The Wave Surfing Lake, Bristol

SuDS used

- *2,000m^2 permeable paving source control (8,400 pieces x 600mm x 400mm x 80mm deep)*
- *22,440m^2 of geocomposite drainage used beneath the surfing lake bed*

Benefits

Permeable paving

- *A heavy duty, lighter weight cellular paving system manufactured from 100% recycled plastic.*
- *Reduced carbon emissions for the full lifecycle of the project due to the ease and speed of installation, with reduced construction traffic volumes required compared to traditional pavement finishes.*
- *Safer manual handling, greater durability and longer lifespan compared to concrete block paving alternatives.*
- *High strength, durable polymer with HGV load-bearing capacity and resistance to flexure, fracture and common chemical degradation.*
- *Surface water source control as part of a SuDS design.*

Geocomposite drainage

- *Provides a defined high flow capacity and long performance life.*
- *Used to provide the drainage and starter layer, preventing floatation of the lake in high ground water conditions.*

1. Location

The Wave, Washingpool Farm, Easter Compton, Bristol, BS35 5RE

2. Description

The Wave is a new inland-surfing lake, the first of its kind in England to use Wavegarden Cove technology to provide over 1,000 waves an hour. The site is located around 2.5km to the southwest of Almondsbury and around 10km north of Bristol City Centre. The site lies on a gently sloping, low lying area of the Pilning Levels, west of the Severn Ridge (along which the M5 extends). Whilst the surfing lake will form the central experience of The Wave, the grounds are to be landscaped to provide different garden areas, woodland walks, wetland experience and wild flower meadows. Open areas are included within the landscape and a natural swimming pool is to be created close to the main buildings. Large areas are designated for native plants, grasses and trees to increase the variety of species and provide linkages between habitat areas adjacent to and further beyond the site.

The new wave pool itself measures approximately 200 x 200m and has a capacity of over 20,000m^3 of water. It features a pier that runs down the centre, which hosts the wave-making mechanics at one end. The £25m development is powered by 100% renewable electricity and delivers the opportunity to surf all year round, independent of weather conditions and tides.

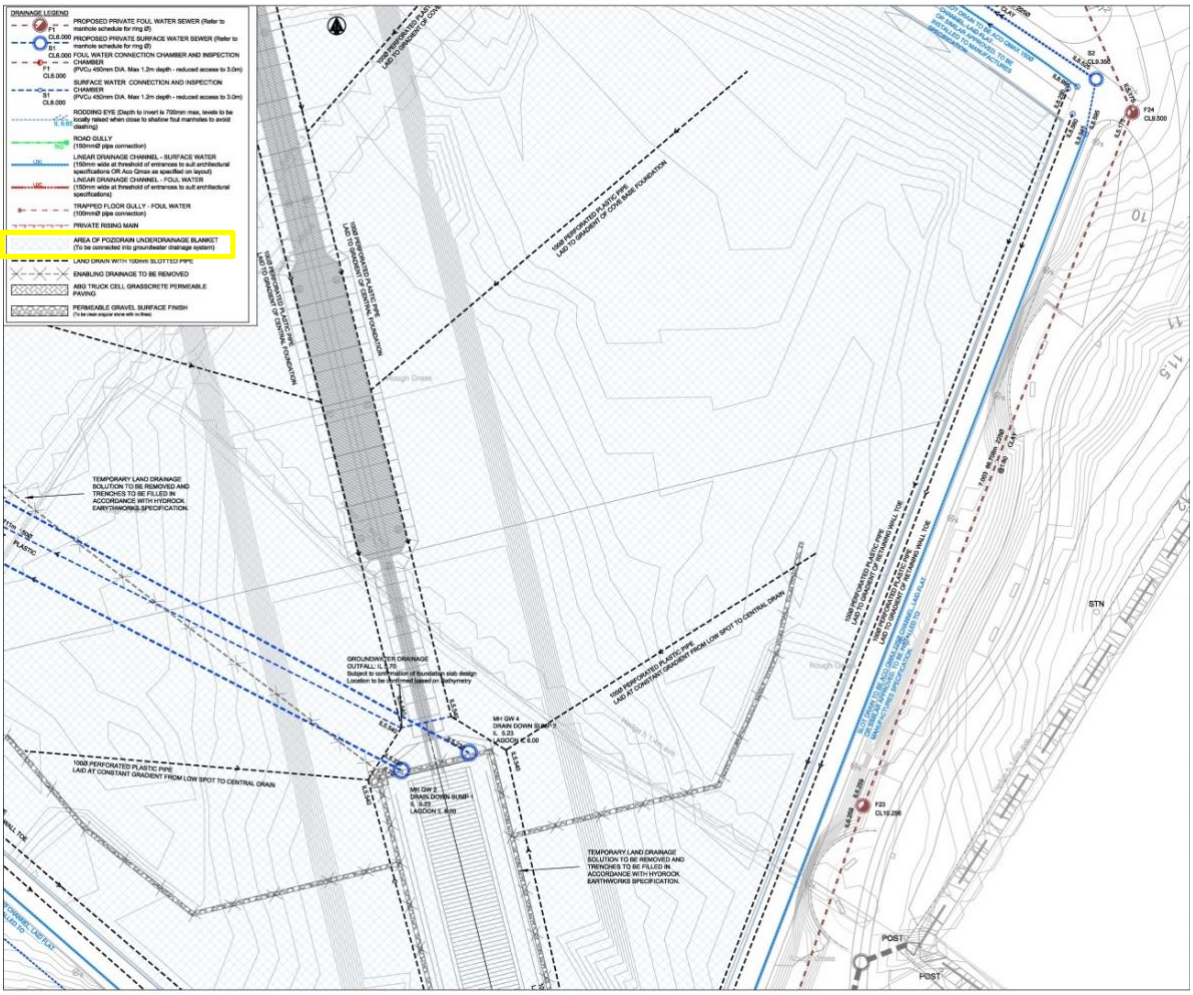
Consulting Engineers Hydrock provided full multidisciplinary engineering and project management services, and the civils, infrastructure, drainage, building and landscaping work were all undertaken by the appointed main contractor Andrew Scott.

3. Main SuDS components used

The site is close to the Severn Estuary and its floodplains, which meant extensive design work was required around the management of both ground and surface water. In places the water table is barely 145 mm below ground level, and with the water table so high, the design needed to take into consideration the potential 'floatation' of the concrete-lined wave pool when empty. A sub-lake

geocomposite drainage system channels away the 10 l/s of ground water flow generated under the cove bed, flowing to the nearby attenuation basin to the north of the pool and then discharging into the local ditch network. The geocomposite drainage layer acts as an impermeable barrier to ground water ingress and channels water away to reduce the groundwater/uplift pressure.

The surfing lake itself represents 17,900m^2 of effectively impermeable area, with a controlled discharge during rainfall events to maintain the still water level (SWL) for the wave formation equipment. The resulting flows also discharge to the attenuation basin adjacent to the main building. The back of the lake's retaining walls are also lined with the geocomposite to provide drainage to the perimeter channels and control flow to the attenuation basin.



The rest of the development introduces approximately 2,750m^2 of impermeable surfacing, notably comprising the proposed main building, decking and camping facilities building. The proposed lake and built facilities fall outside any areas identified as being subject to flood risk. However the existing entrance and car park elements at Washingpool Farm fall within the edge of Flood Zone 3 (with allowance for predicted climate change). The geotechnical study reports the site is generally overlain by a Clayey topsoil. As such, there is the potential for limited infiltration and hence surface water ponding is expected. This is supported by anecdotal evidence of seasonally 'boggy' ground conditions, particularly in the lower lying flatter northern areas of the site.

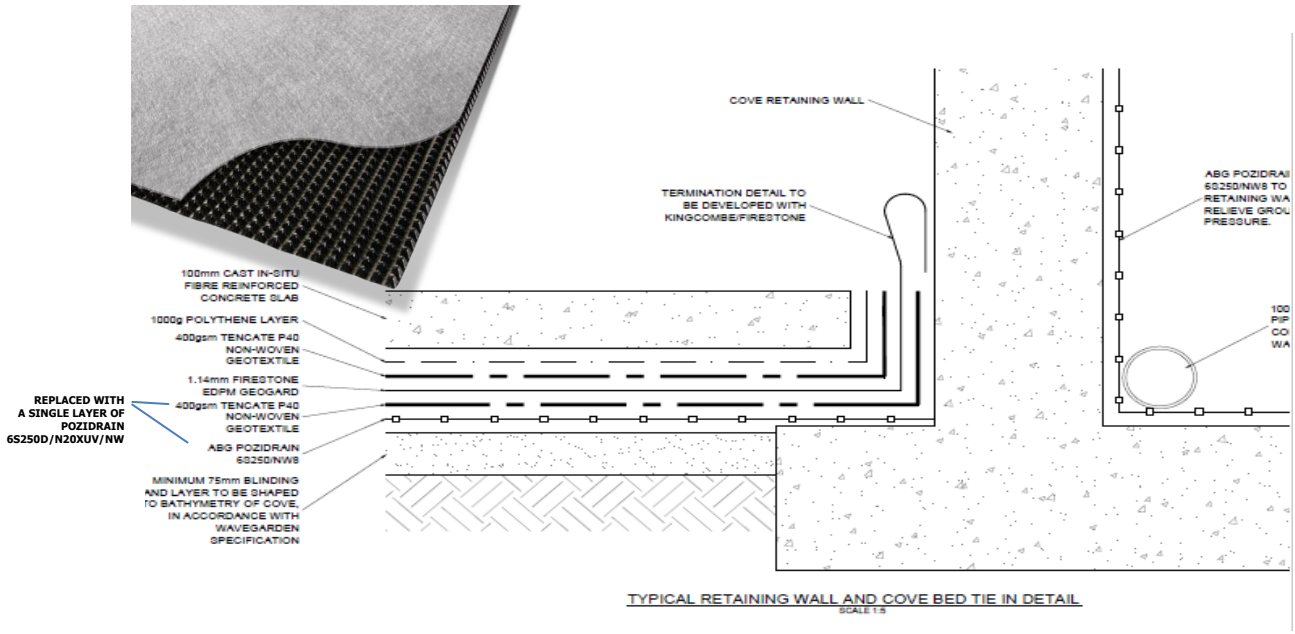
This means that the subgrade on site is very soft with subgrade CBR values estimated to be below 1%. An approach was to use a 'floating road' design consisting of a filtration/separation geotextile at the base, geogrid stabilised road sub-base, and permeable paving at the surface. The permeable paving covered around 2,000m² of access roads and a 950m² maintenance yard to withstand the loads from turning delivery vehicles and refuse collections. The use of porous paving meant that the access roads and maintenance yard did not increase the area of impermeable surfacing, ensuring that there will be no detrimental impact to flood risk either at the site or to third parties off-site.

4. How it works

Geocomposite drainage

As part of the construction of the lake, a groundwater drainage system was implemented to isolate the lake from the groundwater and relieve pressure on the surf lake bed to prevent flotation. The drainage layer also acts to lower the water table beneath the pool (hydro-geologically mapped at 10 l/s flow), linking to the attenuation basin and on into the surrounding drainage rhines and ditches.

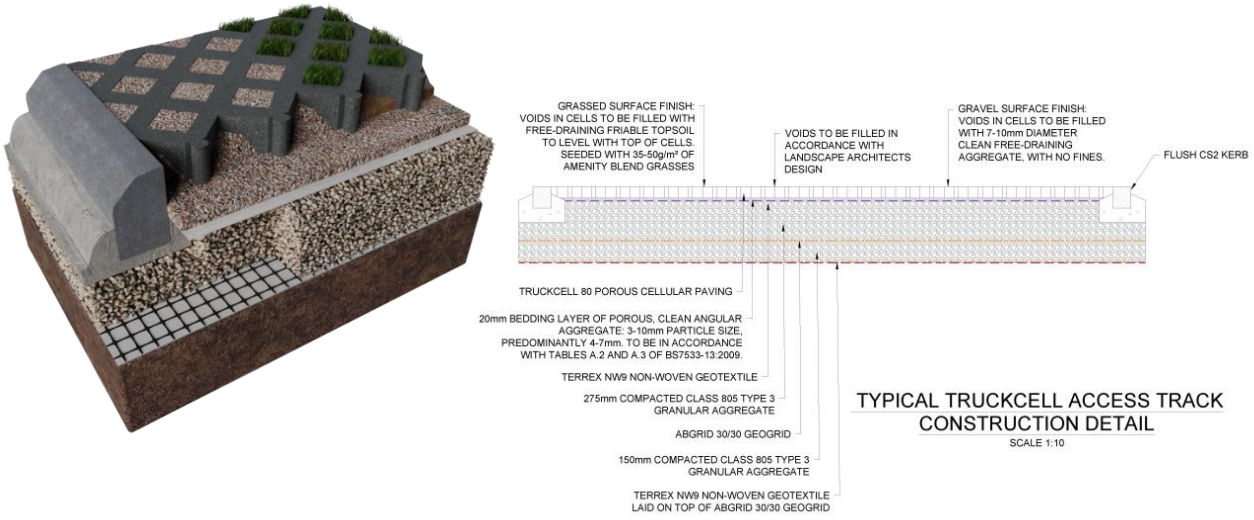
A 6mm thick HDPE cuspated core product was laid dimple side down to provide a defined high-flow ground water drainage rate. The spaces between the cuspates give a clear passageway for water to flow in all directions, even in the event of localised blockages or damage. This also replaced the need for a separate 400gsm protection geotextile layer originally specified above the geocomposite, thus further saving on install time and cost. The non-woven geotextile filter fabric is bonded to the core to ensure that it does not deform into the spaces between the cuspates under loading.



The surf lake's water level is monitored and adjusted as necessary to temporarily store surface water run-off. The attenuation basin receives the run-off from hardstanding areas as well as the surfing lake and discharges to an existing adjacent drain to the pre-development Q_{BAR} run-off rate for the developed area. This has been calculated as 7.9l/s. The attenuation basin has been designed with an approximate volume of 415m^3, to provide attenuation for up to the 1-in-100 year storm event +30% for climate change.

Permeable Paving
The sections of access road and maintenance routes from Washingpool Farm to the surfing lake are surfaced with the permeable paving blocks and filled with free draining angular gravel to allow rainwater to percolate down to the existing sub-soil.

The paving is manufactured from 100% recycled plastic and is strong enough to withstand regular trafficking from vehicles with heavy axle and wheel loadings such as HGV trucks, buses, fire appliances and refuse vehicles. The high load-bearing capacity of the porous pavers make them suitable for applications such as car parks, access roads, coach parks and emergency vehicle access routes. The 100% recycled polymer construction of the permeable paving grids used provides high strength and durability, combined with a greater resistance to freezing and fracture than permeable concrete paving grid alternatives. Each grid unit weighs less than 12kg, keeping it well within Health and Safety manual handling guidelines.

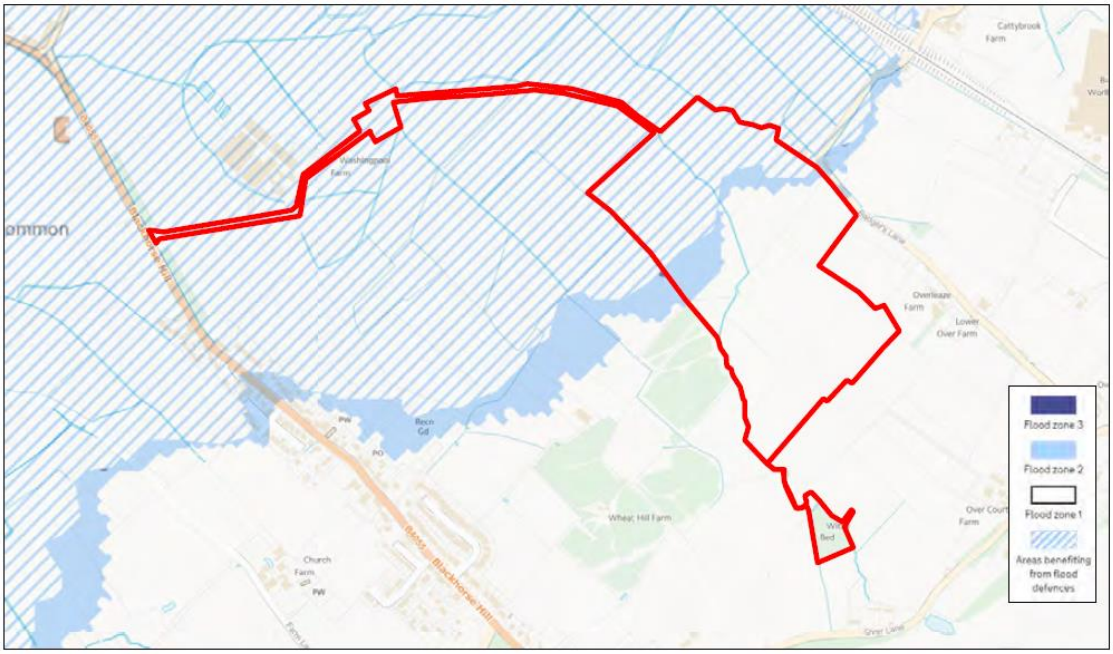


5. Specific project details

Flood risk assessment
The northern portion of the site is shown by the Environment Agency's (EA's) Flood Zone Mapping to be within Flood Zones 2 and 3 (after climate change taken into account). The critical area in which the surfing lake and main building are located is within Flood Zone 1 and has a less than 1-in-1,000 annual probability of fluvial or tidal flooding.

Flood Zone 2 comprises land having between a 1-in-100 and 1-in-1,000 annual probability of fluvial flooding; or, land having between a 1-in-200 and 1-in-1,000 annual probability of tidal flooding. The lower portions of the site are indicated to be at risk of flooding in such an event, to depths of around 1.5m, and the existing Washingpool Farm access road to depths of approximately 1.0m. This means that attention was focused on SuDS treatment of the access routes in the northern part of the site to improve surface water drainage.

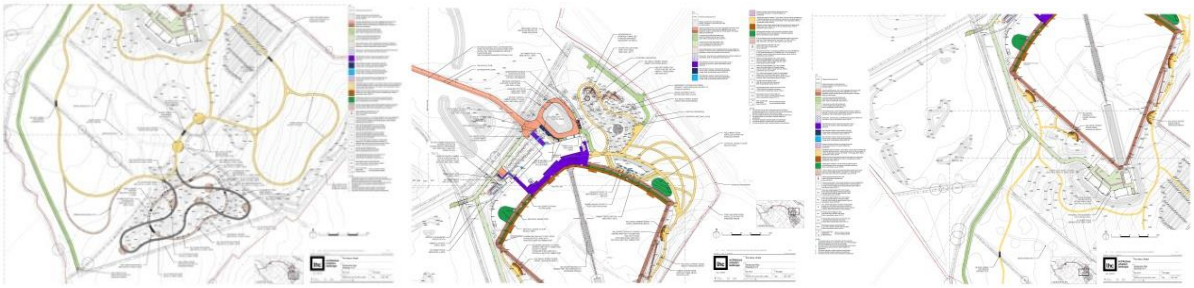
Figure 1: EA Flood Zone Mapping



Site access and parking

There is a shuttle bus service to transport visitors between the main facilities building and the car park. The shuttle bus route is partly via an existing concrete road that has been extended to the main facility to provide both a pedestrian route and cycle path. This route has events at various nodes including information on the biodiversity and viewing points to the lake and Wave facility. On the approach to the clubhouse a wild flower meadow with a mown path completes the journey.

Sections of the new Truckcell permeable paving access roads and the maintenance yard are shaded in lime green on the map below.



6. Maintenance & operation

The geocomposite drainage layers require no ongoing maintenance. Permeable paving is low maintenance, but may periodically require some topping up of the cells with gravel, or cleaning using a road sweeper to remove build-up of surface debris and to help to keep it weed free.

7. Monitoring and evaluation

The wave generation and drainage operations of the lake are closely monitored by the facilities engineer at the Wave. The controlled and high capacity flow rate of the ground water drainage system prevents the usual risks of localised blockages associated with granular drainage layers.

The permeable paving roads are to be periodically inspected by the appointed landscape contractors to remedy any potential issues with clogging or ponding.

8. Benefits and achievements

The value engineered design and the superior flow performance provided by the geocomposite layer beneath the cove bed was integral to the lake's ground water drainage system, achieved at a fraction of the thickness, cost and carbon output associated with using a granular drainage layer (6mm thick vs approximately 250mm thick). The cost saving is estimated by Hydrock's Programme Delivery Manager to be £800,000.

Alternative pavement design options were adopted, utilising permeable paving grids to reduce the road thickness build-up and cost to achieve the required bearing capacity for areas of the site with low CBR / soft subgrade and low permeability soils.

9. Lessons learnt

The need for floatation control below the lake in this application (and for below other bodies of water such as SuDS ponds) is not always considered, but is integral to achieving the innovative cove bed and retaining wall structure design. This saved on thickness, reduced the variability in flow rates and the number of stone deliveries required compared to using a gravel drainage blanket as was initially being considered.

The use of permeable paving for low lying, higher flood risk areas of the site is also in keeping with the sustainability objectives of the development, providing a low cost SuDS alternative to impermeable asphalt pavements or concrete block paving, ensuring run-off remained at pre-development levels.

10. Interaction with local authority

Hydrock's Flood Risk Assessment and drainage plans for the surface and sub-surface water systems and proposed points of discharge were submitted to and agreed by the Lower Severn Internal Drainage Board. Plans were reviewed in collaboration with South Gloucestershire Council as part of the application process.

11. Project details

Construction completed: Surfing lake completed October 2019. Landscaping and access routes completed March 2020

Cost: £25m total / £150,000 *SuDS components*

Extent: 29 Ha

12. Project team

Funders & Clients	• The Wave	
Designers	• Hydrock Engineering (civils, drainage, buildings design) • LHC Design (landscape architects) • ABG Geosynthetics (lake bed drainage & permeable paving systems)	
Contractors	• Andrew Scott (main contractor)	

Geocomposite drainage install (example)

A section of the permeable paving access road

Completed section of permeable paving access road

Maintenance yard area