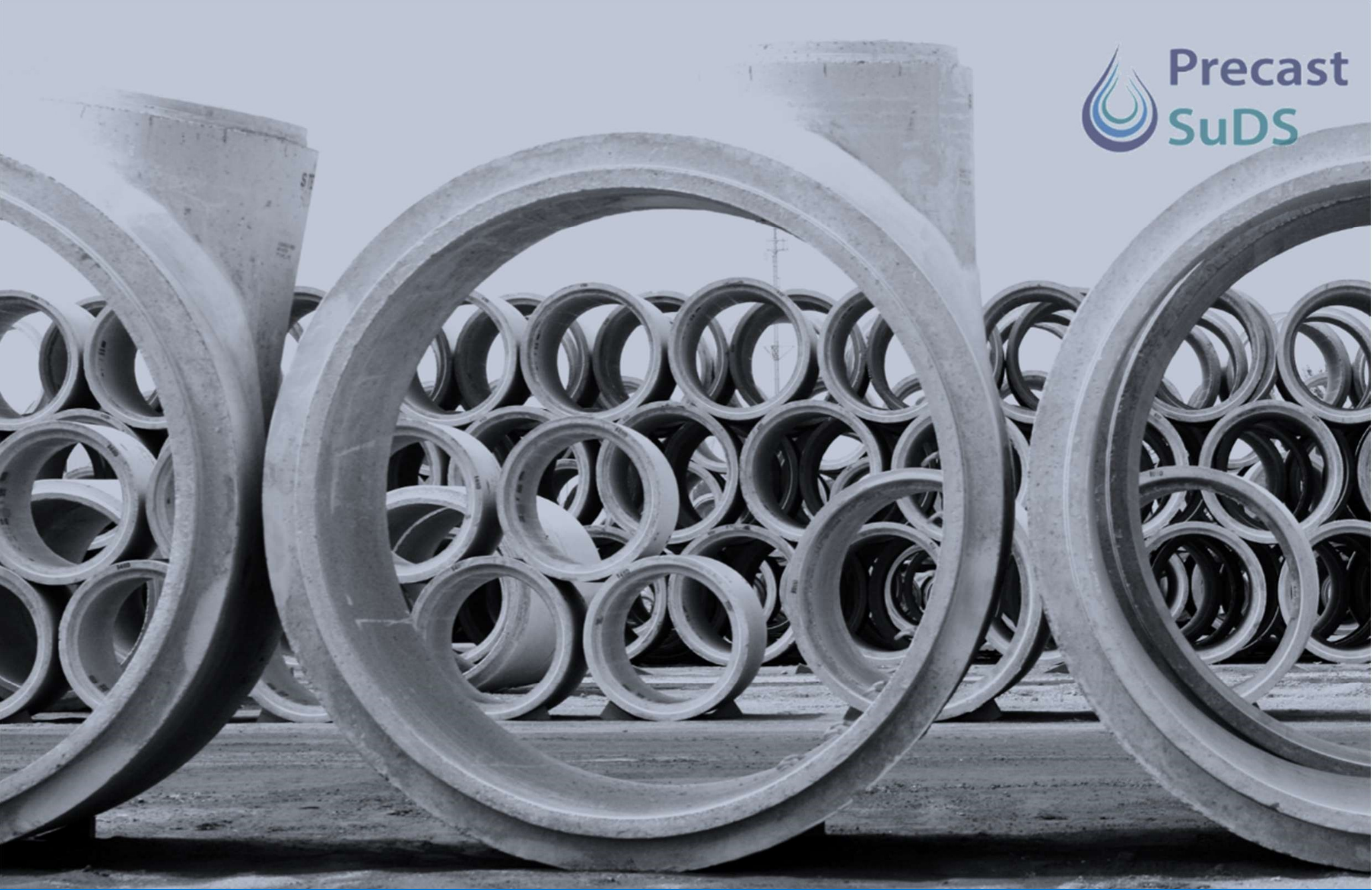

Precast concrete SuDS solutions

Assessing the carbon footprint and whole life GHG impacts of different underground attenuation tanks

*The new sewers' adoption code, which came into force in April 2020, is likely to trigger an increase in the use of stormwater attenuation tanks and other SuDS solutions. However, with several water companies considering embodied carbon reduction targets, there is a need to the industry to understand the carbon emissions associated with different stormwater attenuation solutions and how such procurement decisions can affect their Scope 3 Greenhouse Gas (GHG) emissions. This report uses available data, including manufacturers' data and the Inventory of Carbon & Energy (ICE) Database, to calculate the carbon footprint of two equivalent types of attenuation tanks: Concrete pipe tanks and geocellular tanks. Calculations reveal that Concrete pipe tanks have **19.8%** lower carbon footprint in a Cradle-to-Gate comparison, and around **62%** lower footprint on a whole-life Cradle-to-Grave comparison.*

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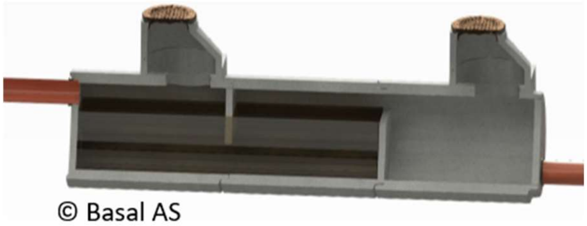
Introduction

In March 2020, the Water industry revealed ambitious plans to achieve net zero carbon across the sector by 2030, becoming the first major sector in the UK to commit to the 'net zero' agenda by such an early deadline. In April 2020, the code for sewers' adoption, the new Design & Construction Guidance (DCG), made a wide range of SuDS infrastructure assets adoptable by water companies. Although the Water Industry target for 2030 only addresses direct Greenhouse Gas (GHG) emissions, the industry will be cautious not to undo its achievements by opting for SuDS solutions with high embodied carbon. There is very little information currently on the carbon footprint or Cradle-to-Grave carbon emissions of different stormwater attenuation solutions. The carbon emissions of two main types of stormwater attenuation are explored at Cradle-to-Gate, Cradle-to-Grave at 50 years and Cradle-to-Grave at 100 years. These attenuation solutions include DN2100 concrete pipes and a popular geocellular tank system believed to be compliant with the DCG. Both systems are assessed based on storage of up to 300m^3 of stormwater.

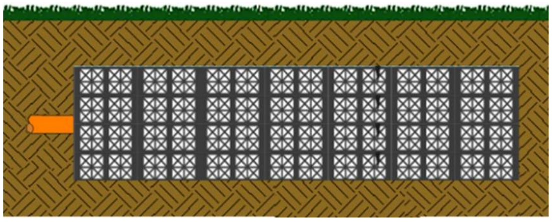
Concrete pipe tank

An underground tank made of a number of DN2100 concrete pipes accessible by side-entry manholes. The total length required to cater for 300m3 of stormwater, with sufficient additional void space to meet DCG requirements, is 86.6 metres. Additional concrete will be needed for a number of end caps, making a total of 306 tonnes of reinforced concrete pipes for the tank.



Geocellular tanks

The geocellular tank option was based on a flat pack style system, with 95% void ratio, made of mould injected polypropylene. The design for the tank requires around 702 box units (with side units) weighing in total around 13.3 tonnes and wrapped with geomembrane.



Carbon footprint assessment methodology

Lifecycle stages considered

Any reliable carbon footprint comparison should consider whole-life, and not only limited parts of the lifecycle. Clause 7.1.3.1 of PAS 2080 states that "*a GHG emissions quantification shall cover all life cycle modules*", which means that all calculations need to address Cradle-to-Grave. The comparison made in this Factsheet includes most lifecycle stages considered crucial for a stormwater attenuation solution: Modules A1, A2, A3, A4, A5, B4, C3 and C4 (see Table 1).

Production			Installation		Use stage							End-of-Life				Next product system
Raw material supply (extraction, processing, recycled material)	Transport to manufacturer	Manufacturing	Transport to building site	Installation into building	Use / application	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction / demolition	Transport to E.o.L	Waste processing for reuse, recovery or recycling	Disposal	Reuse, recovery or recycling potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	X	X	X	X	MND	MND	MND	X	MND	MND	MND	MND	MND	X	X	MND

Table 1. Modules considered in lifecycle assessments.

Asset Service Life

SuDS solutions are infrastructure assets which are expected to continue to perform effectively throughout the life of the housing estate, district or retail/ commercial development it serves. CIRIA's B£ST tool suggests a 100 years life span for a SuDS solution. PAS 2080 recommends 120 years for an infrastructure asset. This is a life span requirement[1] (Reference Study Period) that concrete pipes are designed to meet. Based on BRE's Special Digest SD-1, concrete pipes designed to DC4 have an intended working life of 100 years. Series NG 1700 of the MCDHW suggests that this would be sufficient to meet the 120 years intended working life requirement. There is no proof that a geocellular tank can last for a period of 100-120 years or more. geocellular tank systems are only tested, according to EN 17150/ EN 17151/ EN 17152, to a 50 years design life. The Geocellular tank system considered in this study has a service life of 60 years only. EN 15978 states that whenever a product Reference Service Life (RSL) is shorter than the asset's reference study period, a number of replacements will need to be accounted for to cover the entire study period. This means that the geocellular tank in question will need at least one replacement (usually reported in Life Cycle Module B4).

Scenarios and assumptions behind the calculations

Functional unit/ Declared Unit

The main function used for the comparison is the ability to store and attenuate 300m^3 of surface water runoff, serving for a period of 100-120 years. The scenarios and amount of material and equipment required for both attenuation tanks is as described in Table 2.

Cradle-to-Gate carbon footprint data (A1 to A3)

Cradle-to-Gate data was sourced from the embodied carbon database used by all water companies: the Inventory of Carbon & Energy (ICE) Database:

- Concrete pipe tank: The carbon footprint used for concrete pipes is 146 kg CO2e/t, as indicated in the ICE Database. The carbon footprint for rebar used in the pipes was

[1] In EN 15978, the term used for the period of building/ structure use in an assessment is "Reference Study Period".

based on the European rebar option available in the ICE Database and Concrete Calculator (485 kg CO2e/t). This is due to the fact that all steel used in concrete pipes' rebar is from fabricators who source rebar from members of the British Association of Reinforcement (BAR).

- Geocellular tank: The carbon footprint used was for mould-injected polypropylene, which is around 4,490 kg CO2e/t, as indicated in the ICE Database.

	Concrete pipe tank		Geocellular tank	
Storage capacity (m^3)	300m^3 (overall 320-330m^3)		300m^3 (overall 315m^3)	
Size of attenuation tank	Size of pipes	DN2100	No. of units (2-piece each)	702
			Side units (m^2)	156 m^2
	Total weight of reinforced concrete	306 tonnes	weight of geocellular tank	13.26 tonnes
			weight of geomembrane	0.34 tonnes
Bedding requirements	Excluded		Excluded	
Distance from factory to construction site (km)	100		100	
Lorry delivery	+35t artic		+35t artic	
No. of deliveries to site	12 deliveries (full laden)		2 deliveries (half laden)	
Site machinery for installation/ excavation	JCB JZ 141 (19.54 hrs excavation & lifting operations)		JCB JZ 141 (8.5 hr excavation & lifting operations)	
Jetting/ cleaning operations	Excluded		Excluded	
Replacement after 50-60 years	0 replacement		1 replacement	
End of Life scenario	Recycling/ landfill[2]		Mechanical recycling/ incineration (with or without energy recovery)/ landfill	

Table 2. Main tanks specifications and scenario assumptions.

Transport to site data (A4)

The scenario assumes that both types of attenuation tanks are transported from manufacturers' sites to the construction site using 30+ articulated trucks. The distance between factories and construction site is assumed to be 100 km. Defra's 2019 conversion factors were used to calculate transport carbon emissions. 12 deliveries (fully laden) were considered for the concrete pipe tank. 2 deliveries (half laden)[3] was assumed for geocellular tanks.

Site Installation data (A5)

The scenario assumes the same tracked excavator at both sites. Excavation time was assumed to be the same for both installations. Unlike Geocellular tanks, concrete pipe tanks require mechanical handling: A 20 minutes period was assumed for the installation of each concrete pipe unit (excluding idle times).

Replacement (B4)

As explained above, in order to cover the entire asset life requirement (Reference study period), the geocellular tank will need to be replaced with a similar system shortly after 60 years. EN 15978 explains that this would require reporting GHG emissions equivalent to emissions at stages A1 to C4 (demolition of old tank + manufacture and installation of the new tank). The impacts of industry decarbonation within 50 years are difficult to quantify at this stage as the source of polypropylene resin in 50 years is unknown (e.g. Middle East, Asia, America, etc).

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[2] A re-use scenario will be added as more facts are established about this scenario.

[3] Half laden was the lowest conversion factor available for 33+ artic trucks in the Defra conversion tables.

End of Life (C3- C4)

End of Life assumptions were mainly based on present day technologies, as required by EN 15804 and the current RICS Carbon Statement standard. The assumptions made were as follows:

- **Concrete pipe tanks:** 90% recycled and 10% landfilled. Assumptions for existing pipes reuse were excluded as sufficient data is still being collected on impacts and likelihood.
- **Geocellular tanks:** Geocellular tanks exhumed today are likely to be landfilled or incinerated as such utility arisings are not suitable for recycling with other plastics destined to human consumption. However, a realistic future scenario was used: It is assumed that 33% will be recycled, 33% will be incinerated (with or without energy recovery) and 33% will be landfilled. Impacts associated with these activities were taken directly from Biffa's report "*Plastic Surgery: Managing Waste Plastics*".

Results

Table 3 summarises the results of the comparison:

- The Cradle-to-Gate carbon footprint of the concrete pipe tank is **19.8%** lower than the equivalent geocellular tank.
- The Cradle-to-Grave carbon footprint of the concrete pipe tank can be **23.5%** lower than the equivalent geocellular tank for an asset service life of 50 years.
- The Cradle-to-Grave carbon footprint of the concrete pipe tank can be **61.8%** lower than the equivalent geocellular tank for an asset service life of 100 years.

	Concrete pipe tank	Geocellular tank
Cradle-to-Gate carbon footprint (tCO_2e)	48.32	60.25
Cradle-to-Grave carbon footprint - 50 years (tCO_2e)	51.17	66.93
Cradle-to-Gate carbon footprint - 100 years (tCO_2e)	51.17	133.86

Table 3. Cradle-to-Gate and Cradle-to-Grave Greenhouse gas emissions associated with concrete pipe and Geocellular tank systems.

Conclusions

This assessment clearly demonstrates that despite the fact that concrete pipe tanks may be multiple times heavier than a Geocellular tank alternative, large concrete tanks can have a significantly lower carbon footprint. Over a 100+ years' service life, a concrete pipe tank can be more than **2.5 times** lighter in terms of carbon footprint. It is believed that this result should also be applicable to larger sizes of attenuation tanks with more than $300m^3$ stormwater storage capacity.

Lighter Geocellular tanks may have significantly lower transport-to-site and installation impacts. But based on findings, these elements generally offer a very small advantage which may not exceed 1.6 tCO2e for a $300m^3$ attenuation tank. The overall carbon saving associated with the use of a concrete pipe tank would range between 11.9 tCO2e to 82.7 tCO_2e.

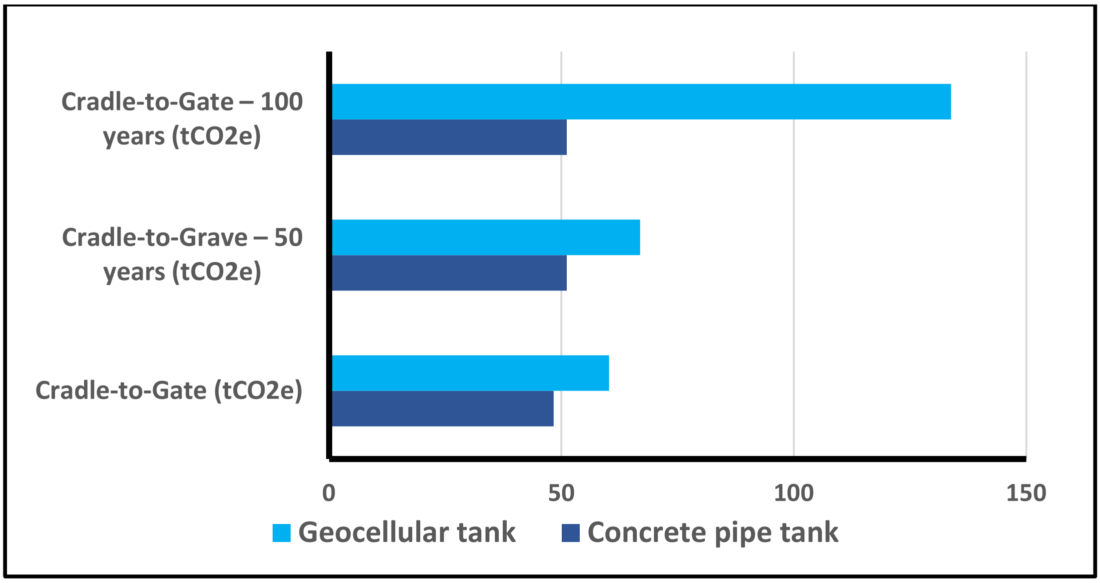

Figure 1. Cradle-to-Gate, Cradle-to-Grave (50 years) and Cradle-to-Grave (100 years) Greenhouse gas emissions of concrete pipe and geocellular attenuation tanks (in tonnes of CO_2e).

However, this assessment only considered one type of adoption code DCG compliant Geocellular tank. As more Geocellular tank options are used in the industry, this assessment will be expanded to include more types of Geocellular and precast concrete attenuation tanks to offer a wider view on GHG emissions associated with stormwater attenuation.

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