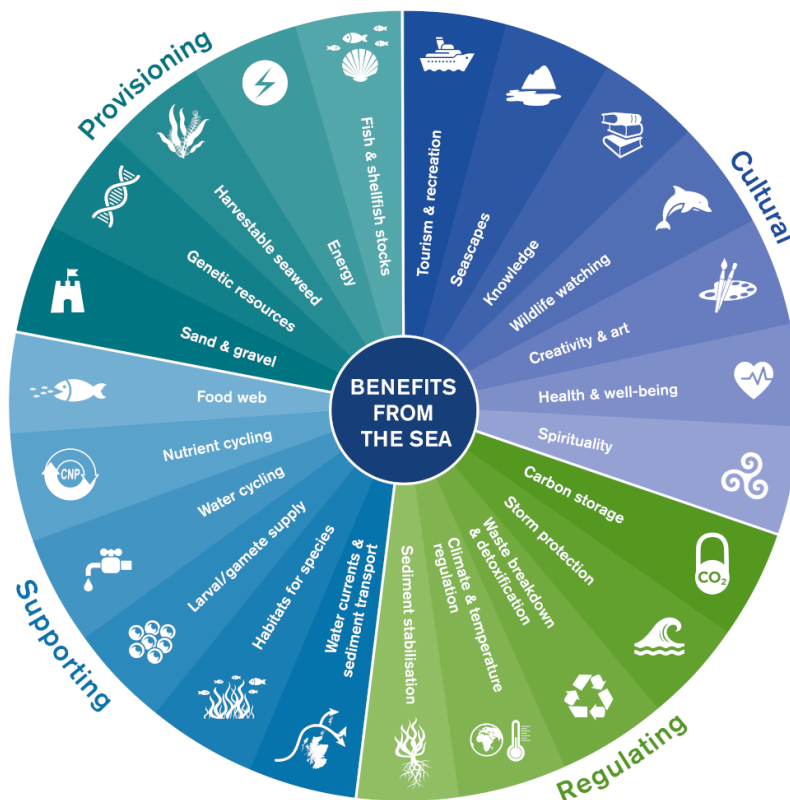


Figure 2. Marine Ecosystem Services, Source: Nature Scotland.

the many services that are provided by introducing marine environments into an urban setting. For example, a micro-wilderness of submerged roots creates an ideal habitat for millions of microorganisms, which use algae, carbon and excess nutrients in the water as a food source, purifying the water.

1.3 How can we add nature to cities?

Interest in Green Infrastructure (GI) and greening the greyest parts of our cities like urban quay walls and bridges has seen a marked increase over the last decade (Naylor et al., 2017). Across Europe,

elements of GI are referenced under the broader use of ‘nature-based solutions’, where emphasis is placed on working with natural processes to tackle issues of flooding, climate change and poverty across a range of spatial scales (European Commission, 2015).

The recent drive towards the implementation of GI extends from the recognition that greater incorporation of natural elements into urban spaces (and beyond) offers a range of ecosystem services (ES) for people and the environment. These services are often categorised into the four overarching themes of provisioning, regulating, supporting and cultural (terminology may vary but categorisations remain broadly analogous; see Dickie et al., 2019). In urban spaces, ecosystem services provided by GI include the reduction of flood risk, improved air and water quality, reduced impacts of extreme weather events, and improved resilience of ecological systems to environmental alterations.

Despite the perceived benefits of incorporating greener, nature-based infrastructure into urban spaces, the application of these approaches is often limited due to perceptions of not being socially, technically or economically feasible (Naylor et al. 2018). In these cases, alternative approaches can be adopted, whereby traditional hard engineering (grey infrastructure) approaches can incorporate aspects of green infrastructure, in what is termed ‘greening the grey’ (Naylor et al. 2017). Here, improvements to the multifunctionality and ecological value of existing grey infrastructure can be observed, providing opportunities to complement corresponding targets and policies in Biodiversity Action Plans, GI plans, Living Landscape plans, and Strategic Nature Areas, among others.

Despite some uncertainty over the economic costs, in addition to concerns regarding the impact on engineering performance, inspection and maintenance associated with the greening of grey assets, a report by Naylor et al. (2017) demonstrated that greening can be achieved relatively cheaply with negligible impacts to asset function, whilst providing a range of multifunctional benefits to ecology and society.

The floating wetlands covered in this report comprise one such blue-green infrastructure measure for ‘greening the grey’ to enhance coastal and estuarine blue spaces in our cities and towns (Naylor et al. 2023). Floating wetlands are one of a number of possible interventions that can be used to green the greyest parts of our cities and towns (see Naylor et al. 2017 for more examples).

1.4 What are floating wetlands? And what benefits and disbenefits do they provide?

An innovative nature-based solution, floating wetlands are designed to harness ‘nature’s ability to regulate, restore and regenerate resources’, (Andrews et al., 2022; Oke et al., 2021). They are designed to be ‘biodiverse wetland ecosystems’ that can be constructed in urban blue spaces, such as rivers and canals (Biomatrix Water, 2023). They can ‘have multiple benefits including habitat creation, urban water scaping, water quality management, and wastewater treatment’ (Biomatrix Water, 2023).

City water pollution is mainly caused by nutrients, heavy metals, and organic pollutants, among which nitrogen and phosphorus are the main factors leading to eutrophication of water bodies. With the development of ecological civilization and the need for environmental improvement, there is an urgent need for water environment restoration technologies that can effectively remove multiple pollutants simultaneously. Floating wetland, as a water environment ecological enhancement measure, can have environmentally beneficial, efficient, and powerful ecological service functions. The removal and transformation of pollutants in floating wetlands integrate physical, chemical, and biological processes, including plant absorption, substrate adsorption, and biodegradation involving microbial participation. Physical effects include the adsorption of pollutants on the substrate and

vegetation. Biological effects include (1) the absorption of pollutants in the water by plant tissues such as roots, stems, and leaves in the wetland, and (2) the accumulation and removal of some pollutants in the water by the rich microorganisms in the floating wetland. Chemical effects involve the conversion of nutrients, heavy metals, and organic pollutants in the water into a part of the organism through the adsorption and absorption processes by microorganisms or plants.

Evidence of the regulatory, restorative, and regenerative impacts floating wetlands have on both terrestrial and marine ecosystems are widely researched as well as the social and cultural benefits they introduce within the areas they are constructed in. Floating wetlands have been proven to improve environmental quality through localised changes in biotic structure (e.g. Rome et al., 2022). Previous studies using floating wetlands have shown success in removing metals from polluted urban water, e.g. from stormwater runoff and use of de-icing salts on the roads. These have been shown to be successful even in areas with cold, saline water, demonstrating that this treatment may be successful in the estuarine River Clyde (Schück, M., & Greger, n.d.).

Blue spaces in city environments also have an array of benefits, with potential global impacts. As part of a cities 'urban fabric', blue spaces have significant social, physical, and mental health and wellbeing impacts (Smith et al. 2022: 2). A Glasgow-based study shows that living near regenerated blue space decreases risk of chronic disease in deprived areas, a widespread issue in Glasgow (Tieges et al. 2022) - floating wetlands have the potential to help improve such health outcomes. Additionally, blue spaces provide integral outdoor learning opportunities and can engender a deeper connection with nature (Hosaka, et.al, 2017). Within Glasgow, these impacts are experienced across a range of services, further explored below, through the lens of cultural ecosystem services. It is thus not only floating wetlands that bring societal benefits, but also the wider space and ecosystem that they are placed in that allows them to have such an impact for nature and society.

1.5 Why do we need a monitoring and evaluation plan?

Monitoring and evaluation is essential since the project must be considered within a wider ecosystem services-based policy framework e.g. policies within the National Marine Plan: GEN 7 (Landscape/Seascape): The project will ensure that development and use of the marine environment takes seascape, landscape and visual impacts into account. The immediate surroundings of Pacific Quay are heavily urbanised, and the installation will greatly improve the visual amenity of the area whilst at the same time be low key and unobtrusive due to the small scale and low height of the floating reed beds overall.

The basin is currently unused, with little to no estuarine habitat for marine biodiversity and ecosystem services derived from them (Woolfenden et al. 2023). Within cityscapes there are limited possible interventions to enhance marine/coastal habitat, and this innovative biodiversity initiative would serve as an exemplar for future projects to 'green the grey' with nature-based solutions in Scotland's estuarine and coastal cities.

GEN 3 (Social Benefit) is also considered in this project: the installation forms part of a wider programme of community engagement and education; GEN 9 (Natural Heritage; c) and GEN 12 (Water quality and resource) of the NMP is also considered: the artificial reed beds are a

pilot project to investigate the extent of enhancing marine health. The reed beds will enhance urban biodiversity and habitat availability which is currently lacking in the inner estuarine reaches of the Clyde. The structure will offer a safe haven for local wildfowl with nesting and preening platforms installed to allow populations to thrive.

The habitat also has the potential to provide important regulatory ecosystem services by sequestering carbon as sediments accumulate, storing and/or bioremediation of harmful pollutants (metals, micropollutants) in plants and sediment – to further benefit local ecosystem function. As well as estuarine planting, the structure will include subsurface fish habitats through the root system. Similar structures in the Thames Estuary have been found to enhance nursery habitat for commercially important marine fish.

As a collaborative project between Glasgow Science Centre and the University of Glasgow, this project can also be used for a number of other useful purposes:

- Living laboratory for university students via this unique collaboration; its nearby, its accessible.
- Science Technology Engineering and Mathematics (STEM) education demonstrator
- Girls into Geoscience and STEM can be a useful example /case study showcasing female geo-, bio- and stem educators working together, raising aspirations
- Long-term monitoring could evaluate the benefits of these three things and provide evidence for funders of success

Lastly, it serves as a proof of concept for these sorts of wetlands/green-grey infrastructure in cities and it hopefully will serve as a stepping stone towards more widespread implementation of similar measures along urban rivers in Scotland and beyond.

1.5.1 Baseline monitoring

Baseline monitoring is important to allow us to understand the current ecosystem services provided by the area, and therefore the potential changes in ecosystem services with changes to the area. This allows us to make predictions about the benefits and disbenefits of projects aiming to enhance these services and provides a reference for comparison to quantify changes over time.

This should ideally cover the current state of each ecosystem service (supporting, regulating, culture, provisioning) in sufficient detail to compare back to; particularly of those that are predicted to change after installation of the wetlands.

Specifically, the current conditions of the Canting Basin, prior to installation of the floating wetlands:

- Biodiversity, including seasonal variation in the area (seasonal changes in the function of the area for wildlife, i.e., breeding, foraging, resting)
- Concentration and types of pollutants (heavy metals, microplastics, pharmaceuticals) in the water and the sediment

- Carbon storage in the water and the sediment
- Nutrient concentrations (nitrogen, phosphorous, carbon) in the water and the sediment
- Social and Cultural value

Due to the funding and time constraints of this project (i.e. occurring over 3.5 months during winter months only), this will require a summer baseline, 3-4 months after colonisation of the floating wetlands, which will allow us to see the changes in ecosystem services over time as the wetland grows (Figure 3, see also Woolfenden et al. 2023).

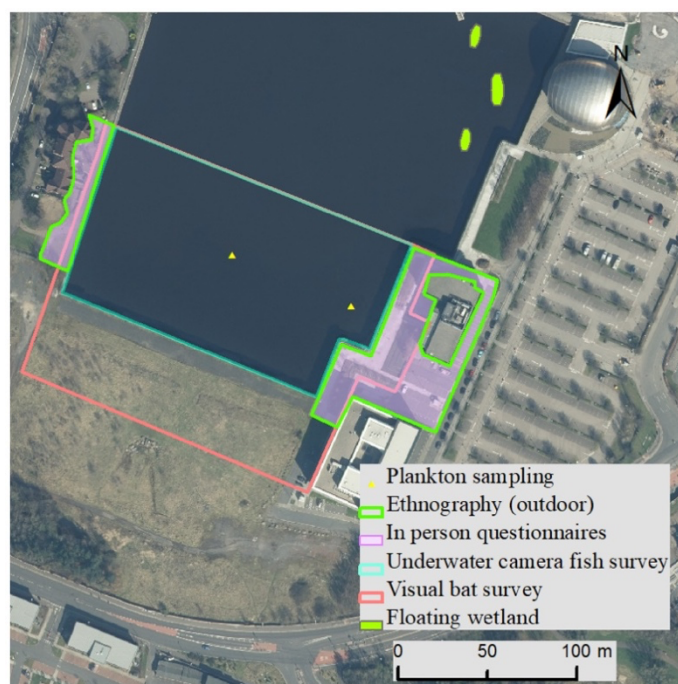


Figure 3. Summer baseline proxy monitoring plan sampling locations.

1.6 What approaches to monitoring and evaluation are there?

The aim to leave the environment in a better state than which we find it in has been a growing area of focus over recent years, responding to drivers such as habitat loss, threat to species, risks to the wider ecosystem and impacts from climate change. There has been a growing sense of ambition and environmental stewardship both from communities and partnerships, as well as Government and private sectors, with a recognition that environmental improvement may often provide a range of benefits.

This ambition has been supported through voluntary measures on a site-by-site basis but now benefits from an increasing framework with commitments for environmental enhancement (e.g. OSPAR restorative targets in the 2010-2020 strategy and new post-2020 Biodiversity Framework and the North-East Atlantic Strategy). Within Scottish legislation (Marine (Scotland) Act 2010) and policies (e.g. Scotland's National Marine Plan) there is a commitment to the protection of marine habitats and species as well as for their sustainable

enhancement and restoration. These are addressed through specific feature and site protection, i.e., Priority Marine Features (PMFs) and Marine Protected Areas (MPAs). They provide a core foundation from which individual enhancement projects can then go on to help achieve more widespread goals and objectives for environmental health as a whole.

The primary objective of monitoring and evaluation may therefore be further defined through a target number or density of individuals, level of biodiversity of the feature, or a target vegetation or marine community. These all require measurement against, and therefore knowledge of, the baseline conditions from which to determine success in the project. It can be useful to consider confidence in achieving these measured outcomes.

Any other benefits that will be achieved indirectly as a form of ecosystem services should be outlined. These may take the form of 'supporting', 'regulating', 'provisioning' or 'cultural', with examples such as improvement of water quality, meeting site conservation objectives, or wider national or international restoration targets. There are several different methods to monitor and evaluate therefore details of site monitoring are required to evidence how the site will be monitored to determine success. This information can include a proposed monitoring plan, identification of elements of the site and/or target feature that will be monitored, for example:

- Feature measurements of density, extent and percentage cover, considering key stages of feature development;
- Measurement of wider ecosystem effects such as sediment stability, water quality and fish / shellfish biomass, especially where these are a primary objective of the project;
- Identifying receptors at risk from the project, especially around biosecurity and other biological / ecological aspects.

There are many approaches to monitoring and evaluating ecosystem services, with different techniques required for each service. As such, it can be a complex task to undertake due to the intrinsic interconnected nature of ecosystems (Reyers et al., 2013).

1.7 What is an Ecosystem services monitoring framework and why use it?

Ecosystems services are a way of framing how we understand the various functional roles that ecosystems can provide for ecology, society and for human-nature interactions in the landscapes in which they live and interact with. Definitions vary and typically include the following concepts:

- A framework that allows us to successfully understand the ecosystem services provided by the floating wetlands and the changes it may generate within the surrounding environment.
- Adopting an ecosystem services framework for monitoring is a widely accepted method of identifying the valued services an ecosystem has and measuring the benefits and disbenefits these can bring within a selected area.

- This is an especially useful method to help better understand the roles nature and nature-based solutions have in tackling major global issues such as biodiversity loss, climate change, and a rapidly declining state of human health (Welden et al., 2021)
- It is important to ensure that nature is not framed as useful due to the services it provides FOR people, or for the services that it provides just for itself. It is important to view nature and people together – the NBS is not transformational if it does not succeed in doing so (Welden et al. 2021).

1.7.1 What can we do with these data from an Ecosystem Services Framework

This approach can allow a future environmental economics appraisal of the value of adding nature-based and/or green grey measures in the greyest parts of our cities and towns; to help improve the business case for adopting these measures more widely (Naylor et al. 2018). Recent examples of successful application of these principles as transformative change in urban development and regeneration planning include Granton Waterfront Development Framework in the City of Edinburgh where a coastal park is being built to improve human-nature connections in cities. This also provides important physical accommodation space on land for future climate change adaptation, so that coastal habitats such as beaches can roll landwards as sea-level rises rather than adding new housing or mixed-use development right to the present-day water edge that would increase future damages and costs as climate change impacts accelerate (Horton et al. 2022; Naylor et al. 2023).

1.8 Why adopt an ecosystem services framework for monitoring?

Ecosystem services is a dynamic term that is typically used to describe the values that humans attribute to ecosystems – the benefits that can be gained from natural resources (Edwards et al., 1998). This can include providing direct and indirect services, such as food and water provision, regulating the environment along with social and cultural features like improving wellbeing, enabling humans to develop a sense of belonging within an area, and a space to learn about the environment around them. As shown in Figure 2, these services are categorised into linked groups of: ‘provisional, regulating, cultural, and supporting services’, (NatureScot, 2020), Table 1.

Table 1. Summary of Ecosystem Services including expected Ecosystem Services that the floating wetlands may provide.

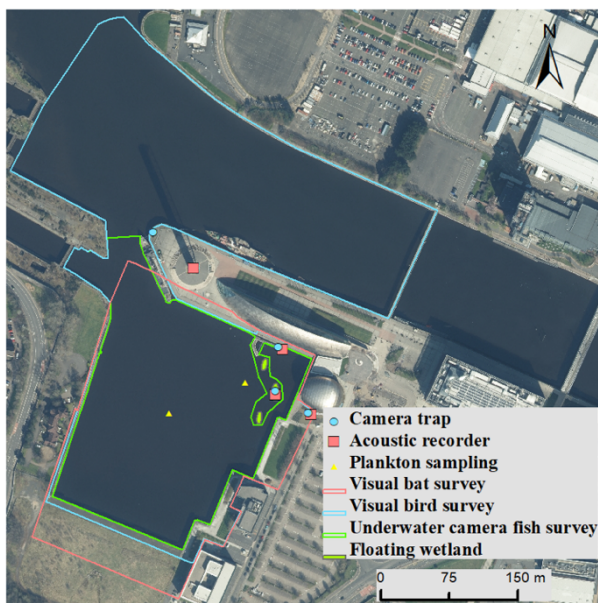
Service Type	Working Definition	Which ES do we expect the floating wetland systems to have
Provisional		N/A
Regulating (also called Maintaining) and Supporting Nutrient Cycle and Soil Formation	<i>“regulating services that occur in the ecosystem that lead to benefits such as climate regulation, flood management, and water filtration*,”</i> monitoring of water and sediment quality to measure	Regulating: <ul style="list-style-type: none"> • Pollutant removal (heavy metals, microplastics, pharmaceuticals) Nutrient cycling and soils: <ul style="list-style-type: none"> • Carbon sequestration • Nutrient removal (Nitrogen, Phosphorous, Carbon)

	nutrient cycling and soil formation.	<ul style="list-style-type: none"> • Alterations to soil /sediment properties
Cultural	Cultural ecosystem services arise when an environment contributes to improving health and wellbeing. An environment can <i>“interact with contemporary cultural values to shape people’s identities, provide experiences that contribute benefits in terms of wellbeing, mental and physical health, and equip people with a range of skills and capabilities”</i> , (Church et al., 2014).	<ul style="list-style-type: none"> • Tourism • Health and wellbeing • Education • Inclusivity and Diversity • Connection to nature • Creativity and Art • Recreation
Supporting (ecological)	<i>“ecosystems could not function without supporting services, such as the nutrient cycle, soil formation and habitat provision for biodiversity, forming the basis for the other three types of services,”</i> Nature Scot*	<ul style="list-style-type: none"> • Habitat diversity • Ecosystem function (i.e. supporting food web, breeding communities, pollination) • Shelter from predators and weather conditions

* <https://www.nature.scot/scotlands-biodiversity/scottish-biodiversity-strategy-and-cop15/ecosystem-approach/ecosystem-services-natures-benefits>

2. What a long-term monitoring plan would ideally involve

A long-term plan would ideally look at all supporting, regulating and cultural services that the wetlands are providing at semi-regular intervals. The specific techniques, sampling procedures and frequency of sampling intervals varies greatly between the various supporting, regulating and cultural services that the floating wetlands are likely to provide. For example, some species such as bats hibernate in winter, others such as



macroinvertebrates only live in warmer months. Similarly, people are more likely to use the basin, or recreate around the edges, such as local art groups painting the wetlands, during more clement spring to autumn periods of the year with favourable weather conditions. Lastly, some of the regulatory services are those that may take the longest to measure any benefits in ecosystem services, as carbon and heavy metals will take time to accumulate in the wetlands as they grow and become established in the Canting Basin.

Figure 4. Recommended sampling locations for long-term monitoring.

Thus, this report and the closely associated appendices are organised around each ecosystem service, and the specific reasons and methods for measuring the potential long-term impacts of the floating wetlands on the landscape, ecology, people and people-nature interactions in cities.

3. Supporting Services

Supporting services are those habitats, landforms and landscapes that underpin ecosystems that create habitat conditions that improve the "structural, compositional, and functional diversity" (Millennium Ecosystem Assessment, p. 80). The floating wetlands will increase the amount of estuarine habitat and habitat diversity in the Canting Basin from a baseline of no available wetland habitat; it will result in an increase of 194 m² of wetland habitat. This new habitat can facilitate some species expanding their range into the Canting Basin. Most supporting services focus on habitat production to support biodiversity, where:

"Biodiversity is the variability among living organisms. It includes diversity within and among species and diversity within and among ecosystems. Biodiversity is the source of many ecosystem goods, such as food and genetic resources, and changes in biodiversity can influence the supply of ecosystem services." (Millennium Ecosystem Assessment, 2003, p. 49)

Biodiversity, and the supporting habitat that enables improved urban biodiversity, is important for the structure, function and resilience of urban ecosystems. The relationship between ecosystem services and biodiversity is complex and can be difficult to define (Mace et al., 2012). It can also be difficult to measure the individual components that make up supporting ecosystem services, such as habitat provision, food web and genetic diversity that contribute to the ecosystem function. Biodiversity is a good indicator of ecosystem function (Hong et al., 2022), and therefore is used in this report as a metric for supporting ecosystem services.

Previous studies of floating wetlands demonstrate their ability to increase the supporting services provided by an area, such as supporting higher fish production in ponds (Neal & Lloyd, 2018); higher species richness and abundance of fish and aquatic insects (Nakamura et al., 1997; Rome et al., 2023); refuge from predators (Karstens et al., 2021); foraging opportunities for predatory species (Karstens et al., 2021); and nesting opportunities for birds (DeSorbo et al., 2008; Hancock, 2000; Nummi et al., 2013; Overton et al., 2015; Shealer et al., 2006).

Floating wetlands in the Canting Basin are likely to provide supporting ecosystem services such as an increase in habitat diversity and local biodiversity across a range of taxa. A baseline study of the existing area (Woolfenden et al. 2023) evidenced a lack of habitat diversity in the current space to sufficiently support a diverse range of wildlife. The few available structures in the existing area, including a disused sea plane jetty, one buoy and

the basin railings, were all observed to be utilised for resting opportunities by birds during the baseline monitoring period (Woolfenden et al. 2023). This provides evidence to suggest that the floating wetlands will increase the amount of habitat available for similar opportunities, increasing the capacity of the area for supporting species abundance.

Based upon the findings of a baseline monitoring study (Woolfenden et al. 2023), we expect an increase in the species diversity within the basin as the floating wetlands will make the area more attractive to wildlife. Through introducing plants to the area where there previously were none, we expect to see invertebrate populations within the basin as floating wetlands support feeding and pollination opportunities for insects (Rome et al., 2023). This increase in invertebrate community is expected to provide foraging opportunities for the insectivorous birds, fish and mammals that were found to use the surrounding area in the baseline monitoring study (Woolfenden et al. 2023), including protected species such as Daubenton's bats. By building this trophic structure, we may expect to see changes in the community over time, supporting an increase in local biodiversity across a range of taxa and trophic levels.

Further to this, installing floating wetlands is expected to increase the number and type of possible breeding (i.e., nesting, spawning) sites, foraging opportunities, and shelter from prevailing weather conditions and predators (e.g. roots of the wetlands may provide shelter for fish from larger, piscivorous fish, birds and mammals (Karstens et al., 2021)). These newly added habitat features will likely increase the functions the ecosystem is able to support as well as increases in local biodiversity. We expect certain benefits to grow more with time, as the plants are still establishing in the first few years, and it may take a while for wildlife to become accustomed to new habitat (see Table 2 for details).

A Phase 1 habitat survey describes the types of habitat present in the area, and their extent and distribution. This gives an understanding of the vegetation present in the area, and therefore provides information about the potential organisms that may be present in that environment. A Phase 1 habitat survey does not give detailed information about the plant and animal communities in the site, but a broad overview of the general habitat present. For measuring habitat quality, a Phase 1 habitat survey is not sufficient as it does not give an in depth understanding of the area and the functions it supports for the wildlife within it that will sustain species richness and abundance.

Table 2. Summary of expected supporting ecosystem services, the rationale for what the future benefits may be, recommended methods and likely measures of success (e.g. evaluation).

Supporting Ecosystem Services			
Service type	Rationale	Method	Measure of Success / Example
Habitat provision	By understanding the types of habitat present, we can predict the wildlife and ecosystem functions the area is likely to support, i.e., breeding and feeding opportunities.	Extended Phase 1 habitat survey	An increase in the diversity and abundance of habitat available and consequently increased ecosystem functions, i.e. feeding and breeding opportunities, indicated success in increasing the ecosystem services provided by the Canting Basin, for example, an increase in habitat diversity may lead to nesting opportunities for swans, which may provide a feeding opportunity for aquatic mammals (otters, etc), which supports higher trophic levels.
Biodiversity and community composition	By understanding the biodiversity within the area, we can predict the health of the ecosystem and the functions that are likely being provided for wildlife i.e. species interactions such as the food web.	Ecological monitoring methods: <ol style="list-style-type: none"> 1. Visual surveys 2. Camera recordings (camera traps, and underwater camera transects) 3. Acoustic recordings 	A higher number of species identified through monitoring methods indicates success in increasing the supporting ecosystem services provided by the Canting Basin, for example, an increase in the number of fish species present in the basin, shows that the floating wetlands support a higher level of biodiversity, which increases ecosystem function and resilience.

4. Regulatory Services

Ecosystems provide many of the basic services that underpin human's ability to exist in an environment. Many natural processes witnessed in ecosystems facilitate the creation of environments that are clean, sustainable, functional, and resilient to change. Regulating services encompass the "the benefits obtained from the regulation of ecosystem processes" (Millennium Ecosystem Assessment, 2005). These services can control the negative impacts and effects of both natural and anthropogenic factors that pose risks to human health and ecosystem quality, whilst also supporting ecosystem functioning and productivity.

Healthy, functioning ecosystems offer a plethora of regulating services to humans through processes such as the purification of air and filtering of water by plants; the decomposition of waste and the cycling of key nutrients by microorganisms; the pollination of pollinator-dependent plants that supply humans with foods, fibre, forage, biofuels, firewood, timber, and medicine (Jha, Burkley & Kremen, 2013); and controls on flooding and erosion by woodland, mangrove and dune habitats (among others). Yet, despite their importance, there is growing concern over the loss of regulating services (Barbier, 2013).

Many regulating services are not marketed, with limited data to link observed changes in the structure and function of ecosystems with quantifiable benefits to humans (Barbier, 2013). This lack of knowledge is often ascribed to the complexity in measuring the benefits regulating services provide, due to the large spatial and temporal scales the corresponding natural systems and processes reside over, rarely with an easily defined 'end-user' (Mengist, Soromessa & Feyisa, 2020). The difficulty in quantifying these services inhibits the ability to attribute a value to their importance, confining their incorporation into policymaking agenda and ES assessment frameworks (Sutherland et al. 2018).

Across Europe, there is substantial heterogeneity in the assessment of regulating ecosystem services, particularly within urban spaces (Larondelle, Haase & Kabisch, 2014). Analogous to Spain and Greece, the UK is characteristically low in ecosystem services provision, particularly with regards to regulating services (Larondelle, Haase & Kabisch, 2014). In response to this need for more data concerning the provisioning of regulating ecosystem services in urban environments, this report has sought to highlight the regulatory ecosystem services anticipated to be provided by the floating wetlands, as explained in Section 1 above, in Woolfenden et al. (2023), and further expanded on below.

4.1 Nutrient storage

Natural wetlands are known to be important in cycling of nutrients, bioremediating chemicals in the environment and for serving as carbon stores; in the marine environment this is known as blue carbon (Smeaton et al. 2020). Biota from microscopic to macroscales are actively involved in the cycling, breakdown and storage of key nutrients including carbon. This is thus a key regulatory service that wetlands provide; adding wetlands in urban environments thus has the potential to improve these regulatory ecosystem service functions. As the pre-installation Canting Basin has virtually no habitat for biota including plant matter that could be acting as a carbon sink, collecting and analysing samples of

wetland vegetation and substrate, and the basin sediment, prior to installation (Woolfenden et al. 2023) and monitoring the efficacy of the wetlands in the storage and/or processing of key nutrients like carbon via flux and stock quantifications will allow assessment of the blue carbon storage potential of these floating wetland systems. These data, alongside an embodied carbon assessment of the wetland construction materials and process and any maintenance, would allow a future evaluation of the net carbon value of the floating wetlands.

4.2 Heavy Metal Concentrations

The Clyde Estuary contains remnant pollution of the heavy industries of Glasgow's past (Jones et al., 2017). Shipbuilding, coalmining, chemical processing and engineering plants once dominated the Estuary and caused a lasting legacy of industrial pollution. Pollution can be stored in estuarine sediments and become a supply of potentially toxic elements to plants and humans. While the main sediments of the main river channel of the Clyde were sampled in 2002 and 2003 (Jones et al., 2017) no analysis has been done on the Canting Basin so chemical characteristics of the water and sediments was unknown prior to our baseline study. To quantitatively assess the interaction between the growth environment and the wetlands a chemical monitoring of water, sediments and plants is required over the duration of the project.

4.3 Emerging Contaminants: Microplastics and Pharmaceuticals

Microplastics and pharmaceuticals are two types of emerging contaminants that are of growing concern to the environment (Blair et al. 2017 and Wilkinson et al. 2022, respectively). Microplastics are small plastic particles that can persist in the environment for hundreds of years and can cause harm to aquatic organisms if ingested. Pharmaceuticals, on the other hand, can accumulate in the environment and potentially harm wildlife, particularly if they have endocrine-disrupting properties. It is important to understand whether the presence of the floating wetlands has an impact, either positive or negative, on the concentration and fate of this contaminants in the water. Regulatory limits on concentrations of these pollutants do not yet exist; however, the Chemical Investigation Programme (CIP) in the United Kingdom (RPS, 2023) is currently investigating the occurrence, sources and removal of trace substances, including from these sources.

Table 3. Summary of expected regulating ecosystem services, the rationale for what the future benefits may be, recommended methods and likely measures of success (e.g. evaluation).

Regulatory Ecosystem Services			
Service types	Rationale	Methods	Measure of Success / Example
Nutrient Storage	By understanding how effectively the wetlands up take nutrients from the River Clyde, i.e., nitrate, DOC (dissolved organic carbon), and phosphate.	Continuous monitoring with the AquaTroll. Partial monitoring with yearly water samples to be ran through a range of	A decrease in nutrients in the water around the floating wetland. Indicating that the wetland is providing regulatory services to

		laboratory tests detailed in Woolfenden et al. 2023.	maintaining the health of the Clyde River.
Pollution (Heavy metal, plastics and pharmaceuticals Concentration)	To understand whether the floating wetlands will change the heavy metal concentration in the sediment below and around the floating wetland.	Partial monitoring with yearly sediment samples to be processed and run as per the methods in Woolfenden et al. 2023.	To assess whether the wetlands are regulating the heavy metal concentration in the basin, especially the sediments.

5. Social and Cultural Ecosystem Services

Cultural ecosystem services can be understood as “the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences” (Sarukhán and Whyte, 2005). These benefits provide significant value to people’s lives and are accordingly outlined below as health and wellbeing, connection to nature, education, inclusion, and tourism and recreation. Often, the benefits stemming from cultural ecosystem services are interrelated and/or interconnect with other ecosystem services, including maintaining, provisioning, and supporting (Milcu, et al. 2013).

Milcu et al. (2013) posit that cultural ecosystem services are a predominant concern of industrialized cities, with demand for cultural services around green and blue spaces continuing to increase (see also: Carpenter et al. 2009); for example, demand for recreational and tourist services have resulted in increasing pressures within city environments. Similarly, the recent COVID-19 pandemic saw a surge in demand for cultural services, aligned with access to, and engagement with, green and blue environments (Beckmann-Wuebbelt, et al. 2021). As a result, access to green and blue recreational spaces has become an immediate concern within cities, with cultural services at the forefront.

However, cultural services are critically understudied also in relation to blue space (Reyers et al., 2013), predominantly because of their intangibility (Milcu et al. 2013). Due to their sensory nature cultural ecosystem services can prove difficult to measure (Sarukhán and Whyte, 2005): “The physical, emotional, and mental benefits produced by cultural ecosystem services are often subtle and intuitive in nature” (Kenter et al. 2011 in: Milcu et al., 2013); therefore, the social and cultural benefits and disbenefits of greening initiatives often remain the least well known (Naylor et al., 2017). Despite this, there is a wide range of social and cultural ecosystem services associated with urban blue spaces, such as rivers and canals (Brown, 2020).

Blue spaces in particular play an important role in providing a wide range of cultural and social benefits. Around 50% of the UK’s population engage with a blue space at least monthly (Brown, 2020), demonstrating their popularity. Blue spaces are considered be part of a city’s ‘urban fabric’ and have been popular sites of urban regeneration in recent years,

particularly through the incorporation of more greenery and nature (Brückner et al., 2021); the associated wellbeing improvements are larger than that of solely greenspaces (Brown, 2020).

Within the context of the floating wetlands, the Canting Basin is likely to provide an array of cultural ecosystem services, including those outlined in the table below. Based upon the findings of a baseline monitoring study (Woolfenden et al. 2023), we expect an increase in the engagement with this space during summer months and subsequent increase of physical and mental wellbeing, as well as a heightened sense of connection to nature through sustained outdoor learning opportunities and increased interaction with the natural environment. The potential of floating wetlands to transform hard-edged and grey water bodies into living water parks is significant and has already been found to increase the value of waterfront areas (Biomatrix Water, 2023). As the Canting Basin at Glasgow Science Centre was previously under-used, the floating wetlands could attract more people to the area. The benefits of this are clear, with frequent blue space use being linked to people feeling healthier and more engaged in highly urbanised areas. Below, we include an overview of the central social and cultural services associated with the study of this project:

5.1 Health and Well-being

Blue spaces provide a range of benefits for both physical and mental wellbeing as people often visit blue environments to socialise, exercise, and relax (Brown, 2020). Resultingly, impacts of blue spaces on health and wellbeing in urban city environments are predominantly positive, including benefits to physical health and mental wellbeing (Brown, 2020). In Glasgow, for example, communities often visit urban blue spaces specifically to exercise and improve their health (Smith et al., 2022). During the COVID-19 pandemic, blue spaces proved integral for both physical wellbeing and mental health; Jo et al. (2022) suggested that during this time blue spaces offered people in city-scapes with predominantly grey infrastructure spaces for stress relief and mitigation, thereby promoting healthy relationships with space, other people, and a positive mindset. When considering blue space, rivers and canals are particularly important spaces, encouraging active engagement through active practices such as running, walking, or cycling; these blue spaces also provide opportunities for wildlife observation and recreational pursuits (Brown, 2020).

5.2 Connection to Nature

Increased opportunities to interact with the natural environment supports nature-positive attitudes, encouraging people to develop a sense of connection to nature (Hosaka, et.al, 2017). Childhood experience of nature is linked to an increase in caring about wider environmental issues, including climate change and health (Hosaka, et.al, 2017). Outdoor learning and opportunities to engage with the natural environment encourages people to more actively take part in behaviours that lead to protecting nature (ibid). As cities are growing, this connection to nature is becoming increasingly lost, with Soga and Gaston (2016: 94) likening it to an 'extinction of experience'. In particular, they state that this extinction of experience with nature has seen a decline in health and wellbeing amongst populations, whilst also engendering negative attitudes and behaviours towards nature. This

aligns closely with Hosaka, et al's (2017) position that consistent and early interaction with nature is essential to forming positive relationships and attitudes.

5.3 Education

Pearson, et al (2017) suggest that blue spaces, and thus floating wetlands, provide additional opportunities for children [and adults] to learn more about the ecosystems in which they live; this in turn prompts a more sustainable and engaged relationship with nature. In the realm of education, the incorporation of blue [and green] spaces in cities promotes connection to nature through environment interaction and learning. Outdoor learning practices, enabled through blue space interaction can "improve academic achievement and social and emotional intelligence for children" (Mirrahimi, et al, 2011: 389); additionally, outdoor learning can encourage more people to realise the restorative capacity cities have to become better homes for biodiversity (Hosaka, et.al, 2017), in turn also fostering a better connection to nature.

5.4 Inclusion

Blue spaces play an important role in helping people to form connections to their local area; as highlighted above, active engagement with place supports the creation of local identity through a sense of belonging (Rugel et al., 2019). Immersion in blue space engenders an attachment to place through practiced experience, thus creating a sense of belonging. However, it is important to note that this is not experienced equally across social spheres and that ethnic minorities are less likely to access blue spaces than others (Brown, 2020). Knifton and Inglis (2020) highlight the relationship between poverty and mental health in Glasgow, outlining that within this city mental health problems are a direct result of poverty-related inequality. As a publicly accessible space, the floating wetlands project in the Canting Basin has the potential to improve the diversity of people able to connect to space.

5.5 Tourism and Recreation

A significant cultural service of the floating wetlands is the recreational tourism associated with the transformation of hard-edged waterbodies into living water parks; Gammon and Jarratt (2019: 38) suggest that blue space facilitates a 'leisure state of mind' by creating spaces for recreational engagement. They highlight that increased blue environments heighten recreational appeal and thereby associated nature-based tourism. In this vein, blue spaces provide inclusive opportunities for different types of tourism through varied avenues of engagement. Additionally, transformation of water-front spaces has significant impacts on the value and quality of surrounding properties, in turn also attracting more tourists (Kostopoulou, 2013).

Details on how each service type can be monitored, including examples of measures of success are included in the Table 4 below.

Table 4. Summary of expected social and cultural ecosystem services, the rationale for what the future benefits may be, recommended methods and likely measures of success (e.g. evaluation).

Social and Cultural Ecosystem Services			
Service Type	Rationale	Method	Measure of Success / Example
Tourism & Recreation	We can experience first-hand the impacts of blue space on tourism and recreation, allowing us to reflect on their direct impacts. Meanwhile, interviews allow us to engage participants directly, learning more about the experiences and perceptions of the public.	Ethnography, Questionnaires, and Interviews	An increase in visitors using the space compared to the baseline figure of 62 people. Gaining positive feedback both in person and online about the quality of the space that relates to the floating wetlands. Participants in the baseline study expressed positive feedback about the project visualisations, and long-term monitoring will identify if the floating wetlands encourage an increase in tourists and those taking part in recreational activities.
Health & Wellbeing	We can experience first-hand the impacts of blue space on our own health and wellbeing, allowing us to reflect on their direct impacts. Meanwhile, questionnaires allow us to engage participants directly, analysing relationships and correlations between demographics and responses, whilst also learning more about participants perceptions of health and wellbeing.	Ethnography, Questionnaires	The baseline study indicated that visitors do use the space for physical activity, and the long-term monitoring will identify if these numbers increase. The long-term monitoring plan would be able to assess how the floating wetlands installation contributes to an improved sense of physical health and mental wellbeing.
Connection to Nature	We can experience first-hand the impacts of blue space on our own connection to nature, allowing us to reflect on their direct impacts. Meanwhile, questionnaires allow us to learn more about the perspectives and opinions of our participants, along with their demographic information. Interviews similarly allow us to learn more about participants perceptions, in more detailed fashion. Workshops	Ethnography, Questionnaires, Interviews, Workshops	Compared to the front of Glasgow Science Centre, the Canting Basin pre-installation did not offer many opportunities for visitors to engage with nature. The baseline data shows that respondents wanted to see the presence of nature increase in the space, including more plants and habitat for a wider range of wildlife than what is currently supported. An increase in visitors using the space and positive feedback relating to the presence of

	enable us to examine artistic interpretations and speak to participants directly about their perceptions.		wildlife and their ability to engage with nature will be gathered in the long-term monitoring plan. This includes observation of activities like wildlife watching. Gathering qualitative information about if this project inspires visitors to become more interested in expanding urban greening objectives across Glasgow is also included in the long-term monitoring plan.
Education	We can observe people's interactions with the floating wetlands as a site of education, allowing us to reflect on their direct impacts. Meanwhile, questionnaires allow us to learn more about the perspectives and opinions of our participants, along with their demographic information. Interviews similarly allow us to learn more about participants perceptions, in more detailed fashion. Workshops enable us to examine artistic interpretations and speak to participants directly about their perceptions.	Ethnography, Questionnaires, Workshops	This same measures of success for connection to nature can be applied here. Additional measures include gathering feedback on the outdoor exhibition that Glasgow Science Centre have created, and recording if there has been an increase in the desire for Glasgow Science Centre to facilitate more nature-based educational activities for visitors and community groups. Detailed information on the impact of these can be collected in the workshops, particularly with the community groups.
Equality, Diversity & Inclusion (EDI)	We can experience first-hand the impacts of blue space on our own connection to nature, allowing us to reflect on their direct impacts. Workshops enable us to examine artistic interpretations and speak to participants directly about their perceptions.	Ethnography, Workshops, Focus Groups	An increase in visitors using the space / positive feedback / increase in nature-based educational activities

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Appendices: Long-term Monitoring Methodology Statement

This section outlines the recommended long-term monitoring and evaluation plan for supporting ecosystem services. These recommendations are based upon a combination of best practice routine monitoring methods (e.g. habitat and bird surveys), state-of-the-art academic science and results of existing studies in the area, most notably the companion winter 2023 baseline survey (Woolfenden et al. 2023).

Appendix A. Long-term Monitoring Methods: Supporting Services

This appendix outlines the supporting services monitoring plan, including the recommended frequency of post-installation monitoring. It is recommended that in addition to the specific taxa methods outlined in Table 5 below, that an extended Phase I habitat survey is carried out in the Canting Basin as well as the surrounding area (i.e. within 250 m of the basin) at the same time intervals.

Table 5. Recommended long-term monitoring approach for supporting services.

	Pre-installation				Proxy survey to estimate pre-installation conditions				Post-Installation Monitoring and Evaluation				Post-Installation Monitoring and Evaluation			
	Baseline Stored (collected in Year -1, Winter 2023)				Summer baseline (Year 0, 2023)				Year 0 monitoring of wetland area in Summer 2023				Long-term monitoring (Years 1, 3, 5, 10)			
Methods:	S	V	CT	A	S	V	CT	A	S	V	CT	A	S	V	CT	A
Birds	Z	Z	Z	Z	O	-	-	-	-	O	O	O	-	O	O	O
Bats	-	-	-	-	O	O	-	O	O	O	-	O	O	O	-	O
Methods:	S	V	CT	A	S	V	CT	A	S	V	CT	A	S	V	CT	A
Fish	-	-	-	-	-	-	O	-	-	-	O	-	-	-	O	-
Marine Mammal	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	-
Methods:	S	V	C	L	S	V	C	L	S	V	C	L	S	V	C	L
Plankton	-	-	-	-	-	-	O	O	-	-	O	O	-	-	O	O
Invertebrate	-	-	-	-	-	O	O	O	-	O	O	O	-	O	O	O

S: Secondary data source; V: Visual survey; CT: Camera trap; A: Acoustic equipment (e.g. acoustic recorder); C: Collection, L: Laboratory (microscope). X: already completed, analysed and reported in the Baseline Monitoring Report; Z: already collected, waiting for analysis and reporting in a future updated Baseline Monitoring Report; O: not yet collected, analysed or reported and would be included in a Year 1 – onwards Post-Installation Monitoring and Evaluation Report. Camera and acoustic recordings are not applicable for plankton or invertebrates (e.g. insects). Methods for these include collecting samples in the field for identification and assessments of abundance of these features in the laboratory.

Visual Surveys

Visual surveys give an opportunity to observe the whole area to understand how the space is being used, including an opportunity to observe behaviour and use of different structures and locations within the study site.

Visual Bat Survey

Visual bat surveys will be conducted once a month, following the survey methods used in the baseline monitoring study, based on the methodology used by the Bat Conservation Trust (Collins, 2016). To capture the peak activity of bats, the surveys will begin at sunset and last for one hour after sunset. A bat detector may be used to identify species presence using call frequency, and the number of passes of each species recorded, either through visual sighting of the bat or through the audible feedback of an echolocation call from the bat detector.

If Daubenton's bat calls are recorded on the acoustic recorders placed out targeting bats, then two further surveys will be conducted in August adapted from the methodology used by the National Bat Monitoring Programme in their Daubenton's Waterways Survey (Bat Conservation Trust, 2001). The first survey will be between 1st and 15th August and the second survey between 16th and 30th August. Surveys will begin 40 minutes after sunset and the number of Daubenton's bat passes in the Canting Basin detected by a bat detector will be recorded for about one hour.

Visual bird survey

Visual bird surveys will be conducted once a month, following the survey methods used in the baseline monitoring study, based on the methodology used by the British Trust for Ornithology for their Wetland Bird Survey (Bibby et al., 2000). These surveys will record the species of birds present on site (excluding feral pigeons); the locations of birds on site, including any structures being utilised (Floating Wetland; Canting Basin; Railings; Buoys; Sea Plane Jetty; River Clyde); and the number of individuals of each species at each location.

All birds will be recorded from the side of the basin using binoculars, moving around as needed to record all birds; a secondary location at the entrance of the basin will be used to record birds in the River Clyde nearby the Canting Basin. Surveys will start at approximately 9am to coincide with peak activity levels and continue until all birds on site had been recorded, taking care not to double count birds whilst moving around the area.

Acoustic surveys

An effective complement to visual surveys, acoustic recorders are able to record more cryptic vocally active species, such as small, elusive songbirds, and are also able to extend biological monitoring to include longer periods and key times of day, such as the dawn chorus, when more species are vocally active. They also enable the detection of nocturnal species or those present in poor weather when observations are not possible. They also

improve detection of species that do not vocalise when disturbed, such as when an observer is present, and can provide some additional behaviour information, such as disturbance levels. Acoustic recorders will be used to monitor birds and bats in the basin and surrounding area by recording calls, song and echolocation in the following locations:

1. Floating Wetland: birds
2. Sea Plane Jetty: bats
3. Moat: birds
4. Glasgow Science Centre Tower: birds

One acoustic recorder has been in place in the moat location, targeting bird song since 10/03/23 for the baseline monitoring period. The acoustic recorders in the pontoon location and Glasgow Science Centre Tower will be placed out in April. These will remain in place for continuous sampling but will require maintenance (i.e., SD card and battery changes) by 1-2 people approximately every 3 weeks.

The acoustic recorders to target bird activity will be set to record for one hour at sunrise to capture the dawn chorus, and then 5 minutes every hour for the rest of the day to sample over a continuous period of time, whilst increasing deployment duration. The acoustic recorders to target bat activity will be set to record for 30 minutes at sunset and 30 minutes at sunrise when a high frequency bat call is detected.

All acoustic recordings will be analysed with the software 'Audacity' in the first instance, with further analysis of longer recordings conducted in Kaleidoscope software (Wildlife Acoustics Ltd) to identify the species responsible for the vocalisations detected on the recorders (Metcalf et al 2022). A larger sample of acoustic recordings was collected during the baseline monitoring period than was analysed, and this data is being stored on a hard-drive and can be analysed in the future. These recordings can also be used to infer biological diversity through the calculation of acoustic indices, following a soundscape ecology approach (Farina & Pieretti 2012, Sueur et al 2014). Over time, comparison may be made between the proportion of urban to biological noise dominating the recordings; the change in this proportion over annual cycles will enable the broad-scale use of these wetlands to be evaluated, while still accounting for natural annual variations (for example the increase in biological sound due to the arrival of migrant birds in spring).

It is possible to measure change between pre- and post-installation of the wetlands for some species in these analyses, however due to the limited baseline monitoring period and the seasonal and migratory ecology of bird and bat species, comparisons may be limited. For example, UK bat species hibernate until April and are not fully active until mid-May, although will occasionally feed during periods of warmer weather before then. Similarly, dependent on temperature cues, before March, the first few summer migrant bird species will begin to arrive in the UK and the first few winter migrant birds will begin to leave, but most species migrations will occur between April and July.

Camera Traps

Camera trap surveys give a better understanding of how key areas within the study site are used through time, including during different times of day and across different days of the week. Camera traps will be used to monitor birds and mammals (including marine mammals) using the area by recording photos and videos in target locations at set intervals, or when triggered in some locations. These will be placed in the following locations:

1. Floating Wetlands
2. Sea plane jetty
3. Mouth of basin
4. Moat

The camera traps will be placed out for the baseline monitoring in April and will remain in place for continuous sampling but will require maintenance (i.e., SD card and battery changes) by 1-2 people approximately every 3 weeks.

The camera traps would ideally have the following formatting (Table 1).

Table 6. Recommended format of the camera traps.

Location	Motion sensor on/off	Interval	Type
Floating Wetland	On	NA	Photo
Mouth of basin	Off	1 hour	10 second video
Sea plane jetty	Off	1 hour	1 photo
Moat	Off	1 hour	1 photo

For the sampling frequency of camera traps and acoustic recorders we initially chose a high sampling frequency. We plan to use that initial high-frequency sampling record to derive an optimal sampling frequency for the long-term monitoring by sub-sampling the baseline record in longer and longer intervals. We will then compare the results from the different sampling intervals and decide which is the longest sampling interval that still gives reliable results (i.e., compared to the original record) in order to produce a reliable but manageable long-term monitoring scheme.

Analysis of the camera trap footage will be manual and will require one person to identify and record species and incidence from the photos/videos. Footage from the baseline monitoring may be stored on a hard-drive indefinitely and analysed after March 2023. It is possible to measure change between pre- and post-installation of the wetlands for some species in these analyses, however due to the limited baseline monitoring period and the seasonal and migratory ecology of bird and mammal species, comparisons may be limited.

Drop-down Underwater Camera

A drop-down underwater camera will be used to record the fish species and potentially abundance in the basin by recording video footage of the underwater environment as a

boat travels around the basin. This will focus on the area around the floating wetland, travelling around using a “star” design (Figure 5). This will further include moving around the basin examining the walls and other structures. This will require 2 – 3 personnel. Analysis will be conducted through manual review of the footage to identify the species recorded by the camera and estimate abundance. It is possible to store this footage on a hard drive and review at a later date.

Initial frequency of these surveys will be every 3 months, starting in April 2023. Sampling frequency will be adjusted seasonally to sample migratory, juvenile and marine fish, if the surveys indicate these groups are present. The effectiveness of drop-down underwater camera as a monitoring technique for fish will be highly dependent on visibility in the water and amount of litter in the area. There is potential for other monitoring techniques, such as traps and nets. There is also the potential for the use of a scanning sonar to look at fish behaviour in the basin, giving insight into where the fish congregate and therefore how they use the space.

It will be possible to measure change in species and abundance of fish using the basin after the installation of the floating wetlands to an extent. Due to project time constraints, baseline data on the fish using the area before the installation of the floating wetlands was not possible and will be collected in the summer 2023 baseline. Comparisons can be made between the use of different locations within the Canting Basin, assessing whether the space around and underneath the floating wetlands are used differently (i.e., differences in species, abundance and behaviours) than the rest of the basin. No large changes in local fish population are predicted due to the scale of the project, however previous Biomatrix projects have noted observations of fish using the pontoons (particularly the root systems) as soon as 6 hours post-installation.

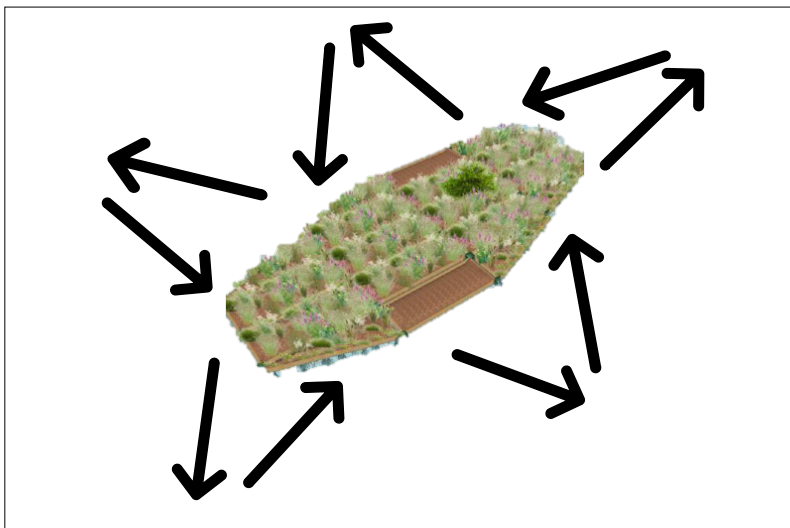


Figure 5. Diagram of the “star” design for underwater camera transect.

Plankton Sampling

Plankton samples will be taken around the floating wetlands and the main channel of the basin. These samples will be collected by lowering a 53 µm or 150 µm plankton net into the water to a depth of approximately 1 metre, leaving it there for 3 minutes, and then retrieving it. The collected sample will be washed into a 250ml bottle and 5-6 drops of Lugol's iodine added immediately to preserve the sample, and the date, time, location, mesh size and depth recorded. After collection, abundance and species diversity for particular groups in the plankton community will be recorded through microscope analysis. Because certain species of plankton are more sensitive or resistant to disturbance, documentation of the presence and dominance of these species can be helpful in evaluating ecosystem health and services (Beaugrand et al. 2010, Lomartire et al 2021). In addition, because these organisms grow rapidly and respond quickly to changes in their environment (such as nutrient levels, light and temperature), they are likely the first trophic link in demonstrating the start of long-term changes in the aquatic environment.

Frequency of sampling will vary depending on season, with initial frequency of one sample per site collected once a month starting in April 2023, with increased frequency in the spring and autumn when increases in temperature and daylight provide improved conditions for growth. Collected samples can be stored for several years for future analysis.

Macroinvertebrate sampling

Macroinvertebrates are highly specialised species, sensitive to changes in environmental conditions, and fundamental to the functioning of corresponding aquatic and terrestrial ecosystems. In aquatic systems, macroinvertebrates play a key role as primary consumers, through the cycling of nutrients as a consequence of their processing of available organic matter, and as prey to larger aquatic species such as fish, amphibians, reptiles, aquatic birds and mammals. The filter feeding behaviours of some aquatic macroinvertebrate species also serves to improve the condition of the surrounding environment: the removal of detritus present in the water column culminates in improvements to water quality, whilst subsequent nutrient loading (through pseudofeces deposits) into surrounding sediments may facilitate the establishment of macrophytes (Wildsmith et al., 2011). Furthermore, many terrestrial invertebrate species (e.g. *mayflies*, *stoneflies*, *dragonflies*, *caddisflies*, *megalopterans*) have early life stages in aquatic systems. Thus, the assessment of aquatic macroinvertebrates offers insights into overall health and functioning of aquatic ecosystems, whilst also providing an indication towards the extent and diversity of important terrestrial species, which are often difficult to monitor in their more mobile adult stages. Methodologies for the long-term monitoring of macroinvertebrates will follow standard protocols, with details to follow in due course.

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Appendix B. Regulatory Services Long-term Monitoring Plan: Water Quality and sediment

Regulatory services benefit the ecosystem processes, this includes water regulation, climate regulation, and pollution regulation. By monitoring the floating wetlands on a long-term basis, it will provide data to assess whether they are an effective regulatory service on the river Clyde as the wetlands grow. As the floating wetlands develop strong root system, they will uptake nutrients from the surface water (Shadid et al., 2015). Tables 7-9 below summarise the key recommended monitoring aspects and the frequency of sampling.

Continuous Water Monitoring

The estuarine environment comprises a complex integration of continuously altering habitats, providing transitional zones through which shifts in abiotic and biotic factors are governed by constantly changing water depths. These changes in depth result in rapidly reversing currents, which drive substantial variation in temperature, as well as quantities of salt and sediment (Ohrel and Register 2006). A further consequence of this flux in up-estuary saltwater movement and down-estuary freshwater flow, is that pollutants and contaminated sediments are retained for long periods in the estuarine environments.

Anthropogenic activities in river catchments have culminated in substantial increases in nutrient loading, in addition to alterations to sediment transport, in downstream estuarine water bodies (Briciu-Burghina et al. 2014). This has impacted corresponding water quality, with dissolved organic carbon and dissolved organic nitrogen highlighted as contributing factors to issues such as eutrophication and hypoxia within estuaries (Panton et al. 2020). Furthermore, increases in suspended solids from sources such as phytoplankton, shoreline erosion, re-suspended bed sediments, organic detritus from streams and excessive algae growth, can cause alterations to the aquatic ecosystems through changes to local food webs and habitat availability (Briciu-Burghina et al. 2014)

Given the considerable spatial and temporal variability in estuarine conditions, driven by the unique hydrological setting, the establishment of high-quality, long-term monitoring of water quality is key to examine the current conditions with the ecosystem, as well as any alterations to these background conditions induced by the floating wetlands. Monitoring programmes in estuarine environments have often focused on the integration of continuous data collection by in situ detectors (Huggett, Purdie & Haigh, 2021; Briciu-Burghina et al. 2014). Here, data can be accessed on-site or remotely, with constant surveillance permitting the detection of modifications to critical indicators, providing early information to assist decision makers.

It is recommended that a minimum of two remote sensing water quality probes are placed in the Canting Basin, providing recordings of key water quality parameters over the duration of the long-term monitoring period: one device positioned at the entrance to the basin; one device positioned at the centre of the floating wetland. Recommended water quality

parameters to remotely sense include water temperature and dissolved oxygen concentrations, water depth, salinity total dissolved solids, pH, nitrates and phosphates.

The data from the remote sensors would provide insights into the estuarine behaviour of key water quality parameters, throughout all seasons and during all types of weather, whilst also highlighting the role of the floating wetlands in influencing particular factors across a wide range of environmental conditions.

Critical to meeting international carbon (C) mitigation commitments as outlined in agreements such as the Paris Climate Accord, maximising sequestration in the environment is required alongside emission reductions. In general, rivers act as organic matter reactors and are net sources of CO₂ to the atmosphere (Liu et al. 2022). However, riparian zones and bordering wetlands act as significant C-stores, trapping organic matter in sediment and biomass. Thus, changing the riverine / wetland balance in a system can potentially change the C-balance of the system. Thus, a detailed C accounting of the artificial wetlands will inform our understanding of their potential wider impact and efficacy as a C ecosystem service.

Carbon extracted from the surface water and atmosphere can potentially be sequestered in the organic material on the wetland, or re-processed and released back into the environment (as organic-C or CO₂). Metabolic processes (photosynthesis / respiration) vary temporally due to aspects like temperature, precipitation, etc. Thus, seasonal evaluations (4 per annum) of the C-content in the soil, plant biomass, and riverine sediment (12 replicates each matching baseline sampling) below the floating wetlands (via sample collection & elemental analysis) coupled to measurements of CO₂ & methane fluxes from the wetland soil (via closed chamber techniques) will allow for a C-budget to be characterised. Conducting this sampling over several years as proposed (yrs 0, 1, 3, 5, and 10) would allow for long- and short-term variability to be assessed. Evaluating this budget in terms of background riverine C-dynamics allow the assessment of the wetlands as a potential significant additional regulator of urban river carbon.

Characterisation of pollutants in sediments and waters is required to identify potential sources of contaminants to the wetland environment and as well as assess the risk of pollution to human health. The basin sediments may be a source of heavy metal contamination given Glasgow's industrial past. In aquatic systems disturbance to the sediment can cause oxygenation and release metals such as Lead and Cadmium into the water column. Plants uptake metals through the root system and while metals such as Copper, Nickel, Zinc can be beneficial to plant growth, the toxicity of all metals is concentration dependant. Monitoring of the Canting Basin is required to determine what concentration metals are present in the sediments and do pollutants transfer across the ecosystem from the sediments, through the water column and into the flora and fauna. In this respect, important metals that we include in our monitoring are arsenic, chromium, cadmium, copper, lead, vanadium and zinc. For metals, sampling is recommended at year 1, 3 and 10.

Table 7. Recommended regulatory services monitoring of Canting Basin

Basin	Stored data pre-installation conditions.		Post-Installation Monitoring and Evaluation		Post-installation Monitoring and evaluation	
	Summer baseline Stored. (Year 0, 2023)		Short-term monitoring (Year 0, Summer 2023)		Long-term monitoring (to be repeated summer at 1 (2024), 3 (2026), 10 (2033) years)	
	Water	Sediment	Water	Sediment	Water	Sediment
Aqua Troll	Continuous monitoring, at near surface, for two-month bursts.					
pH			O		O	
Temperature			O		O	
Salinity			O		O	
Conductivity			O		O	
Rugged dissolved oxygen (RDO)			O		O	
Turbidity			O		O	
Water samples	Partial monitoring once during the summer (1, 3, and 10 years) at three different depths.					
Dissolved organic carbon (DOC)			O		O	
Phosphate			O		O	
Nitrate		O	O	O	O	O
Metals			O	O	O	O
Plastics			O	O	O	O
Pharmaceuticals			O	O	O	O
Sediment Samples	Partial monitoring once during the summer (1, 3, and 10 years).					
Grain size				O		O
Metals			O	O	O	O
Plastics			O	O	O	O
Soil-C and green house gas fluxes		O (soil-C only)	O	O	O	O

From the baseline report it was evident that the sediment was highly polluted, therefore, taking water samples from three different depths (near surface, mid-depth and just above the sediment/basin floor) will provide a further understanding into the pollutants.

For future monitoring, adding water and sediment sampling from the Clyde every 1, 3, and 10 years will provide a wider insight into what effect, if any, the wetlands are having on the water and sediment quality of the Canting Basin. In addition, a reference sampling point at the confluence of the Canting Basin and the River Clyde is also recommended, as detailed in Table 8.

Table 8. Recommended regulatory services monitoring of the confluence of Canting Basin and the River Clyde

Confluence in the River Clyde	Post-Installation Monitoring and Evaluation			
	Short-term monitoring (Year 0, Summer 2023)		Long-term monitoring (to be repeated summer at 1 (2024), 3 (2026), 10 (2033) years).	
	Sediment sample	Water sample	Sediment sample	Water sample
Dissolved organic carbon (DOC)		O		O
Phosphate		O		O
Nitrate		O		O
Metals		O		O
Plastics		O		O
Pharmaceuticals		O		O
Grain size	O		O	O

Table 9. Recommended regulatory services monitoring of the Floating Wetlands

Floating Wetlands	Stored data Pre-installation conditions		Post-Installation Monitoring and Evaluation			
	Summer Baseline stored (Year 0, 2023)		Short-term monitoring (Year 0, Summer 2023)		Long-term monitoring (to be repeated summer at 1 (2024), 3 (2026), 10 (2033) years).	
	Sediment Sample	Plant sample	Sediment Sample	Plant sample	Sediment Sample	Plant sample
Nitrate	O		O		O	
Plastics	O		O		O	
Pharmaceuticals	O		O		O	
Plastics	O		O		O	
Carbon		O	O	O	O	O
Heavy metals	O	O	O	O	O	O

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Appendix C: Social and Cultural Ecosystem Services Method Statements

The table below (Table 10) outlines our recommendations for long-term monitoring of the social and cultural ecosystem services of the Canting Basin floating wetland.

Table 10. Recommended long-term monitoring plan for Social and Cultural Service

	Pre installation								Post installation			
	Baseline Completed (Year -1, Winter 2023)				Baseline Stored (Collected in Year -1, Winter 2023)				Short-term – Long-term (Summer 2024 – Year 1, Year 3 (2026), Year 10 (2033))			
In-Person:	E	Q	W	I	E	Q	W	I	E	Q	W	I
Indoor	X	X	X	Z	X	Z	X	Z	O	O	O	O
Outdoor	X	O	-	O	X	O	-	O	O	O	-	O
Online:	E	Q	W	I	E	Q	W	I				
	-	X/ Z	-	O	-	X/ Z	-	O		O		O

E – ethnography, Q – questionnaires, W – Workshops, I – Interviews. X already completed, analysed and reported in the BMR, Z already collected, waiting for analysis and reporting in a future updated BMR, O not yet collected, analysed or reported and would be included in a Year -1 - onwards Post-Installation Monitoring and Evaluation Report, - not carried out due to methodology not being suitable for this environmental setting.

0 – 1 year will be local studies around the floating wetland in the basin. These will include full questionnaires, interviews, and ethnography, and partial monitoring for workshops. The purpose of these will be to increase public engagement over the summer months and then the following year. In 2023 it is recommended that 30 days of data is collected over 2 months (2 days a week); then 30 days each over each Spring, Summer, Autumn, and Winter seasons.

For years 3-5 the aim will be to shift focus onto future installations within the Clyde River. Full questionnaires, partial ethnography, interviews, and workshops to be conducted maybe focussing on wider greening initiatives along the Clyde River.

In 10 years ideally there will be further installations to evaluate. We would recommend focus on the wider urban river corridor to assess future installations and potentially questions around further development. Suggested methods include partial questionnaires, partial interviews, workshops, and ethnography to focus on this.

Methods Overview

A central facet of the long-term social and cultural ecosystem services monitoring plan is to engage with a wide range of visitors to the Canting Basin. Participants in this research should either be:

- Current visitors of the floating wetlands space (including organised activities such as school and community group visits)

Or:

- Have previously visited the floating wetland space

Carrying out the long-term monitoring plan will require a mixed method approach, including:

- Ethnography
- Questionnaires
- Interviews
- Workshops & Focus Groups

Details of these methods, including how they have been used to carry out the baseline and why they are appropriate to employ for the long-term monitoring plan have been provided below. Details on what types of data can be expected from each social and cultural ecosystem service from the proposed methods are included above in Table 10. The ethical considerations that need to be made before and during research can also be found below.

Seasonal variations of the data are to be expected, particularly for how often the space is visited and the types of visits taking place (Brown, 2020). As such, data should be gathered all year round to best understand the on-going use of the space, and it should be analysed during certain intervals to identify any seasonal trends that develop. Further details on how each method can be taken forward, included a suggested rate of frequency is provided below.

Ethnography

Ethnography is a qualitative research method that allows for long-term data collection of a particular community or group. This includes communities that are linked to specific areas, such as cities or organisations. A major benefit of this method is that it enables researchers to identify the differences between people's opinions and their behaviours. Participant observation forms a key part of this, enabling the researcher(s) to observe the everyday behaviours of community members through experiencing the setting of the research first-hand (Radice, 2022; Rantala, 2011). Observation can include watching what people do, taking photographs, drawing what you see, recording sound, and listening to conversations (Radice, 2022).

Branching off from ethnography, auto-ethnography was used throughout the baseline of this study, and it will continue to be a useful method to employ for the long-term monitoring plan. Auto-ethnographic research calls for the researcher(s) to draw on their personal experiences to further their understanding of a particular topic. This can include details on their

experience of spending time within a social space and interactions they witness (Denshire, 2014).

The baseline project employed ethnographic and auto-ethnographic research to record the researchers' own experiences of the basin, pre-and post-installation of the floating wetlands. Weekly visits to the Clyde basin were undertaken by the research group in pairs and insights were recorded in fieldwork diaries. Visits were carried out at varying times on Fridays, and observations taken at multiple different areas inside and outside Glasgow Science Centre.

Researchers recorded observations in notebooks. A set of guiding questions was also used to encourage their thoughts:

- What are you doing / how are you experiencing in the Clyde basin?
- How does spending time in the space make you feel?
- What are others doing in the space?
- Do others interact with the nature available in this space?
- What other external conditions may be affecting people's experience in the space?
- What are your experiences with nature within this space?
- How might people use the space after the wetlands are installed?

The researchers took notes while in the space and they also reflected on their experience once they had left the area.

As the long-term monitoring plan focuses on Glasgow Science Centre visitors, ethnography is a beneficial method to use because it does not have to involve visitors taking part in more time intensive methods, such as interviews. Therefore, ethnography is a sustainable method that allows for useful data to be collected without cutting into the limited time of visitors (Rantala, 2011). Considering the lack of publicly accessible data on visitor numbers and the use of space in the Canting Basin, ethnographic research provides useful opportunities to collect this information.

Ethnographic data was analysed through processes of inductive coding; accounts were analysed for emerging themes in line with ecosystem services.

Applying Ethnography to the Long-term Monitoring Plan:

Regular observations of the river Clyde basin will effectively monitor how visitors are using the space once the floating wetlands have been installed. Following the baseline study, regular visits all year round to the area are to be undertaken by researchers and / or Glasgow Science Centre staff, with observations to be taken from multiple different areas.

These observations can include personal experiences and perceptions, but there should also be an equal focus on the interactions that visitors and members of the public are having within the space. A set of guiding questions was also used to encourage their thoughts:

- Who is spending time in the area?
- What are they doing / experiencing in the area?
- Are people interacting with the nature available in this space?

- Are people interacting with the floating wetlands exhibition?
- What are you doing / experiencing in the area?
- How does spending time in the area make you feel?
- What are your experiences with nature within this space?

Questionnaires

Questionnaires are a pertinent and valuable method to use to gather information on views and experiences of a wide range of participants within a selected area, particularly when the questionnaire is hosted online (McGuirk et al., 2016). As such, questionnaires are a cheap method to employ, and offer an effective way of gathering large volumes of both qualitative and quantitative data.

A baseline survey was designed in collaboration with Glasgow Science Centre aimed at providing Glasgow Science Centre visitors and members of the public with an opportunity to share their views of the River Clyde Basin and general urban greening objectives prior to floating wetland installation. The survey was split into four sections:

1. Perceptions and use of the space
2. Opinions on the design visualisations of the floating wetlands
3. Looking to the future of urban greening objectives in the River Clyde Basin
4. Participant Demographics (optional section)

The questionnaire was created on Microsoft Forms and included a Glasgow University information sheet and consent form for participants to complete prior to accessing the survey. Posters were created to advertise the survey and were displayed in Glasgow Science Centre IMAX café. They included a QR code that allowed participants to easily access and complete the survey on their phones. The questionnaire link was also advertised to various target groups, including MSc students and staff from the School of Geographical and Earth Sciences at the University of Glasgow, and Glasgow Science Centre staff via newsletter.

Questionnaires were also carried out in person with various community groups, including:

- Hidden Gardens
- Gilded Lily

Questionnaire data was analysed twofold: qualitatively and quantitatively. Inductive/deductive coding was carried out on open-ended survey responses, to assess for the emergence of codes relation to ecosystem services.

Applying Questionnaires to the Long-term Monitoring Plan:

An online questionnaire will be created to provide Glasgow Science Centre visitors and members of the public an opportunity to share their views of the floating wetlands project in the Canting Basin. Although this will be created online, researchers should be encouraged to also carry out the questionnaires in person as per the baseline study to maximise respondents.

This new questionnaire will include closed and open questions to allow respondents to share detail of their views and opinions. Similarly, to the questionnaire designed for the baseline study, it will be split up into multiple sections that focus on gathering different information. These sections are as follows:

1. Perceptions of the space

This will include questions surrounding visitor's opinions of the floating wetlands installation, such as the benefits and disbenefits they think that it brings to the space and if it adds to their experience of being in the space. It will also include questions surrounding what activities respondents use the space for. Following the baseline study, data gained from these questions will be used to identify if perceptions and the use of the space have changed.

2. Urban greening objectives

This section will focus on how impactful the floating wetlands are in generating interest in learning about local wildlife and in supporting further urban greening along the river Clyde. This will also include questions about if the floating wetlands generates an interest in learning more about the biodiversity crisis in cities, climate change, and nature-based solutions. Following the baseline study, data gained from this section will be used to determine how the floating wetlands project has impacted perceptions and opinions of nature-based solutions and climate change in cities.

3. Demographic information

This optional section will be used to gather the demographic data, including post-code, age and gender to monitor how representative the study's sample is of the wider Glasgow population. In addition to this, demographic data will be used for equalities monitoring to determine how the use of the space by different groups of people has changed since the installation of the floating wetlands.

Glasgow Science Centre have already created a questionnaire that can potentially fit into this long-term monitoring plan, but this questionnaire does not have ethical approval from the University of Glasgow Ethics Committee. This means that, following the guidance above, a separate questionnaire would need to be created and submitted for ethical approval before further data gathering or analysis is undertaken by researchers from the University of Glasgow.

Like the baseline study, this questionnaire would gather a mixture of qualitative and quantitative data. The qualitative data can be coded through an inductive or deductive approach, with the main findings being grouped together by several themes. A statistical analysis can be carried out on the quantitative data, particularly to identify correlations between responses and to assess how the data may change during each analysis period.

Interviews:

Interviews provide participants with an opportunity to discuss the floating wetlands project and the social and cultural ecosystem services in way that allows respondents to provide more detail into their answers (Secor, 2010). Flexibility can be easily embedded within interviews

to allow participants to have the freedom to talk about what interests them most and for the researchers to be receptive to this and tailor their responses and questions accordingly (Brinkmann, 2014).

Applying Interviews to the Long-term Monitoring Plan:

Following the baseline study, this report recommends the continued use of semi-structured interviews. This report suggests that a minimum of 10 interviews in total per monitoring period should be carried out. These interviews should include a range of open and closed questions, with opportunities for participants to expand on their answers during the discussion. A wide range of participants can be recruited for this, including Glasgow Science Centre visitors, members of the public who use the space, community groups, and those who specialise in sustainable urban regeneration and nature-based solutions like floating wetland ecosystems.

The content of the interviews will change depending on the interviewee, and this is something that is supported by the flexibility permitted within the semi-structured approach (Secor, 2010). Despite this, the interviews should follow a similar structure to that of the questionnaires, and be comprised of three general sections:

1. Perceptions of the space
2. Urban greening objectives
3. Demographic information

The questions that make up each section can change to best suit the respondent. For example, an interview with a member of public should focus more on the perceptions the respondent has of the space and the impacts this brings for personally. Whereas an interview with a participant who specialises in nature-based solutions should focus more on drawing on their knowledge of the benefits and disbenefits that floating wetland ecosystems can bring to urban waterfronts and the communities spending time there.

Workshops

Workshops are an important method for this study due to their ability to provide accessible community engagement that focuses largely on collaboration where workshop participants could learn about new topics together. As the drive to increase public engagement with urban regeneration and development projects continue, workshops have been one of the main ways in which communities have been invited to feed into a project (Petts, 2007). Workshops have also been found to help in the advancement of issues surround inclusivity by providing opportunities for a wide range of communities, especially marginalised communities, to learn about biodiversity and play an active role in sustainable urban regeneration. This includes supporting the enhancement of social and cultural ecosystem services as workshops can have a lasting impact on participants, allowing them to establish a connection with the areas and ecosystems they learn about (Andrews et al., 2022).

Glasgow Science Centre undertook many workshops with different community groups during the duration of this study. These workshops were hosted by Glasgow Science Centre in their Bothy and each session worked with between 10 – 20 participants. The aim of the workshops

was to involve the community groups in the floating wetlands project – these sessions were designed to provide the community groups with contextual information about the project, as well as give them the opportunity to work on creative representations to be used in the space. The workshops followed a specific structure and included a presentation on the floating wetlands project, group discussion of the floating wetlands project, and the creation of artwork for the floating wetlands community almanac.

University of Glasgow researchers attended two of these workshops with the community groups Gilded Lily and Hidden Gardens, and implemented the following methods:

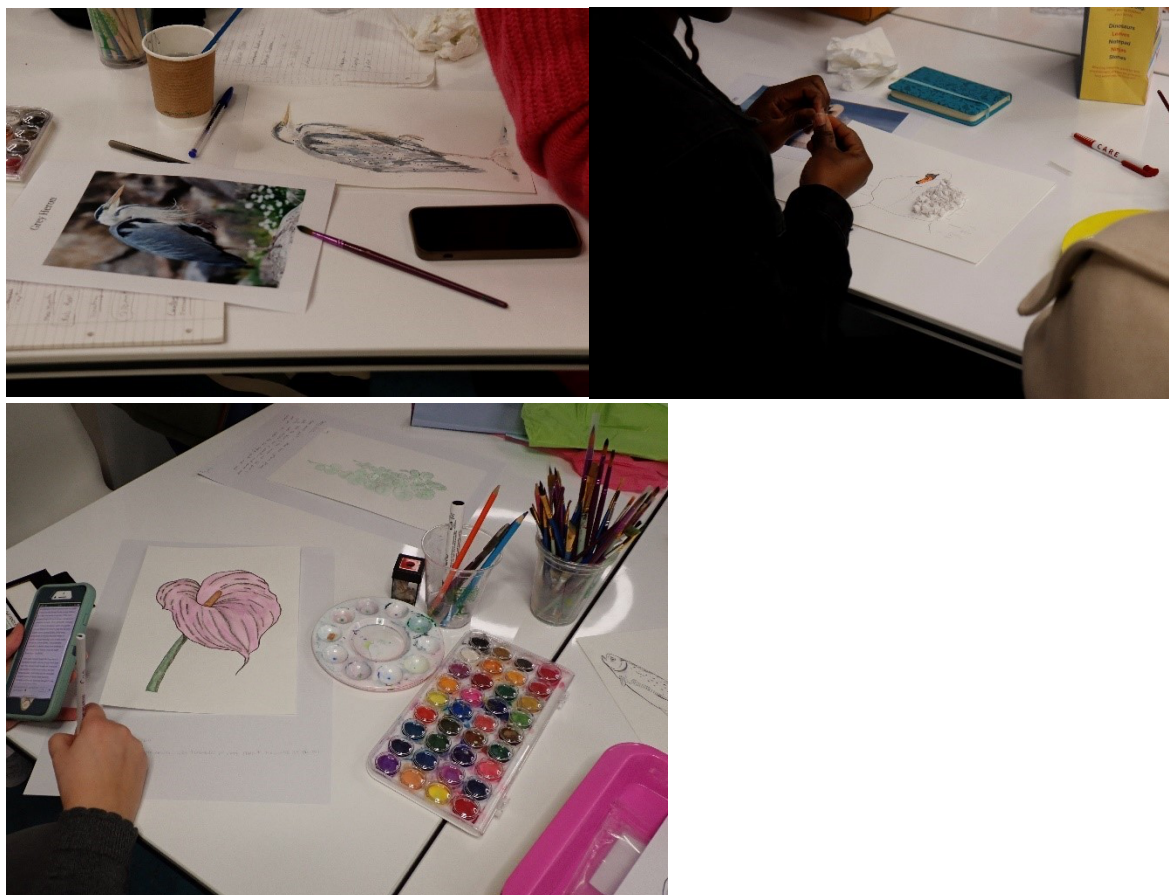
- Participant Observation – attending the session and taking part as participant observers.
- Recorded Interviews – short conversations with community members regarding their perceptions of the floating wetland project relative to participants history in Glasgow, and greening objectives more generally.
- Photography - photographs of participants creating artwork and artwork to be used in the community almanac.

Sessions began with general introductions from participants, Glasgow Science Centre staff, and researchers – everyone introduced themselves by name and participants from the community groups outlined how long they had been members of their groups. Following introductions there was an hour-long PowerPoint presentation and discussion facilitated by Glasgow Science Centre – this included an overview of the project, a history of Glasgow and the Canting Basin, and an overview of the potential impacts of the project. This was informal in its approach and participants were encouraged to ask questions and discuss these topics, including biodiversity, floating wetlands, the Canting Basin, impacts of floating wetlands on biodiversity, culture, society, etc. Researchers from the University of Glasgow offered context around the project, outlining both the physical and human elements of study. As a way of contextualising the floating Wetlands, all participants, researchers and Glasgow Science Centre staff collectively visited the Canting Basin, observing through the Science Centre windows; Glasgow Science Centre spoke briefly about the history of the site, what it had been used for and encouraged participants to reflect on what they remember from the past. This gave participants the opportunity to see the site prior to installation and to reflect on how the space had been used before. Participants were also asked to contribute suggestions for what else they might like to see in the space. We then returned to the Bothy, where the PowerPoint was concluded with an overview of the impacts Glasgow Science Centre expect from the project.

The PowerPoint was followed by lunch during which time participants completed UofG questionnaires, including relevant consent forms and information sheets. While participants were completing questionnaires, UofG researchers answered questions regarding the questionnaire and the research being conducted.

After lunch, Glasgow Science Centre introduced participants to the creative activity, outlining that participants were being asked to create a piece of art for their community almanac. The community almanac is going to be linked to the information boards at the wetlands via QR code – members of the public will be able to virtually look through the community almanac when visiting the site. This was framed as a way of bringing the community together and getting them involved in the project.

Participants were asked to select a piece of artwork to draw/paint/collage/etc. Or create a piece of artwork of their own, relating to nature – this included pictures of plants, birds, animals, etc. Participants were able to trace these, free-hand, or paint what they wanted. There were three workstations set up across the room – one station had lighting boards for tracing, one station had coloured pencils and paint, and the other station had watercolour pencils and paint. Participants were given approximately 1.5 hours to create their artwork and were asked once finished to write one factual statement about the element they had chosen and a sentence about why they chose it, to be included with their piece in the almanac. While participants were painting, researchers also took part in the activity and sat discussing the history of Canting Basin, participants' experiences of the site, or participants opinions and understandings of greenspace, or they moved around the room to take photos of the workshop in action. Photographing the artwork gave the researchers an opportunity to talk one-on-one to the participants and discuss their interests in the project and how they view the wetlands. Some of these discussions were recorded by the researchers upon agreement from the participants, which led to a deeper understanding of community member's usage of the space around the Canting Basin and how that may change with the installation of the wetlands. At the end of the session the pieces of art were collected by Glasgow Science Centre, and participants left.



Applying Workshops to the Long-term Monitoring Plan:

Following the baseline study, Glasgow Science Centre should continue to facilitate workshops aimed at members of local community groups that should follow a similar structure as before, such as:

- Presentation
- Discussion
- Creative activities
- Summary

Workshops should have a range of 10-20 participants and ensure that the collaborative and creative environment from the baseline study is continued throughout all future workshops. A key limitation to the application of this method for the baseline was that ethical approval to work with vulnerable groups was not granted. Moving forward, it is important that research on the long-term monitoring plan includes ethical approval to work with vulnerable groups in order to gain a better sense of the benefits and disbenefits the floating wetlands have for all members of the community, ensuring that the study is representational of wider Glasgow population.

These workshops should include a focus group element, where staff or researchers can ask participants more detailed questions about the floating wetlands and related topics in order

to gain a more detailed insight into social and cultural ecosystem services. This would be particularly useful opportunity to find out more about if the connection to nature has changed since the floating wetlands have been installed. Engaging with community members also provides them the opportunity to provide feedback that may be helpful for Glasgow Science Centre in terms of drawing in more interest. In addition to this, valuable insights from communities can be used to inform future urban greening projects, allowing communities to play more of an active role in how their local area changes. The baseline data shows that a number of individuals from the community groups included within this study enjoy using the area around the Glasgow Science Centre on a regular basis for commuting or leisure and have an interest in improvements around the basin.

Ethics:

This project was granted full ethical approval by the University of Glasgow's College of Science & Engineering Ethics Committee.

Before participants could take part in both the questionnaires and the workshop, they were asked to provide informed consent. As part of this, participants were required to read an information sheet detailing the aims of the study; it also provided relevant contact details for researchers on this project, allowing participants to contact the researchers with any questions or concerns about their participation in the project. A consent form was also provided asking them not only to consent to taking part in the study, but also to consent to how the information they provide could be presented. Both documents outlined that consent was voluntary and could be withdrawn at any time without reason.

As part of the ethics application, it was outlined that this project would not include the participation of any vulnerable groups. This includes people under the age of 16 or adults at risk of harm. The project obtained confirmation from Glasgow Science Centre to ensure that there would not be any at-risk adults or children participating in the community group sessions we attend.

Total anonymity of the participants could not be provided due to optional provision of demographic data in the questionnaire, such as gender and postcode. However, efforts were taken to ensure that participants could be granted partial anonymity, including the use of synonyms for data storage and analysis. All data gathered, including signed information and consent sheets, are stored on a secure University of Glasgow server, with only the relevant researchers being able to gain access to this on a password protected laptop or computer.

Ethical considerations surrounding the ethnographic methods did not require the use of information sheets and consent forms. Data collected was based on the researchers' personal experiences within a public space. Researchers refrained from using personally identifiable details to describe people observed, ensuring that participants would remain anonymous. Photographs were taken of the public space, and it was a personal choice if the researchers

decided to include identifiable images of participants within this. Observations were recorded in handwritten notes while in the space, with these later being typed up and stored securely.

Applying Ethics to the Long-term Monitoring Plan:

It is expected that the long-term monitoring plan will employ the same ethical approach as the baseline study, with a detailed research and methodological proposal being submitted to the University of Glasgow's Science & Engineering Ethics Committee for approval. This includes ensuring that the methods for data collection, storage, and analysis are compliant with GDPR.

Glasgow Science Centre have different approaches to ethics than that of the University, with ensuring that their work and research is GDPR compliant being the only concern. As such, future collaboration with Glasgow Science Centre and the University must involve a discussion of how to move forward in a way that would comply with the University of Glasgow's Science & Engineering Ethics Committee guidance.

It should be emphasised that total anonymity of the participants would not be able to be granted due to the collection of personally identifiable demographic data, such as postcode. Despite this, efforts should still be taken to ensure that participants can be granted as much anonymity as possible. This should include employing the use of synonyms throughout data analysis and ensuring that all data gathered is stored on a secure server, with only the relevant staff and researchers being able to gain access to this on a password protected laptop or computer.

Summary

The methods outlined above are complimentary to one and other, with Table 10 outlining how these methods can be used separately and together to identify social and cultural ecosystem services provided within the Canting Basin and monitor the seasonal changes to provide a holistic yet detailed overview.

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