mpa

British Precast Drainage Association

Publications from the British Precast Drainage Association (BPDA):

BPDA was formed in 2017 from the integration of the Concrete Pipeline Systems Association (CPSA) and the Box Culvert Association (BCA).

Information published by both CPSA and BCA will be rebranded and replaced as BPDA in due course. New material will be branded BPDA.

All CPSA and BCA web traffic will be redirected to the new BPDA web site at www.precastdrainage.co.uk

cpsa
concrete pipeline systems association

Environmental Assessment of UK Sewer Systems

Groundbreaking Research

BCA British Cement Association

BRE

INTRON

dti

Department of Trade and Industry

This research into the life cycle of sewer pipes in the UK was sponsored by the DTI as part of our ongoing commitment to helping the construction industry to meet the challenge of embedding principles of sustainability through all its activities.

The importance of a safe, effective and efficient sewerage system has been recognised in the UK for over 100 years. 19th Century engineers set high standards of efficiency and durability, the 20th Century provided new and innovative materials, including concrete and plastics. In the 21st century we are seeking not only to ensure that systems are designed effectively, built of the most appropriate material, and meet rigorous health and safety standards, but that they also embody the economic, social and environmental principles of sustainability.

This research demonstrates the importance of evaluating the environmental effects of the materials and processes we use. But research alone achieves nothing. I therefore welcome the publication of this brochure which demonstrates exactly what has been done to evaluate the whole lifetime of sewerage pipes, from design, through sourcing, construction, through use to disposal. I hope that it will provide a useful guide to those within the industry who will be responsible for designing and building safe, sustainable sewerage systems for the 21st Century.

John Hobson
Director, Construction Industry Directorate
Department of Trade and Industry

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NAPM APPROVED RECYCLED

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Contents

which material is best

Several European studies have been published in recent years on the environmental performances of sewer pipes, based on Life Cycle Assessment methodology (LCA). However no such study had been undertaken in the UK, so the Concrete Pipe Association (CPA), supported by the British Cement Association (BCA), initiated a comparative LCA for sewer systems in the UK.

The objectives for this comparative life cycle assessment were: "To build on the work already undertaken in Europe and to position concrete as the most environmentally friendly material for drainage and sewerage pipeline systems".

A leading Dutch consultancy INTRON, was commissioned to perform this environmental life cycle assessment study of sewer systems in the UK. The project started at the end of 1998 and data collection took place during 1999 and 2000. The goal and scope definition report was produced in January 2001 followed by the final report that was issued in April 2001.

The full life cycle was included, from raw materials, production of manholes and pipes, construction, maintenance and decommissioning at the end of the design life. Numerous parties were involved, with most manufacturers participating in data collection, as well as suppliers of materials, contractors and water companies. The results can therefore be regarded as representative of current practice.

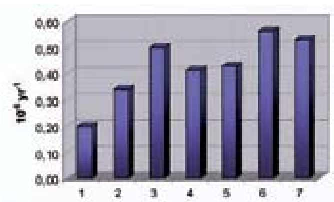
The comparison with other materials, clay and five different types of plastic, was based on publicly available product information, from producers and relevant British Standards.

Since the aim was for high quality, openness and transparency, the Building Research Establishment, (BRE) was invited to perform an independent critical review of the research, according to ISO 14040.

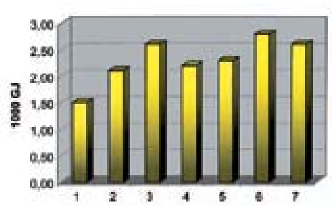
The study concluded that: Concrete proves to be an environmentally sound material for the studied sewer systems. In general the environmental load of a concrete sewer system can be regarded as comparable to clay and more environmentally sound than PVC, HDPE and PP sewer systems.

The thirteen environmental measures considered can be combined into resources, energy, emissions and waste – overall concrete comes out the best as illustrated below. More detailed information can be found on Page 12.

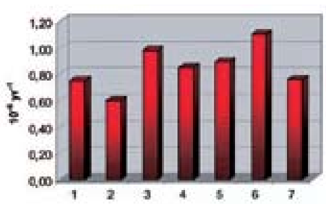
Resources



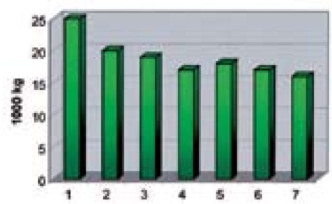
Energy consumption



Emissions



Waste

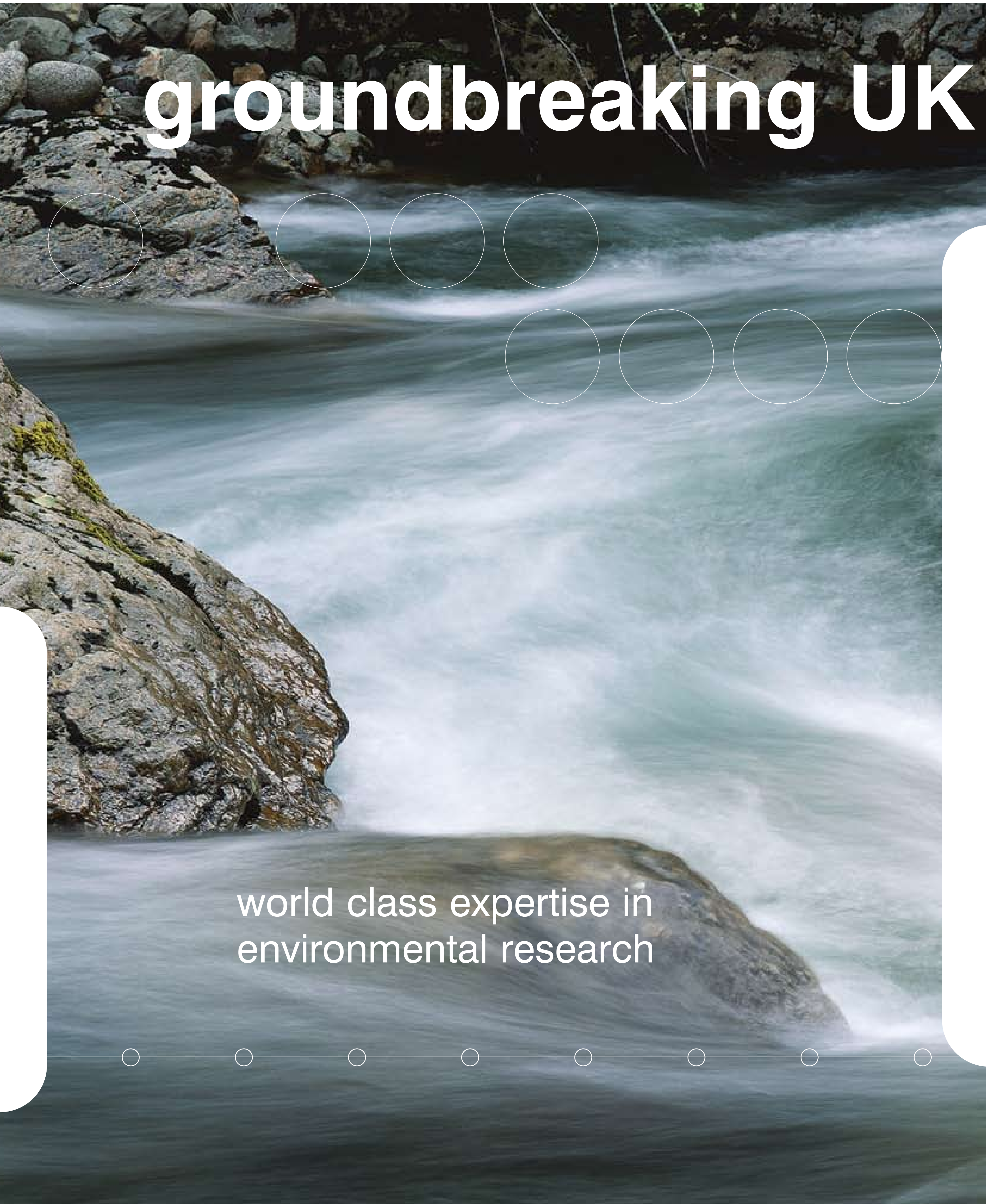


Key = 1 – concrete, 2 – clay, 3 – solid wall PVC, 4 – twin wall PVC, 5 – ultrarib PVC, 6 – twin wall PP, 7 – spirally wound HDPE

for the environment?

major UK study confirms that concrete is an environmentally sound product for pipeline systems

groundbreaking UK



world class expertise in environmental research

research

INTRON is an independent services institute based in the Netherlands, working for clients in the construction sector, industry and Government. They are world leaders in environmental life cycle analysis, having managed many LCA projects since 1992 and previously undertaken a similar comparative research on sewer systems in the Dutch market.

INTRON were commissioned to undertake the research which included determining the goal and scope, inventory analysis, life cycle impact assessment and interpretation of the results.

Since the LCA compares different materials an external critical review was required.

BRE's Centre for Sustainable Construction in the UK is at the forefront of research and consultancy in LCA and Building in Europe. They were appointed by the CPA to critically review the LCA research produced by INTRON.

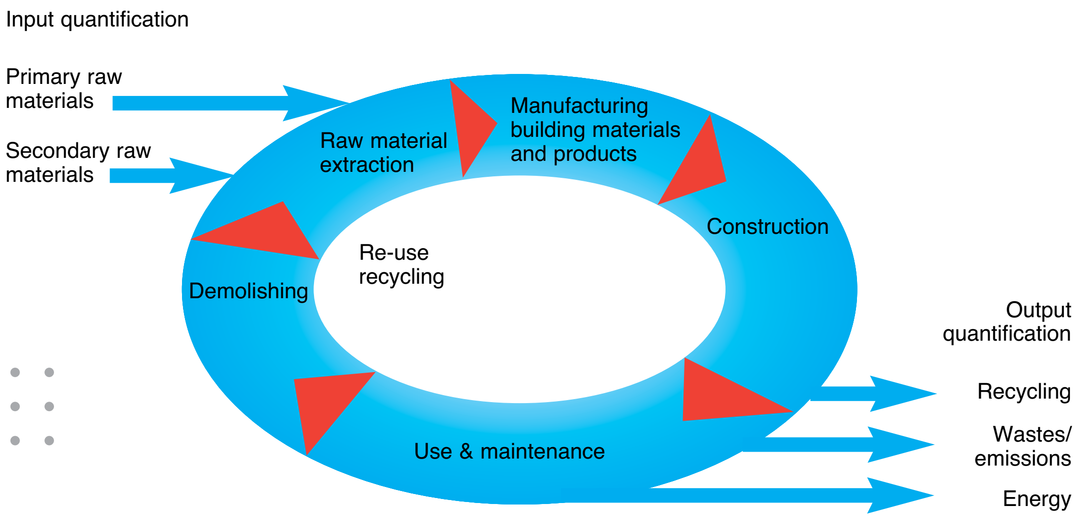
In the opinion of BRE:

- *The methodology was scientifically and technically valid*
- *The method of data collection and data sources were appropriate and reasonable in relation to the goal of the study*
- *The interpretation reflected the limitations identified and the goal of the study*
- *The study was transparent and consistent*

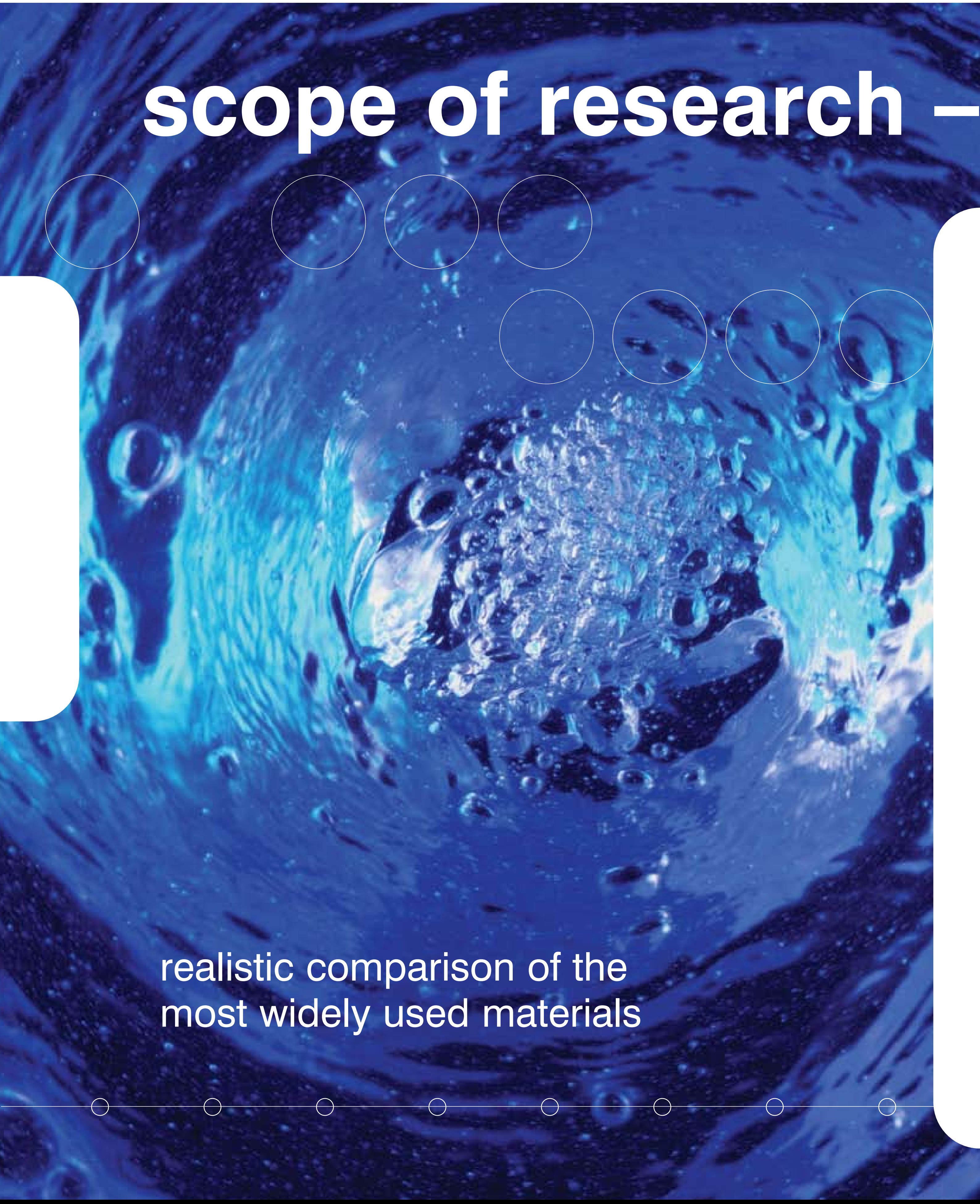
INTRON and BRE's world leading expertise in environmental research and BRE's understanding of the construction industry combine to make this one of the most important research studies in recent years

BRE

INTRON



scope of research –



realistic comparison of the most widely used materials

what was included?

A number of functions were defined that the examined sewerage system should be able to perform. These functions were chosen to represent general UK practice and the table gives an overview of these requirements.

This leads to the functional unit of:
1 km of gravity sewerage system under a road in a non-aggressive soil and groundwater environment, used for the removal of mixed household water, consisting of pipes DN 300 or DN 450 and manholes DN 1200 or DN 1350, with a service life of 50 years.

The functional units were independent of material types and the following pipes materials were studied:

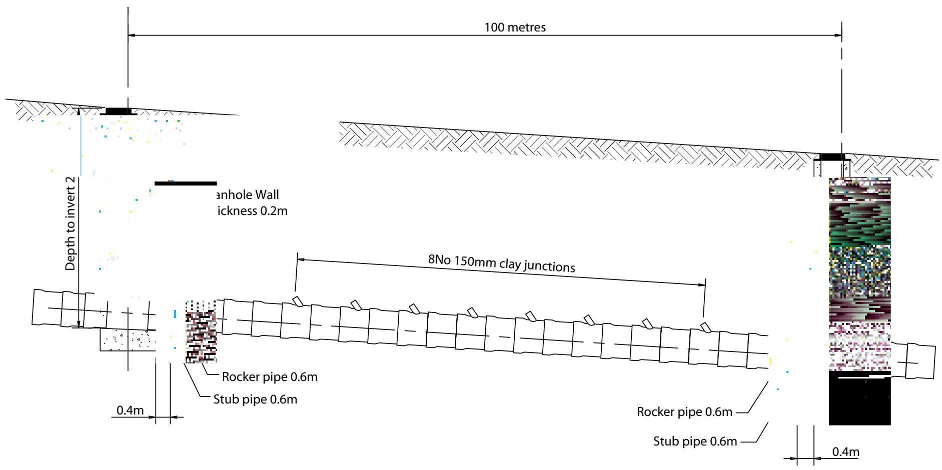
- concrete
- clay
- solid wall PVC
- twin wall PVC
- ultrarib PVC
- twin wall PP
- spirally wound HDPE

A separate product system was defined for each functional unit, based on publicly available information from the producers and relevant British Standards.

The manholes were the same for all product systems, made of concrete with ductile iron covers. Connections (seals) were considered equal for all systems and a sensitivity analysis showed this was unacceptable.

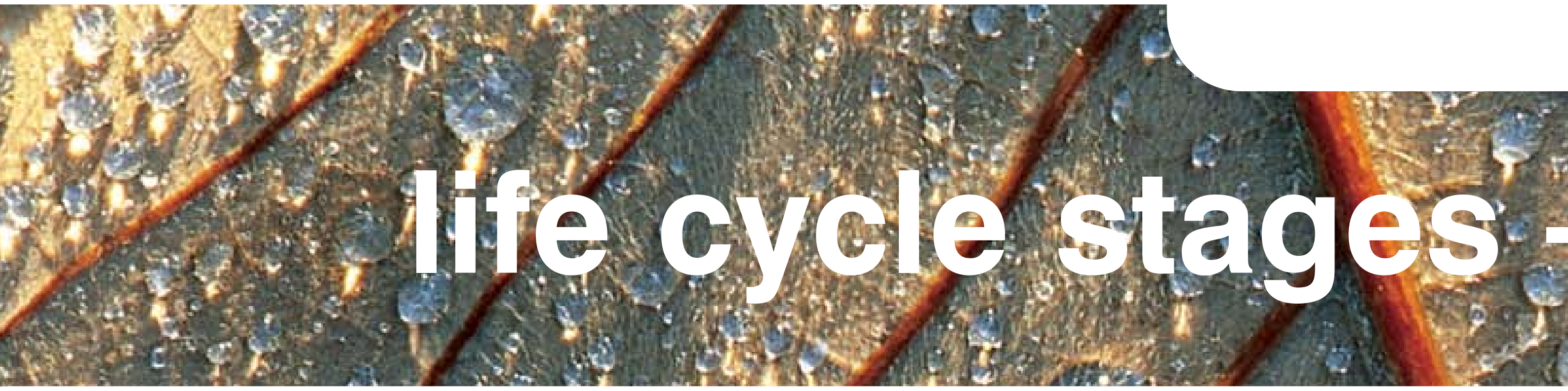
Sewer type	Gravity sewer system
Effluent type	Mixed household water
Soil type [1]	Non aggressive
Groundwater type [1]	Non aggressive
Pipe dimensions [2]	Pipe diameter DN 300 and DN 450
Number of junctions	4 per 50 metres
Number of manholes	One every 100 metres
Type of steps in manhole	Double steps
Bedding	According to the TRL design guide
Total length of sewer system	1 km
Service life	50 years

[1] In the UK, precast concrete pipeline products are normally manufactured to meet Class 4 sulfate conditions as defined in BRE Digest 363 (now superseded by BRE Special Digest 1). These products will satisfy the requirements for virtually all of the ground sulfate conditions actually encountered in the UK.
[2] Typical sizes for comparison of sewer pipes of different materials for gravity sewer systems.



Schematic overview of the sewerage system

A standard functional unit was defined which could be used for all the materials being considered. Comparison was between concrete, clay and five various types of plastic sewer pipelines



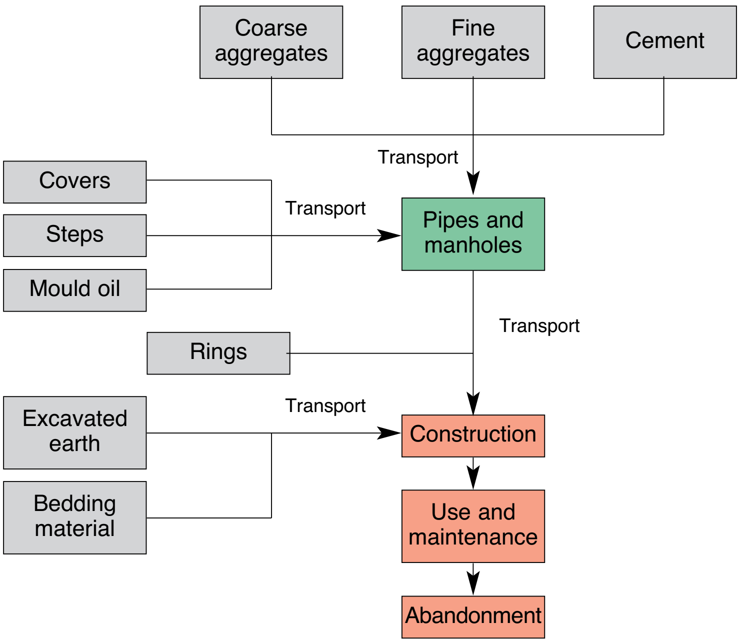
life cycle stages -

In this study all sewer systems were modelled from cradle-to-grave with all life cycle stages included, namely:

Manufacturing sequence of all parts of the sewer system
The production process for sewer pipes depended on the material of the pipe. For clay and plastic pipes, the applied literature data include processes from raw material extraction up to production of the finished products.

This in depth study considered all raw materials, the manufacturing process, transport, construction on site, use and maintenance over 50 years and the ultimate decommissioning and disposal of the system

Transport of these parts to construction site
Concrete pipes and manholes are transported by truck over an average distance of 130 km. The type of transport, and thus diesel consumption, is mass related. Clay and plastic pipes are produced at fewer locations and therefore, on average, require more transport. The distance for these pipes was assumed to be double, using mass related transport for clay pipes, and volume related transport for plastic pipes.



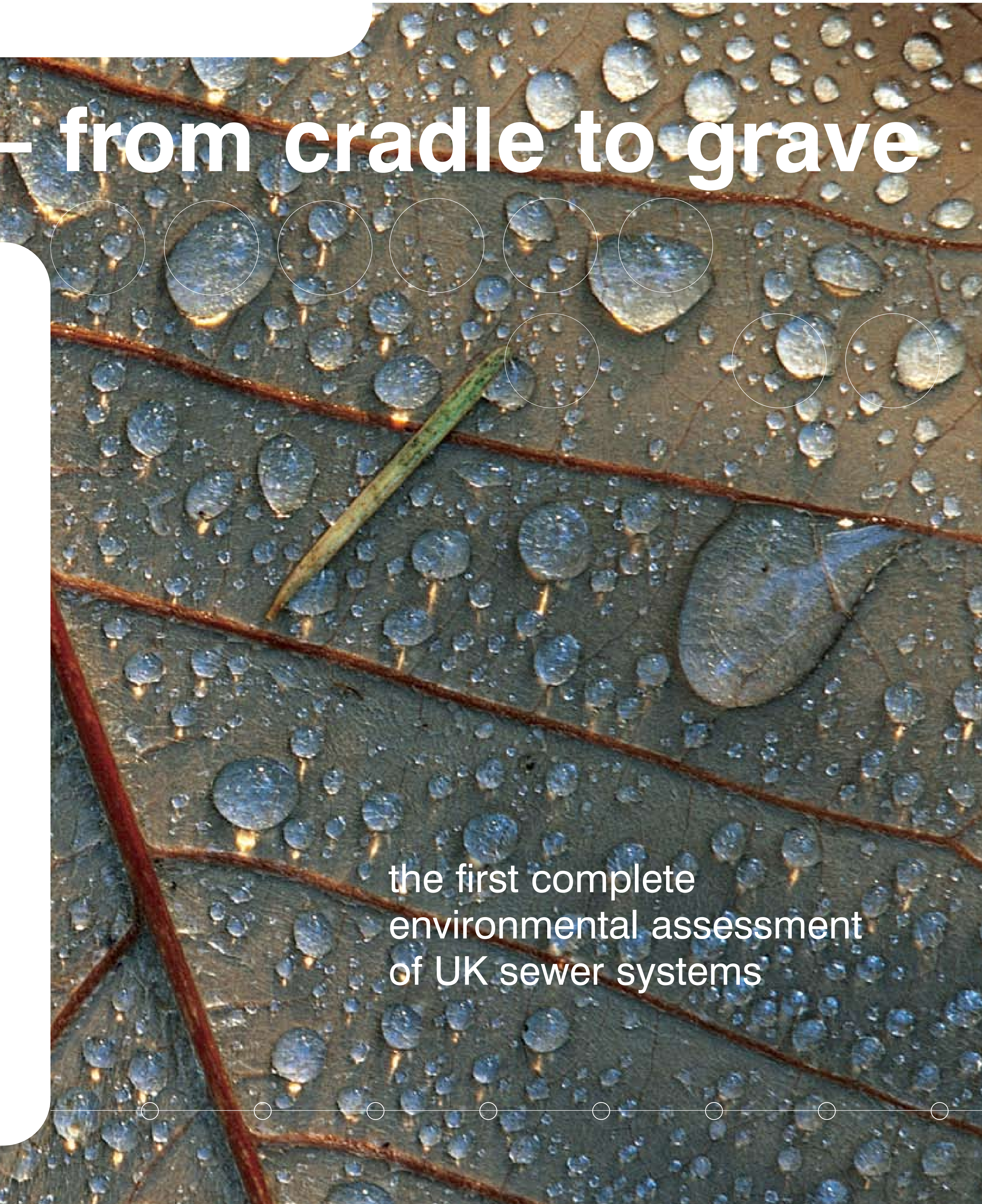
Construction of the sewer system and related processes
The trench width and required bedding class depends on the type of pipe material. The actual physical construction process (digging, placing bedding material, handling of pipes, backfilling) was assumed to be similar for all sewer systems.

Use and maintenance of the sewer system over 50 years
For the purpose of this study it was assumed that all sewer systems stay in service for 50 years. The way in which they are used and maintained during this period is similar for all the systems.

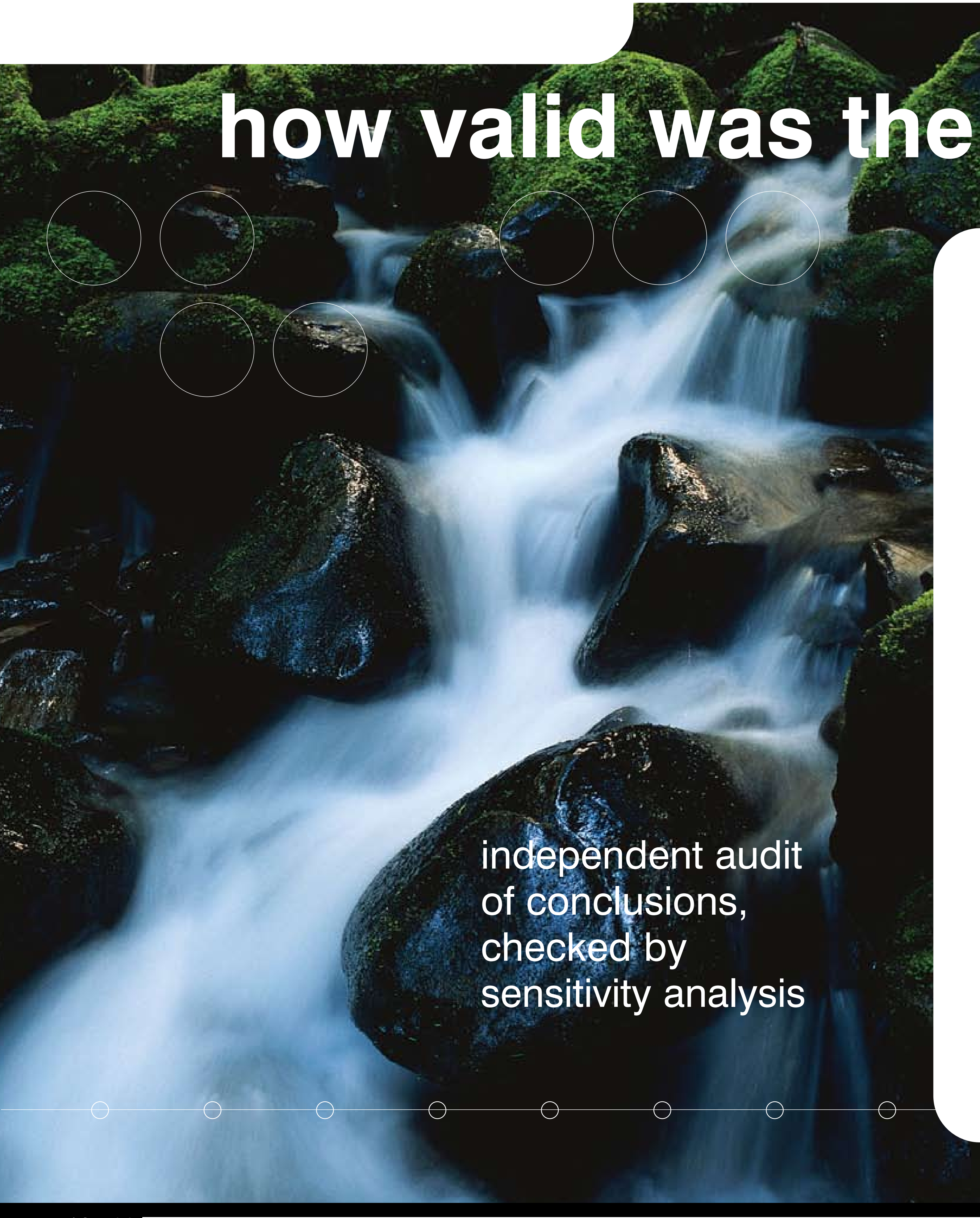
Demolition or abandoning of the system
In the UK sewers are only occasionally decommissioned and filled with material, such as grout. This study has however included this process in order to enhance completeness. There are no differences between pipe materials.

Disposal of waste and products
Building waste (an average of 3% of the pipes) is disposed of as non-chemical waste on a landfill site. The weight of the pipes determines the amount of waste that is released. The upper metre of manholes, demolished at the end of the service life, is also disposed of as non-chemical waste on a landfill site.

– from cradle to grave



the first complete environmental assessment of UK sewer systems



how valid was the

independent audit of conclusions, checked by sensitivity analysis

analysis?

Data from raw material suppliers, concrete pipe and manhole maufacturers, pipeline contractors and water companies – checked for robustness by sensitivity analysis

For every process in the life cycle, data on environmental inputs and outputs were collected and included –

- Input of raw materials
- Input of energy
- Output of emissions to air, water and soil
- Output of solid waste

Data for the research was provided by CPA members, suppliers of raw materials and components used in pipeline systems, pipeline contractors and water companies. For the other materials, product information from the producers and publicly available data was obtained by INTRON, who also checked on the validity of the various pieces of data used.

The "robustness" of the results was checked using a sensitivity analysis, where the major assumptions used were examined in order to determine their effect on the results. These included:

Using identical rubber rings for each system.
Conclusion - Assuming identical rubber rings for all systems can be regarded as a worst-case for concrete. The overall conclusions will therefore not change.

Transport distance of pipes to construction site – assuming the distance from factory to site is greater for clay and plastic than for concrete.
Conclusion - Altering the transport distances would not change the results for the clay and plastics sewer systems significantly. Therefore the overall conclusions would not change.

Transport distance of bedding material and excavated earth –assumption of a distance of 25 km.
Conclusion - The use of 25 km is a conservative estimate and is believed to be a worst case for concrete. The results of the LCA are affected significantly by changing the transport distance for bedding material and excavated earth. Increasing transport distance adversely affects systems which require more bedding.

Abandoning of the sewer system at the end of its service life.
Conclusions - The relative differences between systems hardly increased.

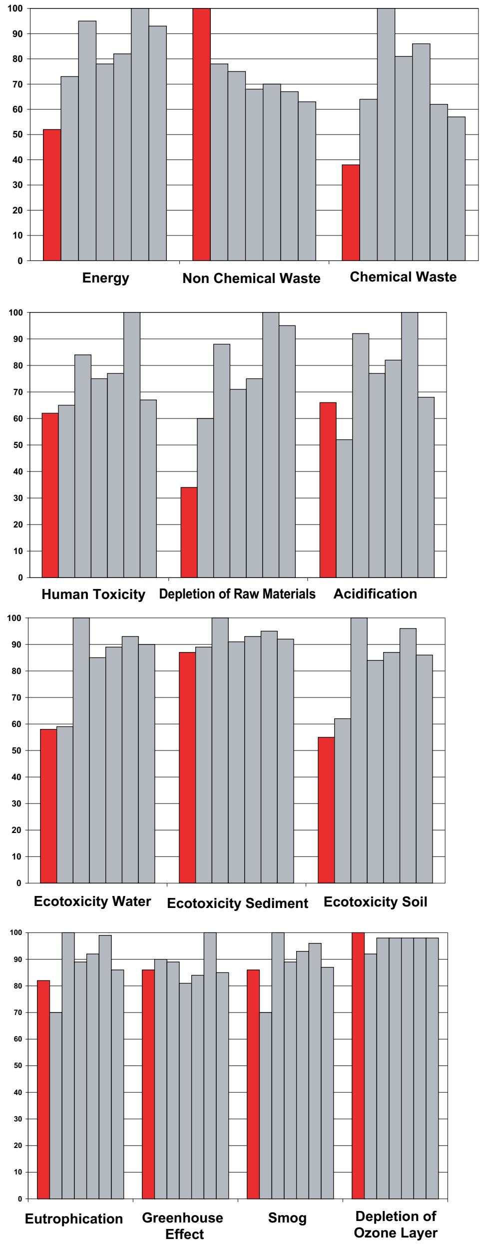
The results from the sensitivity analysis strengthen the conclusion that concrete proves to be an environmentally sound material for the studied sewer systems. In general the environmental load of a concrete sewer system can be regarded comparable to clay. Concrete proves to be more environmentally sound than the PVC varieties, PE and PP sewer systems.

what were the

The environmental performance of products can be measured using numerous parameters. Energy consumption, emissions, work environment and waste are examples of these parameters. These environmental aspects are divided into environmental effects and environmental measures. An example of an environmental effect is "acidification", an example of an environmental measure is "energy". The table gives an overview of environmental aspects that can be relevant in LCAs.

The environmental effects during the life cycles of the sewer systems have been compared making it possible to make statements about the environmental positioning of concrete in the functional units of this study.

- ***Concrete and clay sewer systems can be regarded as comparable***
- ***Concrete can be regarded as more environmentally sound than PVC***
- ***Concrete can be regarded as more environmentally sound than twin wall HDPE/PP***
- ***Concrete can be regarded as moderately better than spirally wound HDPE***



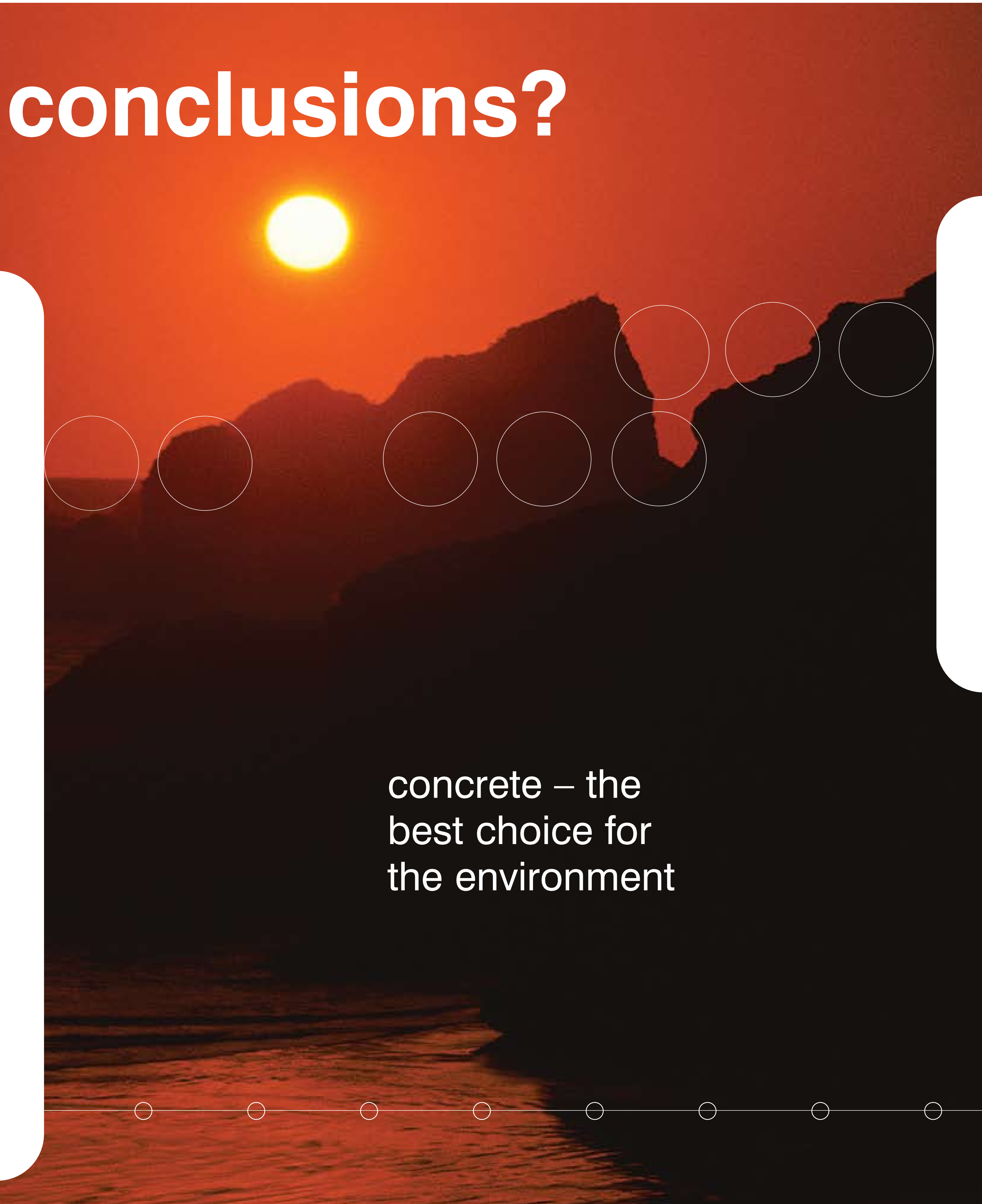
Comparison of environmental effects of DN450 sewer systems – concrete highlighted in red

Concrete performed best in seven categories and second best in three for the materials considered

Depletion of raw materials	**1st**	**Acidification**	**2nd**
Ecotoxicity sediment	**1st**	**Eutrophication**	**2nd**
Ecotoxicity soil	**1st**	**Smog**	**2nd**
Ecotoxicity water	**1st**		
Energy	**1st**		
Human toxicity	**1st**		
Waste chemicals	**1st**		

There is no significant difference between the materials in the other three categories, other than Waste Non Chemical

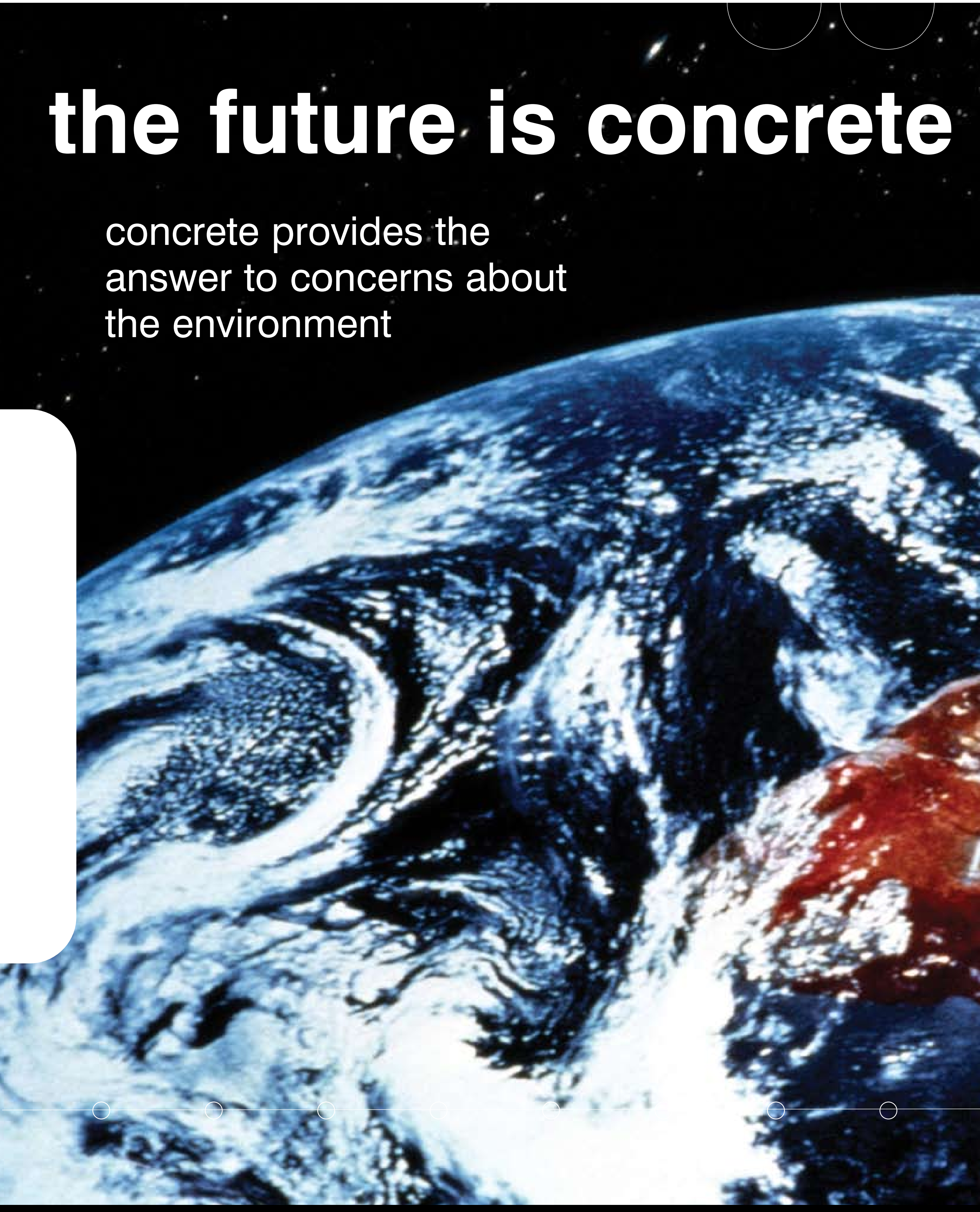
conclusions?



concrete – the best choice for the environment

the future is concrete

concrete provides the answer to concerns about the environment



“With the energy that is saved by using concrete DN450 pipes instead of solid wall PVC pipes, a truck loaded with concrete pipes could circle the world 1.5 times…, for every kilometre of sewer system.”

– INTRON

“With this study a representative environmental life cycle assessment for two sewer systems in the UK market is available.”

– INTRON

“Because plastics require more bedding material (and thus more excavated earth needs to be removed) construction of concrete (and clay) sewers is more environmentally sound than construction of plastic sewers”.

– INTRON

“Concrete proves to be an environmentally sound material for the studied sewer systems. In general the environmental load of a concrete sewer system can be regarded comparable to clay. Concrete proves to be more environmentally sound than PVC varieties, HDPE and PP sewer systems.”

– INTRON

“The total amount of waste generated by 1 km of a DN450 concrete sewer system is less than 3% of the amount of surplus excavated earth which has to be removed…”

– INTRON

“The proposed method of data collection and data sources are appropriate and reasonable in relation to the goal of the study.”

– BRE

“BRE believes the methodology to be scientifically and technically valid.”

– BRE

In recent years the environmental issue has been high on the agenda, with research being undertaken in many European countries to determine which materials are the most environmentally friendly.

An environmental Life Cycle Analysis (LCA) was undertaken by INTRON in the **Netherlands**, which compared concrete with clay and plastic pipes and concluded that in each of four categories, energy, raw materials, emissions and waste, concrete was the most environmentally friendly.

In **Austria**, the government commissioned the Research Institute for Chemicals and the Environment to report on the ecological comparison of pipes made from different materials. Data was collected for factors such as energy, emissions and waste and in six out of the eight categories concrete was the most environmentally friendly.

In **Germany**, a study carried out at Stuttgart University showed that the energy needed to produce concrete pipe was lower than for all the other materials examined.

In **Finland** it was concluded that, in its whole life cycle, concrete pipes used much less energy than plastic pipes.

When analysing the results of all these research projects, one has to conclude that concrete is the most environmentally friendly material for drainage and sewerage pipelines.

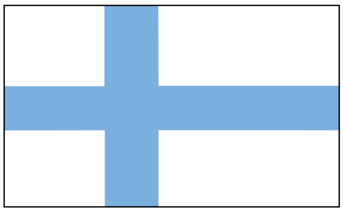
There are also many other factors that support the opinion that concrete pipelines are significantly more environmentally friendly than plastics.

Members of the **European Parliament** (MEPs) have echoed the European Commission's opinion that voluntary approaches to regulating the environmental impacts of PVC are insufficient and have called for even tougher measures. They have also backed calls from the Committee for the Environment, Public Health and Consumer Policy demanding a substitution policy, starting with a rapid replacement of PVC.

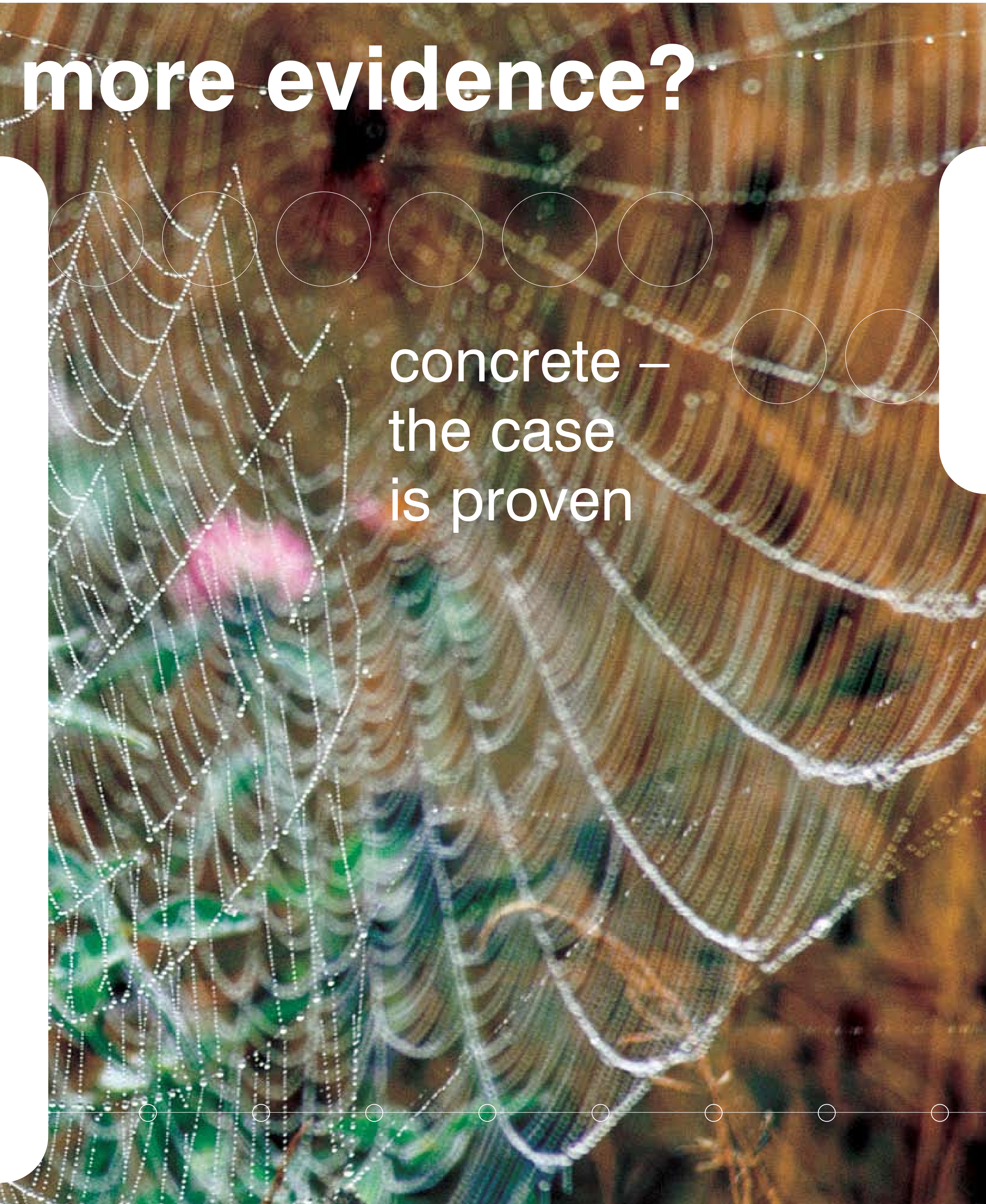
With the current replacement time for sewerage systems in the UK being more than 1000 years, there must be total confidence in the long-term durability of the pipeline material used. The vast majority of the tens of thousands of kilometres of concrete pipelines that have been laid in the UK over the past 100 years are still in service today, confirming the durability of concrete.

The installation of concrete pipes using trenchless techniques such as microtunelling and pipe jacking can play a significant role in further reducing the social and environmental costs associated with pipeline engineering works.

When reviewing all the work that has been undertaken, it becomes apparent that concrete pipes have a good environmental pedigree when compared to other materials.



more evidence?



concrete – the case is proven

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The CPSA is a member of the British Precast Concrete Federation

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