



symbiorem

**FLOATING WETLAND PILOT
INSTALLATIONS**

ALCN
29/02/2024

PROJECT INFORMATION

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| Project Acronym | SYMBIOREM |
| Project Title | Symbiotic, circular bioremediation systems and biotechnology solutions for improved environmental, economic and social sustainability in pollution control |
| Grant Number | 101060361 |
| Project Coordinators | Dr. Leire Ruiz Rubio, Dr. José Luis Vilas Vilela, Dr. Mónica Loyo-Menoyo University of the Basque Country - UPV/EHU |
| Project Duration | 1 September 2022 - 31 August 2026 |

DELIVERABLE INFORMATION

| | |
|---|------------------------|
| Deliverable No. | 4.4 |
| Dissemination Level ¹ | PU |
| Work Package | 4 |
| Task | 4.5 |
| Lead Beneficiary | ALCN |
| Contributing beneficiary(ies) | THAMES, CNR, UPWR, EZY |
| Due date of deliverable | M18 – 29 February 2024 |
| Actual submission date | M18 – 29 February 2024 |

¹ PU = Public



PP = Restricted to other programme participants (including the Commission Services)

RE = Restricted to a group specified by the consortium (including the Commission Services)

CO = Confidential, only for members of the consortium (including the Commission Services)

DOCUMENT HISTORY

| V | Date | Beneficiary | Author/Reviewer |
|-----|------------|-------------|---------------------------------|
| 0.1 | 23/01/2024 | ALCN | Marco Hartl |
| 0.2 | 25/01/2024 | ALCN | Tiziana Centofanti/Eriona Canga |
| 0.3 | 29/01/2024 | T21 | Nathalie Gilbert |
| 1.0 | 21/02/2024 | ALCN | Marco Hartl |
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| 3.0 | 28/02/2024 | EHU | Leire Ruiz |



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EXECUTIVE SUMMARY

Deliverable 4.4 provides a comprehensive update on the current progress and results related to Task 4.5, 'Development of Floating Wetland Enhanced with Mussels.' This innovative solution is being tested at two primary sites: the Wulka River near Lake Neusiedl in Austria, and two distinct locations in Thamesmead, London, UK.

Originally, Lake Neusiedl was selected as the pilot site in Austria. However, due to its low water table and high salinity, which are not conducive to the optimal growth conditions for freshwater mussels, the trials were relocated to the Wulka River. The Wulka River, a major tributary and a significant source of pollution to Lake Neusiedl, was deemed a more suitable location for the trials.

An initial survey was conducted to assess the presence of native mussels in both the lake and the Wulka River. However, no native mussels were found. As a result, it was decided to procure mussels, common species found in major European lakes, from Poland. These mussels will be procured and supplied by Uni Poznan, Poland.

The experimental tests will be conducted in IBC tanks strategically placed near the river. This setup allows for the inflow of water pumped from the river, which is then treated with the combined system of Floating Treatment Wetlands (FTW) and mussels, and subsequently discharged back into the river as clean water.

For the Wulka River site in Austria, the final exceptional environmental permit and final water permit were submitted as soon as all necessary information was available, specifically in early February 2024. The results of these submissions are anticipated for March/April 2024. Depending on the results and requirements, further actions will be taken to implement the floating wetland enhanced with mussels.

At Gallions Lake in the UK, also no native mussel species were found. Due to the absence of native species, the Environment Agency withdrew its initial approval for the introduction of mussels. Instead, they offered support to establish tests under controlled conditions in a tank system at a location near the lake. Thames21 has already installed the Floating Treatment Wetlands (FTWs), without mussels, in Gallions Lake on the 22nd and 23rd of February 2024. They are now preparing for separate mussel tests in the tank systems.

Unfortunately, several issues have led to delays in the progress of the task at both sites. Consequently, the current version of this deliverable can still be viewed as a draft. The partners involved in Task 4.5 aim to submit an updated version of the deliverable once the mussel tanks are installed in the UK and the FTWs and mussels are installed in Austria. This is projected to occur approximately in September 2024.

DISCLAIMER

The SYMBIOREM project is funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency (REA). Neither the European Union nor the granting authority can be held responsible for them.



1 Introduction

The Floating Treatment Wetlands (FTWs) consist of a suspended matrix planted with wetlands plants such as reeds (*Phragmites spp.*), cattails (*Typha spp.*), *Iris pseudacorus*, *Carex spp.* or *Lythrum salicaria*. This nature-based solution has the capacity to purify water through microbial removal processes in the attached biofilm, the root zone of the plants and plants themselves, in combination with a set of biogeochemical and physical removal mechanisms, with several co-benefits and ecosystem services such as enhanced biodiversity and aesthetic features in urban environments. However, depending on the context and degree of pollution, the purification performance is sometimes not sufficient to significantly improve the surrounding water quality (Cross et al., 2021). Freshwater mussels are considered ecosystem engineers and contribute significantly to important ecosystem services as they can filter water and sediments, trapping nutrients (e.g. N, P) and bioaccumulate heavy metals and other contaminants in the process (Bakshi et al., 2023; Calheiros et al., 2020; Gillis, 2012). Hence, the main objective of the T4.5 investigations is to develop an improved understanding of the performance and functionality of the bioremediation of contaminated water with the combined use of CW and mussels and will be trialled at two sites: Wulka river in Austria and Gallions lake in the UK.

In Austria, the interaction of freshwater mussels with the FTWs will be tested in a field-scale environment at the Wulka, Lake Neusiedl (see Figure 1), whereas the water quality is mostly affected by nutrient inputs from agricultural surface runoff (Kovacs et al., 2012). This is facilitated by the local project partners alchemia-nova (ALCN), Esterhazy Betriebe (EZY, on-site partner, stakeholder management) and the mussel experts of the National Research Council of Italy (CNR, Nicoletta Riccardi) and Poznan University of Life Sciences (Uni Poznan, Maria Urbańska).

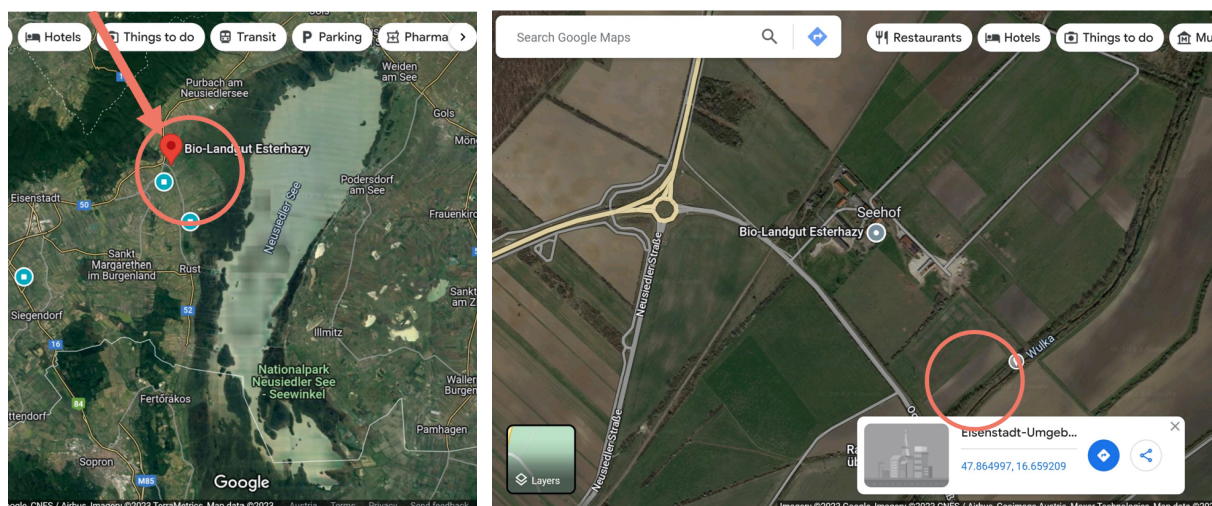


Figure 1 Site location at the Wulka upstream from Lake Neusiedl (“Neusiedler See”) close to the EZY owned estate (“Bio-Landgut Esterhazy”). Left: Large scale regional overview. Right: Close-up of the surroundings (source: Google Maps).

Mussels will also be trialled in a semi-field situation close to Gallions Lake, situated in Thamesmead and is based in the Marsh Dykes and Thamesmead Catchment of southeast London, UK (Lat: 51.498133, Long: 0.087007, Figure 3) by project partner Thames21 (THAMES) – with expert advice from CNR and Uni Poznan. THAMES work locally in conjunction with partners external to the project including the Peabody Association (the landowner), the Environment Agency (the UKs environmental protection agency) and the local community.



Figure 2: Site locations the Gallions Lake mussel trials in

for the

Thamesmead area of east London, UK. Regional scale map showing Gallions Lake (smaller red circle and inset), where the floating wetlands were implemented and the location of the holding tanks at the Environment Agency's facility at Crossness Pumping station (large red circle) where the trials of mussels will take place.

Field trial activities at the two sites will be discussed below.



2 Lake Neusiedl Wulka Site, Austria

2.1 Statement on the draft version of D4.4 for the Lake Neusiedl Wulka site

The D4.4 description of the field scale trials at Lake Neusiedl is a draft version and the final version will be handed in once the field scale trials are installed. The reasons for the delay in installation are manifold and listed shortly below and described in more detail in the subchapters after that:

- *ALCN handed in the available project task description and actions planned at Lake Neusiedl to the local authorities for permit evaluation (more details see “Permits” section below), right at the beginning of the project and got a reply with additional information needed to consider a positive permit evaluation. Meetings, mail discussions of all involved partners, and a couple of onsite visits of the project mussel experts from CNR and Uni Poznan at Lake Neusiedl were needed to gather and define this information.*
- *After a first visit by the mussels experts, Lake Neusiedl itself was found to not be a feasible site for FTWs enhanced with mussels, as the water level is extremely low and variable in the last summers, also the salinity of the lake is not favourable for freshwater mussels, therefore an alternative was investigated and found in the Wulka river (main tributary of the Lake), however, this change delayed the project progress by a few months.*
- *From the first contact with the local authorities, it became clear that to hand in the final environmental permit an initial survey of mussels in the new site, the river Wulka, had to be made. However, for this initial survey also a permit was needed, which again coordination with the task partners Esterhazy Betriebe (EZY) and of course consultation and discussion with the mussel experts from CNR and Uni Poznan, to define the field setup and experimental design, and provide the right information to the authorities. Of course, this also had to be discussed and approved by the project coordinators. Hence, adapting to the new circumstances and redefinition of the task naturally needed more time than planned initially.*
- *The above-described initial mussels survey (necessary for the final environmental permit) needed to be done by the project mussel experts from CNR and/or Uni Poznan in person, for which a suitable date for all partners had to be found and the weather needed to be right to provide the conditions to be able to survey mussels.*
- *To hand in the final environmental permit as well as the necessary water permit (for extracting water from the Wulka) all the steps above and information gained from the actions thus far as well as comprehensive discussion and feedback loops on the final setup were necessary to finally hand in the two permit requests at the beginning of February 2024.*



2.2 Initial investigations and adaptations

Task 4.5 faced several initial challenges regarding field experiments at Lake Neusiedl;

- 1) *Lake Neusiedl had historically low water levels, which is not uncommon as it is a shallow steppe lake, however, 2023 broke records in that aspect, partly due to climate change, usage patterns and other factors.*
- 2) *During the first planned site visit by the mussel experts from the SYMBIOREM partner institutions (Nicoletta Riccardi from CNR and Maria Urbanska from Poznan University) together with partners alchemia-nova (ALCN) and Esterhazy Betriebe (EZY) on 27 March 2023 faced unexpected environmental conditions that were not conducive to sampling and the installation of the mesocosms for the mussels. The lake was not visible for hundreds of meters from the shore due to low water levels and the wind pushing the lake to the other side (Figure 3). These fluctuating water table conditions together with the inherent slightly increased salt concentrations in the lake are not suitable for freshwater mussels. The low water levels and high variations also made it impossible to install the FTWs within the initially planned field scale mesocosms within the lake.*



Figure 3 Left: Site visit by SYMBIOREM mussel experts with the lake gone for hundreds of meters from the shore on 27 March 2023 (see left in the picture). Right: Exemplary treatment wetland system within a cut-open IBC tank

Given these factors, the field site was relocated to the Wulka river, a key surface tributary significantly influencing Lake Neusiedl's water quality especially due to the agricultural surface runoff in the catchment (Kovacs et al., 2012). The main sources of nutrients originate from agriculture, surface runoff, and wastewater treatment plant (WWTP) effluents. As the Wulka is a relatively small river and water

level and runoff quantity can vary highly, it was decided to test the FTWs and mussels in cut-open IBC tank systems next to the Wulka riverbank (see exemplary system in see Figure 3, right).

The selected location for the IBC field test is at the coordinates: latitude 47.8647370 and longitude 16.6589595 (see Figure 1), near a farm estate of the SYMBIOREM partner EZY (*Bio-Landgut Esterhazy*, Seehof 1, 7082 Donnerskirchen, Austria). At this location, the land around the Wulka section is owned by partner EZY and easily accessible from their estate and generally well accessible by vehicles.

2.2.1 IBC tank field trial setup

The extracted water from the Wulka will be pump-fed into 8 cut-open IBC tanks above the Wulka riverbank (see Figure 4). The overflow and/or drainage water from the tanks will be returned to the Wulka, so in the end all the water taken from the river - minus the evapotranspiration - will be gravimetrically returned to the Wulka. All tanks will be equipped with small aquarium aeration pumps in the bottom to the necessary oxygen levels for freshwater mussels to survive. In four of the eight IBC tank systems, floating treatment wetlands (FTW) are placed. The FTW will be provided by Biomatrix, a London-based manufacturer that successfully installs such FTWs worldwide and also provides the FTWs to THAMES at Gallions Lake. The design was discussed with all Task partners to agree on a suitable design for FTWs, mussels, and the aims of the investigation (see Figure 5). Autochthonous and local plants will be used in the FTWs with species such as reeds (*Phragmites spp.*), cattails (*Typha spp.*), *Iris pseudacorus*, *Carex spp.* or *Lythrum salicaria*.



Figure 4 Sketch of the setup adjacent to the Wulka with 8 IBC tanks, water intake and backflow.

The FTW floater materials are extremely strong and resilient (primarily HDPE, no PVC or Styrofoam) which were carefully selected due to their recycled content and recyclability and only non-toxic materials are used. Once the plants and biofilm are established, the system consists of ca. 60% living biomass and

30% marine engineered materials. The FTW itself also has space for the colonization of bacteria for metabolization and absorption of pollutants (see also <https://www.biomatrixwater.com/floating-ecosystems/>).

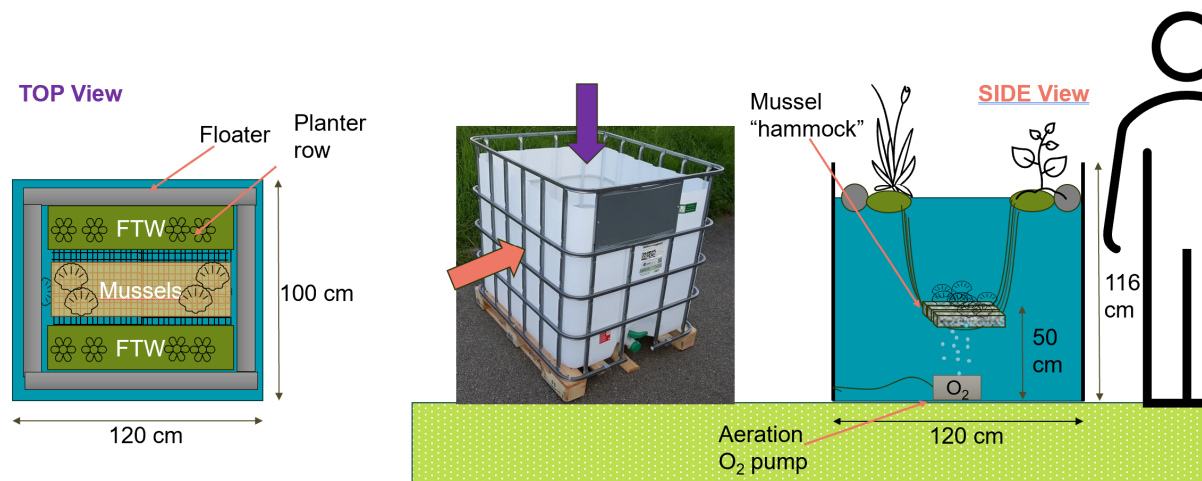


Figure 5 Top and side view sketches of the proposed IBC tank system including FTWs and mussels.

To determine the effect of FTWs and mussels separately and in combination, four treatments in duplicates will be tested:

- 1) Duplicate without macrophytes and without mussels [control],
- 2) Duplicate with macrophytes but without mussels,
- 3) Duplicate with both, macrophytes and mussels,
- 4) Duplicate without macrophytes but with mussels.

These four duplicates will be arranged in a randomized fashion to exclude external effects (e.g. wind or sun exposure) on the treatments as much as possible (see exemplary arrangement in Figure 6).

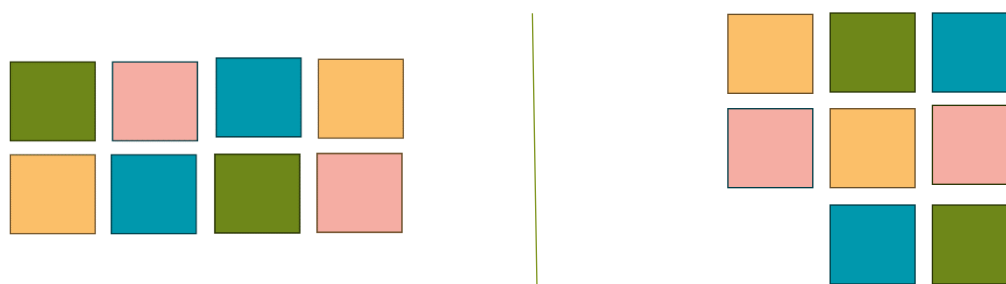


Figure 6 Two possible randomized arrangements for the four treatment duplicates.

As one mussel can be estimated to filter 40L of water per day, a stocking of 25 mussels per system will be proposed for the ca. 1000L holding IBC tanks, which would mean that theoretically the whole water volume is filtrated once per day. Therefore, the potentially foreseen daily water change would be a maximum of 8,000 L, i.e. 8 m³ of Wulka water, whereby it could be possible that there could be extraordinary peaks due to maintenance work or the like. Therefore, a water withdrawal of max. 10 m³ per day will be requested (see **Permits** section below). Water samples taken from the IBC tanks would be analysed for nutrient content and other relevant parameters by a certified body (e.g. Institute of BOKU University or the Austrian authority AGES).

2.2.2 Permits

Already at the start of the project, ALCN submitted basic information on the project which was available at the time to the authority for the environmental exceptional permit (*naturschutzbehördliche Ausnahmegenehmigung*) to assess the requirements and additional questions of the local authorities. From the received answer from 5 April 2022, it became clear that to be able to provide the necessary information for the final environmental permit to the local authorities it was necessary to perform an initial “visual survey of mussel species” in the Wulka River which in turn also needed an exceptional environmental permit. Also, a water permit (*Wasserrechtliche Genehmigung*) will be necessary to withdraw the inflow of water from the Wulka. The initially foreseen experimental period was around March 2024 until October 2024, but **permits will be requested from March 2024 to October 2025** to accommodate delays in the project and potential extension of the experiment's planned duration- due to the adaptations needed, elaborate permit requirements and other factors - or to allow the system to run even longer and carry out further investigations if desired.

a) Initial exceptional environmental permit “Visual survey of mussel species”

The initial exceptional environmental permit for the visual survey of mussel species was handed in by alchemia-nova on 6 September 2023 and a permit was obtained on 10 October 2023. This initial exceptional permit could not have been handed in earlier due to the reasons stated in the points of the above statement (final permit requirements, site change, information and setup definition, coordination with partners and coordinators etc.). The initial visual survey of mussel species in the Wulka river was then performed by Maria Urbanska and a colleague from Uni Poznan (as Nicoletta Riccardi from CNR was incapacitated due to a medical issue) on 11 December 2023. The results of the survey showed that numerous Asian clams (lat. *Corbicula fluminea* – an alien and invasive species) but no living Unionidae bivalves, known as river mussels, or simply as unionids, were found. Only an empty shell and a fragment

of a shell of *Anodonta anatina* (duck mussel) were found. Since the habitat in the investigated section of the Wulka river is not suitable for *Anodonta anatina*, the mussel experts assume that these shells were washed down from upstream sections of the Wulka, and they estimate the chance of large populations *Anodonta anatina* to be low.

b) Final exceptional environmental permit “Floating treatment wetlands with enhanced with mussels in IBC tank systems”

As the initial visual survey results showed that there are no local mussel populations present at the section of the Wulka which could be used for the IBC tests, the current plan is to use the mussel species that Uni Poznan and CNR can provide, namely the swollen river mussel (*Unio tumidus*), given that the local authorities will accept it and release the permit. CNR will provide expert support throughout the experiment by making sure that the specimens are healthy and free of parasites, etc. Freshwater mussels, an endangered species, are challenging to import due to the protected status of Lake Neusiedl and its surroundings. The task partners anticipate difficulties in obtaining a permit for this. The plan is to argue that mussels require a specific fish species for reproduction, and since no fish are used in the IBC, mussels won't reproduce during the experiment. The difficulty in propagating and deploying mussels contributes to their endangered status. It remains uncertain whether authorities will accept this argument or adopt a precautionary stance, prohibiting mussel import altogether. Alchemia-nova submitted the permit application once all partners agreed on the experimental setup in late January 2024.

c) Water permit “IBC system inflow extraction from Wulka”

The water intake from the Wulka River to the IBC tank system will need a water permit. This permit application was handed in by alchemia-nova at the beginning of February 2024, as soon as all partners agreed on the experimental setup and provided the necessary key figures, such as the daily water exchange rate needed for the mussels, resulting in a water intake request of 10m³ per day.

2.3 Outlook and timeline of next developments

1. **Permit Applications:** Wait for the results of the environmental and water permit applications submitted at the beginning of February 2024.
2. **Permit Approval:** Within 1-2 months, the permits will either be granted (likely with conditions) or denied.

3. **Ordering FTWs:** *Once the permits are approved, the FTWs can be ordered from Biomatrix, likely around March/April 2024, with earliest delivery expected around May/June 2024.*
4. **Installation Decision:** *Depending on the timeline, a decision will be made on whether to install the systems in 2024, despite the short vegetation period left. The alternative is to wait until early spring 2025 to allow proper development time for the mussels and plants. Overwintering could risk the need for restocking.*
5. **Outreach Activities:** *Regardless of the timeline, EZY and ALCN will conduct outreach and showcase SYMBIOREM as soon as the system is set up. This includes participation in the “Biofelddtage” agricultural fair on 24 and 25 May 2024, and activities with interested citizens or school groups. These activities could potentially support operation, maintenance, sampling, and monitoring activities.*

3 Gallions Lake Site, UK

3.1 Statement of the draft version of D4.4 for Gallions Lake

The D4.4 description of the field scale trials at Gallions Lake is also in draft form and will be updated once the field scale trials of mussels are installed. Several challenges were faced in the delivery of the FTW with mussels in Gallions Lake. An expert team, sent by project partner CNR to assess the mussel populations of Gallions Lake and surrounding area, discovered that there were no mussel populations in the catchment. It was decided to proceed to install the FTW, as per the plan for D4.4 and Milestone 5, whilst at the same time investigating alternative options for sourcing of mussels which could be installed later if necessary. The FTW were installed on the 22nd and 23rd February 2024 (details in the sections below). However, it later transpired that it would not be possible to install mussels into them due to permitting issues arising from various concerns raised by the Environment Agency (the UK's environmental regulatory authority) with whom THAMES work closely. The Environment Agency shifted from a position of approval in principle for the installation of the mussels into Gallions Lake at the start of the project after it was discovered by CNR that there were no mussels already present in the catchment. These concerns arose during discussions of various options for acquisition of mussels that occurred late during the delivery phase of the FTWs. These concerns are primarily centred on reluctance to introduce a species into a catchment where it is currently not present and also the biosecurity risk of importing mussels from elsewhere. These and other concerns (ethical and ecosystem service impacts) are discussed in more detail in the sections below.

Instead of installing mussels into the FTW in Gallions Lake, an alternative system is being developed which will install mussels in tanks at a nearby facility owned by the Environment Agency. These experiments will comprise a semi-field environment in which mussels are exposed to water from the lake, including ideally road runoff pollution, and will permit further understanding of the capacity of mussels to survive in and filter water from a polluted urban location. These experiments will also inform us of the challenges of mussel acquisition and their life support which may be relevant for the business case of future roll out of mussels as bioremediation solutions in other catchments.

3.2 Initial investigations and adaptations at Gallions Lake, Thamesmead

Gallions Lake (2.9 acres in area) is situated in a series of canals and lakes built in the 1960s to store and manage surface water runoff prior to discharging into the tidal Thames River. It is situated within a housing development and is popular with anglers, specifically the Thamesmead Angling club. Gallions

Lake has no fresh source of water entering, and any water added to the lake comes from two surface (storm) water drain inlets and a gravity outlet. As a result, Gallions Lake is known to experience high levels of siltation and be heavily polluted by raw sewage from plumbing misconnected into the surface water drainage system and also road runoff pollution. The lake is artificially stocked with carp and other fish, used by the angling club for sport, however, there have been fish kills suspected to be linked to pollution levels and a history of carp specific diseases noted at the lake. A pump at the north side of the lake maintains a level of 0.61mAOD (Metres Above Ordnance Datum) before draining the water in the Tidal Thames. Further details about the lake and its issues can be found in D2.1 and D2.2.

The initial experimental concept for Gallions Lake was to design two FTWs with mussels suspended in baskets beneath them. One would house the mussels in a closed system, where water from Gallions Lake would be added at the start of the experiment the other would be open to lake water. Water samples and potentially also mussel tissue samples were to be taken at various time intervals and comparisons would be made between the open and closed systems. The aim in particular was to assess the effectiveness of mussels at filtering road runoff pollution as well as nutrients deriving from raw sewage pollution.



Figure 7: Experts searching for the mussels in Gallions Lake and another site in the canal nearby in September 2023. Not the anoxic silt stirred up by these activities. The CNR team also raised concerns about the long-term wellbeing of the mussels due to the hyper-

eutrophic nature of the lake and the deep, anoxic silt layer. However, these concerns could be mitigated by:

- i) use of oxygen bubblers and flow pumps powered by solar panels / batteries housed on the FTW. These systems would be designed by CNR and would ensure sufficient oxygen and water flow over the mussels housed in shallow trays beneath the wetland;*
- ii) Installation of mussels in short duration field trials as proof of concept rather than as long term / permanent fixtures.*

On this basis, it was decided to continue with the existing plans for designing the mussels housing and FTWs and to install them in line with the T4.5 timeline and milestone D4.4. Simultaneously, options for acquiring mussels from outside the catchment would be explored recognizing that acquisition and/or permitting challenges may result in mussels being installed after the FTWs.

3.2.1 Floating treatment wetlands

3.2.1.1 FTW: technical design and community co-design

THAMES worked with the team at Biomatrix Water (www.biomatrixwater.com) to develop a bespoke and novel FTW design that enabled the accommodation of mussels beneath it (**¡Error! No se encuentra el origen de la referencia.**). The design, 6.7 m x 2.3 m in dimensions, comprised traditional buoyant sections with coir matting and soil for the accommodation of wetland plants and two sections that can be lowered to the desired depth suspended by chains to provide a platform on which the mussels can be housed. This design permits easy depth adjustment as required and for the raising of the mussels to surface depth for inspection/maintenance. A bespoke design was also generated for the anchoring system to allow for low levels of silt and the inability to drill down into the base of the lake. This comprised concrete plates connected on chains to the FTW (Figure 9).

The planting scheme for the two FTWs was co-designed in conjunction with the local community of Thamesmead. Biomatrix Water supported the event by permitting THAMES staff access to their wetland plant planner tool. A community floating wetland co-design event was held on 18th January 2024. Due to the inclement weather this was held in a local community space and soup kitchen rather than by the lake itself. During this event members of the public were invited to view a shortlisted selection of native wetland and marginal plants and select their preferred plant species for each of the two FTWs (Figure 10). This plant shortlist (Figure 11) comprised species selected to provide multiple benefits including their attractiveness for local visitors to the lake (enhanced health and wellbeing benefits from visiting an

attractive wild space), benefits to pollinators and insects as well as their potential to take up nutrients from the lake water via roots extending down through the coir matting. As Gallions Lake is a fishing lake with an active fishing club, the benefits of the dangling root systems as habitat for fish spawning and refuges for fish fry were well received by the fishing club. This is a particular benefit because the lake margins comprise a mix of short areas of reeds with extensive sections of concrete banks which provide minimal natural habitat.

For optimal balance between water pollution removal and habitat creation, Biomatrix determined that 20% of the plants should be Edging plants, 60% Cover plants, and 20% Seasonal plants. This number of each species to be used was calculated based on the number of votes each received. The most popular plant was the Dwarf Ragged Robin.



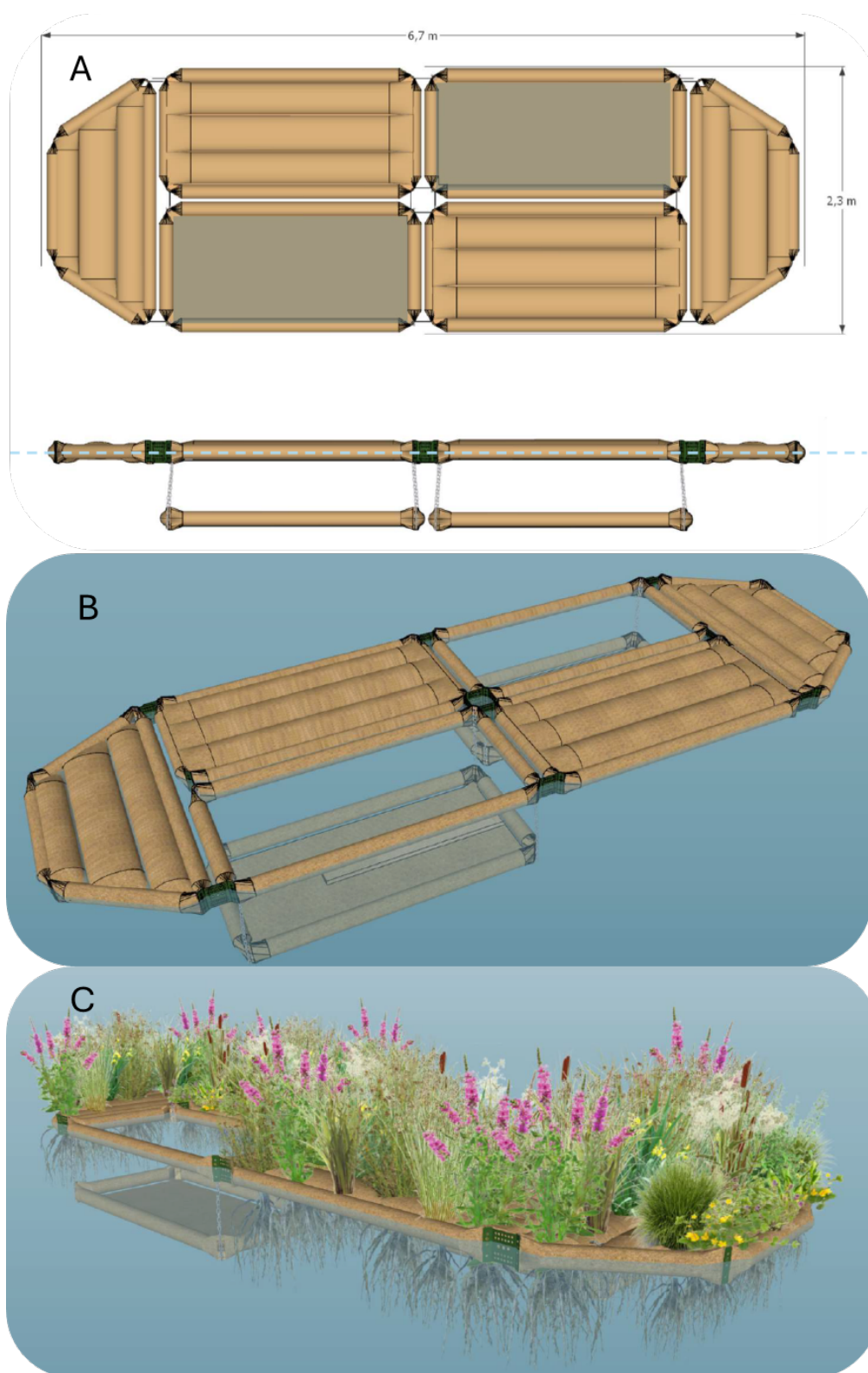


Figure 8: The FTW designed for Gallions Lake. A) Birdseye view showing the dimensions of the FTW B) Demonstrates the drop-down aspect of the FTW, these sections would have housed the mussels. C) A conceptual mock up to show how the FTW could be planted.

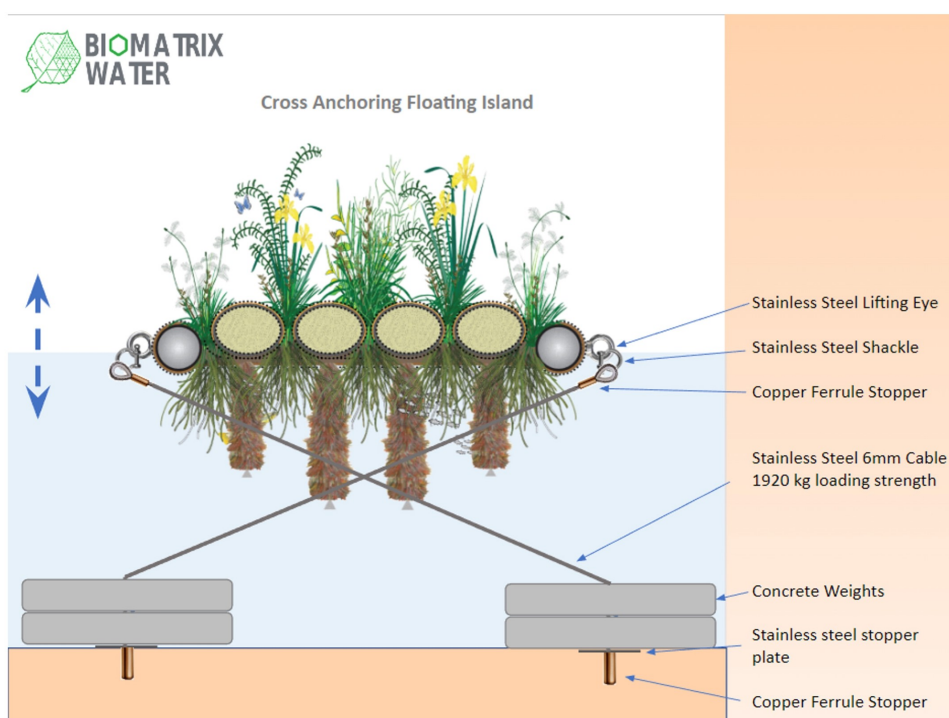


Figure 9: Anchoring system for the FTW designed by Biomatrix for Gallions Lake.



Figure 10: Members of the public selecting the plants for the FTW at the Plant Consultation day on the 18th January at the Love Soup Café.



Figure 11: The final decision of the number of plants that will be added into each FTW. This was calculated by taken the proportion of voters and converting this to the proportion of each plant type allowed to generate a final number of plants.

3.2.1.2 FTW: installation with the local community

The FTWs were built and installed with the support of the local community over 2 days (February 22nd and 23rd 2024).

February 22nd – Installation of Anchoring System

This event was not open to the public and was run entirely by THAMES and Peabody (the land owner) due to:

- *Safety concerns surrounding entering the water in Gallions Lake*
- *The use of 42kg concrete plates; therefore raising safety concerns to volunteers lifting heavy weights*

THAMES and Peabody had planned to install the anchoring system by first connecting the concrete plates together and attaching the chains to the top of the concrete plates. Peabody staff in PPE (dive suits, gloves, suitable footwear etc.) were then going to enter the lake and maneuver the concrete plates to position them in their correct locations. However, on the day, due to current planted revetments installed already in Gallions Lake it was decided to add the concrete plates and chains into the lake on Friday 23rd along with the wetland units. This was done so that the concrete could be floated out (Figure 12) onto the floating units instead of having to walk them through the silt mud layer, making it easier to position them.



Figure 12: Concrete plates and anchoring chains being transported on the floating wetland units passing through the existing revetments at Gallions Lake, Thamesmead.

February 23rd – Installation and Planting of FTWs (Figure 13 to 18)

THAMES along with 17 volunteers (4 from Peabody, 5 adults taking part, 4 adults watching but not taking part and 4 children watching but not taking part) installed the two FTWs. The wetland units were planted up in sections then taken into the lake by Peabody and connected together. The event faced some difficulties which included:

- *Plant species arriving with no labelling making it difficult to correctly identify them*
- *Allowing the volunteers to be involved in different aspects which was the result of health and safety concerns of them entering the water*

The volunteer turn out was higher than expected and the day ran smoothly resulting in positive engagement with the locals of Thamesmead.



Figure 13: Volunteers carrying a floating wetland unit along the side of Gallions Lake, Thamesmead.



Figure 14: Volunteers standing holding plants that were used to plant the floating wetlands.



Figure 15: Peabody staff in their dry suits inside Gallions Lake arranging the floating wetlands and connecting them together.



Figure 16: Volunteers laying out the plants into the coir matting and planting the wetland units.



Figure 17: Peabody staff connecting the floating wetland pieces together.



Figure 18: Floating wetland placed within the existing revetment work in Gallions Lake.

The FTW will be monitored regularly to ensure no wildlife destroy the plants during their growth phase. The wetlands were initially meant to be covered with protective wiring to ensure wildlife, particularly the local geese and other large birds, cannot enter and graze the new plants. However, due to constraints the wiring was not added onto the FTWs on the 23rd February when they entered the water. Therefore, there are concerns regarding the effect of wildlife onto the plants. The landowners, Peabody, regularly visit the location and will check the FTW to ensure no damage has occurred, and will aim to add the wiring on the 27th February.

The site in the first few weeks will be visited weekly, and in between these regular visits, once or twice a month THAMES staff will also monitor how the wetlands are establishing with the help of local volunteers. Once the plants have settled water quality monitoring samples will be taken by staff and local volunteers in order to monitor the benefits of the floating wetlands. Volunteer monitoring will be carried out using Hanna Pocket Checkers which measure ammonia and phosphate. Further monitoring will include sampling of road runoff pollution, with analysis by laboratory.

3.2.2 Mussel acquisition challenges

In the absence of any mussel populations of any species in Gallions Lake or the wider catchment surrounding it, it became necessary to investigate the acquisition of mussels from elsewhere for installation into the FTWs. CNR indicated a preference for *Unio tumidus*, the swollen river mussel, to best align with their concurrent laboratory experiments and suggested THAMES investigate three possible options:

- i) *Purchase native mussels through the aquarium trade*
- ii) *Acquire native mussels from a river catchment or waterbody (such as a reservoir) from elsewhere within the UK that already has a substantial population of mussels*
- iii) *CNR could arrange collection of U. tumidus from their European field sites (Italy and Poland) and send them to the THAMES team in the UK after first quarantining them in the CNR labs to minimise the risk of introducing harmful parasites/bacteria.*

THAMES consulted the Environment Agency, the UK's environmental protection agency, with regards to the feasibility and permitting of these options. Prior to the awarding of the funding for this project, and during initial discussions with THAMES as this project got underway, the Environment Agency had agreed in principle to the installation of mussels in FTWs in Gallions Lake. However, the lack of mussels in the catchment, discovered by the CNR team, made the situation more complex.

The Environment Agency raised concerns about all the above solutions options for acquiring mussels, citing the risk of conveying parasites and/or harmful bacteria into the catchment through introduction of mussels from elsewhere (even if quarantined first by CNR). They were also against introducing a species – even one native to the UK – into a catchment where it is not currently present. Gallions Lake connects eventually to the river Thames via a series of overflow conduits therefore poses a potential biosecurity risk and route for mussel dispersal across a wide area.

There were also ethical concerns raised both for the mussels and the local fish population of Gallions Lake. Mussels burrow and move through the sediment so being constrained in a basket or tray beneath a FTW may restrict their natural behaviour, as well as considering their exposure to the potentially high pollution levels occasionally experienced in the lake. There were also concerns about the larval stage of the mussels living in the gills of fish already stressed by pollution and disease.

Another objection of note in the context of this project is the impact on the ecosystem services in the location of the source population – i.e. harvesting mussels, potentially in substantial numbers, from one population to install them elsewhere could result in a reduction in bioremediation benefit which would be detrimental to the original site. This would need to be justified in terms of the source population site.

Various modifications to the experimental design and the design of the mussels housing beneath the FTW were discussed as part of an ongoing conversation with the Environment Agency – including creation of entirely closed systems to increase biosecurity and avoiding mussels being in the lake during spawning periods. However, the environmental and ethical risks of installing mussels in the lake were too large to overcome so instead a new plan was devised in conjunction with the Environment Agency that involved housing mussels as holding tanks in their nearby facility at Crossness Pumping Station (51.508782, 0.1382910).

3.3 Trials of mussels in holding tanks

At time of submission of this document, the details of the experiments of the mussels in holding were still being discussed and finalised with CNR, Uni Poznan, other members of WP4 (in particular ALCN) and the project supervisory team (EHU); also locally with the Environment Agency whose facilities, equipment and time of local site staff were being offered to support the experiments.

The Environment Agency offered four holding tanks for project use (measuring 2.15 x 2.15 metres with a depth of 0.6 metres and volume of 2700 L (Figure 19). These would be equipped with flow circulation pumps and possibly also oxygen bubblers. Different numbers of mussels would be installed in three of the tanks (30, 20, 10 mussels in tanks 1, 2 and 3 respectively, based on each mussels filtering approx.. 40 L of water per day) with a fourth containing no mussels as a control. Laboratory experiments at CNR use the swollen river mussel (*Unio tumidus*) but swan mussels (*Anodonta cygnea*) seem to be easier to acquire in the UK as they are sold through the aquarium trade. CNR have confirmed that using *A. cygnea* would be acceptable alternative and likely more cost effective than shipping *U. tumidus* from CNRs field sites to the UK. This strategy will potentially also be less time consuming in terms of international import permits so will allow field trials to get underway sooner.



Figure 19: Holding tank available at the Environment Agency's site at Crossness Pumping Station in the same catchment as Gallions Lake. To be filled with water from the lake and mussels.

The 4 tanks would be filled with artificial sand and water abstracted from the lake. A specific water quality testing regime and full experimental method will be determined following a pilot study lasting approx. 1 week that will determine experimental boundaries, for example: the duration of individual experiments, how frequently water should be changed, frequency of maintenance and mussel wellbeing checks, feeding (if required) and other details.

Broadly, the experiments will comprise sampling water initially (T_0) then at subsequent time intervals (T_1 , T_2 , T_3 etc) to determine the ability and rate that the mussels filter different pollutants from the lake

water. The chemical species sampled will include nutrients (such as ammonia and phosphate, typically found in raw sewage pollution) and various metals, hydrocarbons, and combustion derivatives commonly found in road runoff pollution (e.g. copper, zinc, cadmium, BTEX, pyrene). Ammonia and phosphate levels, should they exceed certain thresholds, can also act as an indicator of whether an experiment needs to be ended through carrying out a water change for the wellbeing of the mussels. Other data concerning the survival/restocking rates of the mussels will also be collected as this is potentially relevant for the development of business plans and stakeholder approval of use of mussels as bioremediation in future.

Results from these experiments will feed directly into T2.4 Collaborative Catchment Management and tasks associated with WP6 (Assessment Methods and Environmental, Economic and Social Impact Evaluation).

The Crossness Pumping Station site is not open to the public, but the Environment Agency have agreed to permit volunteers trained by THAMES to access their facility in order to support the experiments through assisting with maintenance checks and water sampling.

There are various challenges still to be overcome with the above experimental designs, namely:

- *Water changes – Completely filling the 4 holding tanks requires 8 journeys by tanker truck to abstract from the lake, which is 6.5 km away by road. Including travel time and time for the water to be lifted into then emptied from the tanker, this represents considerable logistical and resource effort by the Environment Agency. A balance therefore needs to be struck between mussel wellbeing and experimental design.*
- *Abstraction – As mentioned above, water levels in Gallions Lake are regulated by a pump as they are generally low. Regular abstractions from the lake, especially if the weather is dry with little rainfall, will be detrimental to the lake and, if very regular, may require an abstraction license.*
- *Capturing road runoff – A key aim of the activities in Gallions Lake was to monitor the impact of a FTW enhanced with mussels in mitigating road runoff pollution. However, conveying lake water to the holding tanks is a large undertaking and is unlikely to be sufficiently agile to capture event driven pollution such as road runoff. Alternatives (such as local volunteers collecting road runoff pollution in jerry cans provided to them as it occurs) may be possible but requires further thought and discussion with the local community to determine their willingness to participate.*
- *Mussel's monitoring and maintenance – Regular checks on mussels housed in tanks was not a previously anticipated project requirement. Environment Agency staff do not necessarily visit the*

Crossness Pumping station site daily and THAMES staff live several hours journey away. This poses challenges for regular checks on the mussels. Again, trusted volunteers from the local community may be able to support this.

- *Training of staff and volunteers in mussels care and maintenance. Neither the THAMES nor Environment Agency staff at Crossness have previous experience in care of mussels so support from CNR in the form of a training program and ongoing support for queries and troubleshooting will be required.*
- *Current disconnect between the FTWs installed in Gallions Lake and the mussels experiments taking place in Crossness Pumping Station. It may be possible (time, budget and permits permitting) to install into the Gallions Lake FTWs other forms of bioremediation developed through this project, should they prove to be successful. An example would be inoculating the wetland with bacteria to enhance the bioremediation potential of the microbiome, T4.4). In this way the FTWs on Gallions Lake could provide additional field data to support project outcomes and serve as a site for discussion with UK catchment decision makers seeking to tackle water quality issues using bioremediation.*

3.4 Outlook and timeline of next developments in Thamesmead

1. ***Finalise experimental design (1-2 months)***
2. ***Source and purchase mussels: To be actioned once the design set up is fully developed (1-2 months)***
3. ***Provisional start date for mussels trial: late May 2024.***
4. ***Monitoring of FTW with the local community: From after the plants have established (from May 2024)***
5. ***Monitoring of mussels in holding tanks with the local community: Provisionally from late May, depending on final experimental design. The holding tanks are available for 6 months.***

4 Conclusions

The goal of T4.5 is to trial floating treatment wetlands (FTWs) in combination with mussels at two primary sites in order to investigate the treatment performance and potential improvements due to the mussel introduction. However, both sites faced a variety of legal and technical challenges.

After several hurdles and feedback loops between project partners and the authorities, the Austrian Lake Neusiedl Wulka site partners ALCN and EZY in collaboration with CNR and Uni Poznan were able to obtain all the information required by the authorities in order to hand in the necessary environmental and water permit documents at the beginning of February 2024. The plan is still to test FTWs and mussels combined in cut-open IBC tanks next to the main tributary to Lake Neusiedl, the river Wulka. Again, the introduction of mussels due to the lack of a local population can be expected to be the key issue. The decision and potential requirements by the authorities can be expected in March-April 2024 and will determine the next actions at the site. In case of a favourable outcome the installations could potentially be implemented in spring or early summer 2024.

The UK partners THAMES in collaboration with CNR and Uni Poznan were able to define the FTW design for Gallions lake and even install the systems in late February 2024. However, since the Environmental Agency finally withdrew its support regarding the introduction of mussels to the lake, due to the finding that no native population is present, the FTWs could not be combined with mussels but could potentially host another enhancement strategy researched in SYMBIOREM such as the enhancement with special microorganisms. The mussels itself will be tested in tanks not connected to the Gallions Lake water body, which causes several challenges to be overcome, including the logistics of water supply, regular operation and maintenance checks as well as the introduction of road runoff in the systems.

Apart from the technical and legal aspects, the social dimension of the task is well underway with active citizen engagement in the UK and several events and activities planned at both trial sites.

The Task 4.5 partners aim to hand in an updated version of once the mussel tanks are installed in the UK and the FTWs and mussels are installed in Austria.

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