# 2. Case Studie: United Kingdom

## Initial Situation

Ein Bild, das draußen, Pflanze, Gelände, Stein enthält.

Automatisch generierte BeschreibungThe case study is located to the north-west of the centre of Exeter - UK (USDA zone 8a). The site is dominated by a slope and was modified by structural measures so that the pond facilities and the natural pool are ideally integrated into the surroundings. The slope to the west has been terraced in several sections, firstly to secure the underlying terrain, but also to create new utilisation possibilities. To this end, the bridge at the highest point of the property was demolished and redesigned so that the existing stream runs underneath it and can flow towards the garden. Care was taken to ensure that the stream could be optimally integrated into the overall project. Coming from the south, the water cascades over small and large, precisely placed natural stones into an approx. 60 m² pond basin at the foot of the farmhouse. These gradations also ensure that the rising water does not develop into a torrent in winter. Starting from the pond basin, the water from the stream is channelled past the natural pool by means of a ditch (see Fig. 1) and down into two settling basins that are offset in height. The ditch is designed to prevent the swimming pond from flooding in the event of high water. Two 50 cm diameter sewer pipes (KG pipe) are installed under the ditch for further drainage. After the course of the stream was adjusted, the natural pool was planned in the resulting trough. The trough was extended further and a swimming area with a filter and planting zone was created. Starting from the sedimentation basin, the stream flows below the road through two 50 cm wide sewer base pipes. From there, it flows into another pond basin and is channelled back into its original form.

Fig 1: Drainage Ditch  
(Goedermans 2024)

## 2.3 Location and Design Principles

## Ein Bild, das draußen, Pflanze, Baum, Himmel enthält. Automatisch generierte BeschreibungThe natural pool is located to the west of the house in the centre of the property (see Fig. 2). The pool measures approx. 100 m² and is surrounded by a wooden deck on the left and the filter zone and shallow water zone on the right. A formal design was chosen for the swimming pool itself. Integrated boulders serve as diving rocks. These can be reached from the upper and lower parts of the pool through the shallow water zone. The area is surrounded by a wooden walkway that leads to both the house and the wooden deck.

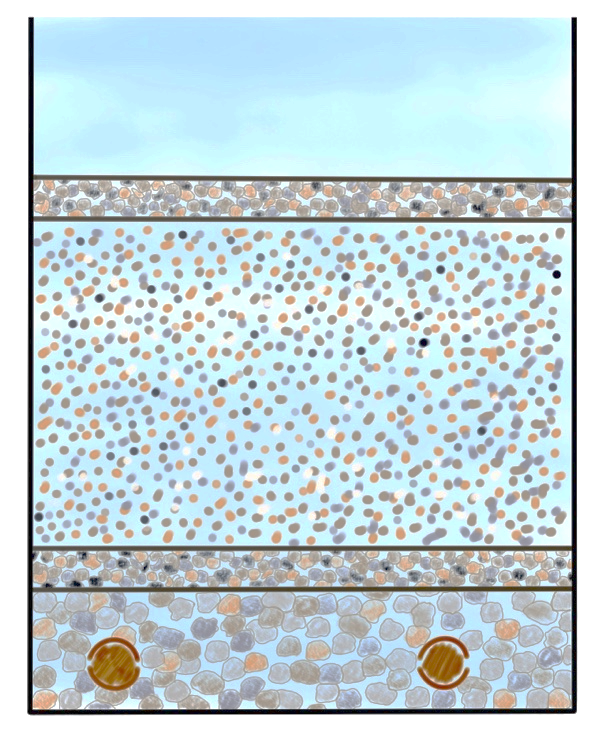
Fig 2:View of the natural pool from the west towards the house  
(Goedermans 2024)

The terraced slope in the background provides an optimal view of the natural pool on several levels. The individual terraces are enclosed by natural stone walls and are used in different ways by the owner. Whether as an outdoor kitchen with integrated vegetable and herb beds, as a simple retreat or as a fireplace. The terraces offer a welcome change with fantastic views. The natural stone walls are skilfully designed and integrate perfectly into the site itself. Well thought-out planting of the individual walls brings additional colour and texture to the garden, making the wall appear more lively. The different heights of the natural stone walls also leave room for expansiveness and therefore do not restrict the plot, but rather expand it.

## Purification

The case study north-west of Exeter, UK, has a biofilm-building substrate filter (BSF), a sand filter pump and a UV light filter to keep the pool water clean. A surface skimmer, an underwater gravel suction system, two pumps and three inlet nozzles are also installed. The substrate filter in the case study is 15 m² in size and was designed to be completely submerged. This means that it is below the water surface.

#### BSF Filter

The BSF system is an intensively flowing filter bed that oxidises dissolved phosphorus well. The resulting compound is then bound in the filter. The filter's biofilm successfully absorbs nutrients and effectively removes them from the water. In order to maintain constant phosphorus reduction, percolation takes place 24 hours a day. This ensures that the biofilm is constantly maintained and damage is avoided. The filter contains little to no anaerobic areas due to the additional air supply. Bacteria that live under anaerobic conditions do not need oxygen for their cycle. The rapid flow of water through the substrate provides the water with a stable aerobic environment. Aerobic bacteria need oxygen for their metabolism and to live. The water flow rate through the filter should be 1.5 m/h. The BSF system concentrates on the biofilm as the main cleaning method. Biofilm, also known as biological turf, has the task of cleaning the water in the natural pool. It grows in all areas under water that are supplied with oxygen and light. It consists of algae, fungi, bacteria and viruses that continuously communicate with each other. A three-dimensional matrix is created. This substrate filter can create a biofilm on the filter medium within a short time. This can then optimally purify the water with a constant supply of oxygen through conversion and decomposition processes. If the filter system is switched off or the oxygen supply is cancelled, this can have considerable consequences. ‘The redox potential in the filter drops to 0 or below - the pH value and oxygen saturation also drop - this releases phosphorus that was bound in the filter. This results in shock fertilisation with subsequent mass algae formation in the pond.’ In order to support the biofilm as well as possible, a very permeable substrate (kf value > 103) is required. This enables a good microclimate with even water movement. It is important to ensure that the substrate does not exceed a phosphate content of 6 mgP/kg. When designing the filter system, care must be taken to ensure that there is a coarse-grained layer at the bottom as a water distribution zone and a stabilisation layer at the top. The case study has a depth of 1.50 m and was constructed as follows: Distribution layer incl. central supply line with integrated distribution system, an intermediate layer, the filter layer, the top layer and the surface water (see Fig. 3).

Water

Top Layer

Filter material

Transition Layer

Distribution Layer

Fig 3: Section of BSF  
(Goedermans 2024)

#### UV-Filter

In order to get the current algae problem under control, a UV system for disinfecting the water was installed in addition to the filter systems described above. The system was integrated into the existing water system. The water, which is sucked in by pump 1 via the underwater gravel intake, first flows through the flow housing of the UV filter. It is then channelled along the UV lamp from all sides. This allows the UV light to kill algae and germs (see Fig. 4). The intensive irradiation ensures that algae clump together and become more easily caught in the mechanical cleaning chambers. The UV system runs daily due to the high degree of algae contamination. However, this also has disadvantages. The constant exposure to ultraviolet light not only kills algae and germs, but also important microorganisms. As a result, the water may gradually be transformed into ‘sterile’ water in which bacteria can no longer participate in the transformation process, such as the nutrient cycle. It also damages the biofilm that has already formed.

#### Sandfilter

There is also a sand filter pump in which the water flows through a filter sand. This consists of a grain size of 0.4-0.8 mm, which also filters the water that has already been sucked in to remove algae and insects. The sand filter pump has several functions that can be operated via the 6-way valve.

** Filtering: W**ater is pressed through the filter sand and pumped back into the natural pool. This function is in permanent use.

** Return flow:** The water flows from the bottom upwards through the sand filter so that the dirt is loosened and can be transported to the outlet. If clear water flows through the outlet, the filter has been sufficiently backwashed.

** Rinsing:** After the return flow, the water flows through the filter again from top to bottom. This distributes and compacts the sand in the filter again. The filter can then continue to work normally.

** Recirculation:** The water is circulated in the natural pool without flowing through the sand.

** Waste product:** This function is used when water needs to be removed from the natural pool without it running through the filter (backwashing).

** Closed:** If maintenance is required, the valve can be closed completely.

#### Interaction of the filter systems

The interaction of the individual components is completely automatic: the water is sucked in by the underwater gravel suction system. It is then passed through the integrated sand and UV filter system. From there, it is fed back into the filter zone from bottom to top on the opposite side. The skimmer then sucks in the surface water again using another pump and discharges it back into the natural pool through three mounted inlet nozzles.

## Planting Desing

Ein Bild, das Entwurf, Blume enthält.

Automatisch generierte BeschreibungThe design focus of the natural pool lies in its neighbouring planting. The aquatic plants create a new image of the area. The plants transform the artificial swimming pond into its own ecosystem with a variety of species. The planting of the natural pool in the case study lies to the east of the swimming area and draws a boundary between the pool, garden and farmhouse. The modelling of the vegetation area was based on the principle of the loading zone of a natural lake (see Fig. 5). The swamp zone forms the beginning of the vegetation belt. This is characterised by its permanent soil moisture. The edge zone lies above the swamp zone. This has been worked out with pond gravel and protrudes approx. 30 cm out of the water. Many of the selected plant species in the shallow and deep water (30-50 cm deep) of the swamp zone, like *Bolboschoenus maritimus*, *Carex pseudocyperus*, *Geum rivale*, *Dactylorhiza incarnata* and *Eupatorium purpureum*, additionally different Species of *Iris i.S.* enjoy mesotrophic to eutrophic locations.

Fig 5: Vegetationzone Naturpool (Goedermans 2024)

As marsh water lilies prefer the water wheel in marshy shallow water, an additional natural stone wall was built (see Fig. 6). However, it also prevents nutrients from entering the swimming pond area. This can promote algae growth. Adjacent to the swamp zone is the Ein Bild, das draußen, Gras, Wasser, Wasserpflanzen enthält.

Automatisch generierte Beschreibungshallow water zone. The water depth here is up to 50 cm, and the planting is mainly made up of various types of Nymphaea (water lilies) and Stratiotes aloides (crab claw). In the deeper area of the shallow water zone, the planting was carried out with plant baskets. These are made of black plastic and are filled with pond soil, the plant itself and sand, as well as a thin layer of gravel. The planting baskets ensure that the plants do not spread so rapidly in the first few years. This is why this is also referred to as a type of ‘bonsai cultivation’. In conclusion, it can be said that planting vegetation only provides an impetus for further development. This further development results in a well-functioning regeneration surface, which Ein Bild, das draußen, Baum, Wasser, Landschaft enthält.

Automatisch generierte Beschreibunguses microorganisms and plants and the resulting biofilm to naturally clean the water of dirt and nutrients (see Fig. 7). In the shallow water zone, the planting was carried out using plant baskets. These are made of black plastic and are filled with pond soil, the plant itself and sand, as well as a thin layer of gravel. The planting baskets ensure that the plants do not spread so rapidly in the first few years. This is why this is also referred to as a type of ‘bonsai cultivation’ (cf. In conclusion, it can be said that the planting of vegetation only provides an impulse for further development. This further development results in a well-functioning regeneration surface, which uses microorganisms and plants and the resulting biofilm to naturally clean the water of dirt and nutrients (see Fig. 7).

Fig 6: Area between Planting- and Filterzone  
(Goedermans 2024)

Fig 7: Regenerationzone (Goedermans 2024)

## Maintainance

In order to keep the natural pool in an acceptable condition all year round, maintenance of the system plays an important role in addition to upkeep and water purification. As the natural pool has no cover, pollutants such as dust, leaves and pollen can spread over the surface of the water. However, to minimise the amount of dirt, a cleaning robot is used for the floor and lower walls of the natural pool. It sucks up the surface with a vacuum and automatically cleans the area with a brush attachment. Dirt particles such as leaves, dead plant parts or algae residues can also be removed from the natural pool by hand using a scraper or special rake. As the upper part of the pool walls in the example is clad with natural stone, this part is cleaned by hand (with a brush). Depending on the intensity of use, the sand filter system installed with the natural pool is backwashed every six to eight weeks. As the tap water in England contains a lot of phosphate, the water evaporated by the sun is topped up with the falling precipitation. To prevent the pH value in the water from becoming too low, the water quality of the natural pool is therefore checked regularly after long rainy days. This is because the rainwater can have a very low pH value. The natural pool from the case study also has an unidentified algae problem. This problem is contained with a special filter system and also with mechanical measures. It is important to remove the floating components from the circulation of the swimming pond as quickly as possible, as new nutrients are formed during the decomposition process of the algae.

## Technical Data

Fig 8: Naturpool Maßstab 1:100

##  Average annual precipitation (Exeter-UK): 825 mm, USDA zone: 8 a

##  Pool waterproofing: protective fleece 800 g/m², EPDM pond liner 1.5 mm

##  Size of the swimming area: approx. 100 m2 / 2.50 m deep

##  Size of the BSF: approx. 15 m2,  Size of the regeneration area: approx. 70 m2

##  Water circulation rate: 2x total volume per day

##  Pumping system: 2 Certikin Auquaspeed pumps, installed dry:

## 1. underwater gravel softener and BSF + 2. surface skimmer and inlet nozzles

##  Additional filter systems: Sand pump filter and UV filter

## Speciality

#### System against flooding / Storm Water Management

Visually, the swimming pond emerges from the flowing stream. However, this is a misconception, as they are two independent systems. The stream merely flows past the swimming pond. Coming from the south, the stream flows into a designated pond basin measuring approx. 60 m². From there, the water flows underground via two KG pipes into the lower settling basin at the end of the natural pool. Above ground, the water flows through a ditch built for this purpose, which runs past the natural pool behind the wooden deck. In order to be able to control the flow of water through the ditch, an electronic water gate was installed at the exit of the pond basin leading to the ditch. This allows the water to flow first into the upper and then into the lower settling basin. From there, it then flows into the second pond basin and back into its original stream form. Due to climate change, natural weather phenomena continue to increase, including heavy rainfall. This leads to rising water levels in the stream and the subsequent overflow of surface water. As a result, the neighbouring natural pool is flooded in an emergency. This is exactly what happened at the beginning of 2024. Subsequently, the entire water volume of approx. 300 m3 had to be drained and replaced. As the water quality on site is relatively poor, the natural pool was filled with filtered water by a specialist company. This company brings the water to the farm in water tanks and releases it into the natural pool.

To prevent this from happening in future, the electronic water sluice has been upgraded to a fully automated flood protection system. This consists of an infrared water level meter, an actuator with diagnostic function (electronic water gate) and a separately mounted control unit. The actuator has an enormous sealing concept in combination with a high level of corrosion protection, double-sealed cable entry at the electrical connections, internal sealing rings on all housing covers and a solid shaft made of stainless steel prevents water from entering the inside of the housing (see Waterproof AUMA actuators regulate underwater turbines 2024). The actuator is operated by a separately mounted actuator controls. However, this can also be controlled wirelessly via a Bluetooth connection. The centrepiece of the fully automated flood protection system is the separately mounted control unit. It is linked to the infrared water level meter and the actuator. If the water level in the stream rises to 30 cm above normal, the infrared sensor sends a control signal to the control unit, which activates the actuator. The electronic water gate then opens, ensuring a higher water flow through the ditch.