BATH
A WORLD HERITAGE SITE

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In the spring 2001, the naturally occurring thermal springs of Bath southeast of Bristol, England, a World Heritage Site, will be home to a state-of-the-art new Spa, and public bathing will once more be available–for the first time since 1978.

But, this will be a new Spa with a difference–it already has more than 2,000 years of history, and the water in which people will bathe, relax and recuperate fell as rain over 10,000 years ago!

The Bath Spa Project and the revival of the new Spa has been made possible by an £8M (US$ 12M) grant from the Millennium Commission, and a collaboration between: The Local Council in Bath–Bath & North East Somerset, The Bath Spa Trust, and the company selected to manage the operation of the Spa–Thermae Development Company.

HISTORY: BATH THROUGH THE AGES

There is archaeological evidence that occupation based around the hot springs on which the city of Bath is built began at least 8,000 years B.C. Coins thrown by Celts into the water, probably as offerings to their God, Sul were found during excavations of the King's Bath. The legend that Bath was founded by Bladud was first documented by Geoffrey of Monmouth, who published his "History of the Kings of Britain" in 1136.

The story is told that Bladud had returned from his travels a leper. Because of his illness he was confined, but escaped in disguise from his father's court and came to a place called Swainswick where he was employed as a swineherd. In cold weather, he saw his pigs wallowing in a mire. He found that the mud was warm and the pigs enjoyed the heat. Noticing that the pigs which bathed in the mire were free of scurfs an scabs, he reasoned that he might benefit from the waters. Cured of his leprosy, he returned to his father's court where he was restored to his inheritance. He succeeded to the throne on his father's death; whereupon he founded the city of Bath around the hot springs and built the baths so that others might benefit as he had done.

ROMAN

AD 43–The Romans started the development of "Aquae Sulis" as a sanctuary of rest and relaxation, not a garrison like most Roman towns– through the taking of the waters was described by Tacitus in AD 80 as "one of those luxuries that stimulate to vice."

AD 70–The Romans built a reservoir around the hot springs, a sophisticated series of baths, and a temple, dedicated to the goddess Sulis Minerva. As a religious shrine and bathing complex, Aquae Sulis attracted visitors from across Britain and Europe–foreshadowing Bath's status as a tourist attraction. The Romans also used the Cross and Hetling springs.

AD 367–With demise of Roman occupation of Britain, the great baths and temple of Aquae Sulis fell into ruin. They remained hidden until 1790 when foundations were being dug for the Pump Room.

MEDIEVAL

11th Century–The King's Bath was built over the temple precinct and spring, as part of an infirmary.

12th Century–Founding of St. John's Hospital. Henry of Huntington writes: "Where the hot springs...supply the warm baths which stand in the middle of the place, most delightful to see and beneficial to health....infirm people resort to it from all parts of England, for the purpose of washing themselves in these salubrious waters; and persons in health also assemble there, to see the curious bubbling up of the warm springs, and to use the baths."

1449–Barnwell writes: "...a report has reached the ears of the bishop that the heavenly gift of warm and healing waters with which the city of Bath has been endowed from of old is turned into an abuse by the shamelessness of the people of that city."

ELIZABETHAN (1558-1603)

16th Century–The three baths (King's Bath, Cross Bath and Hot Bath) continued to attract visitors who came in search of a cure of various ailments. Interest in the curative properties of spring water helped to revive the economy of Bath after the decline of the cotton trade.

1562–The first medical treatise on Bath's waters awakens renewed interest in the spa.

1574–Elizabeth I's visit draws the nation's elite to Bath.

1576–Queen's Bath built besides the King's Bath.

1661–Installation of the first drinking pump at the King's Bath.

1663–Charles II brought his infertile wife to bathe in the Cross Bath.

1687–The Catholic wife of James II became pregnant soon after bathing in the Cross Bath–ensuring a male Catholic successor and prompting a Protestant uprising.

1692, 1702, 1703–The visits of Queen Anne in the 1690s and 1700s set in motion a period of development in which the city became "the premier resort of frivolity and fashion." Queen Anne visited Bath to take the waters–where royalty led, the aristocracy followed and in time, led to the rebuilding of the city, which in 1668 had a population of just

1200. The subsequent popularity of the baths in the Georgian era resulted in the great rebuilding of the city to produce the 18th Century layout and architecture of today's World Heritage site.

GEORGIAN (1714-1820)

1738–Start of the construction of The Royal Mineral Water Hospital reflected a new period of faith in the healing properties of the waters. It is also notable as the only building on which the three men most responsible for the construction of Georgian Bath–John Wood the Elder, Beau Nash and Ralph Allen–collaborated. While the beneficial and healing properties of the water have always been acknowledged, modesty and decency have not always been inherent in Bath's "spa culture." John Wood the Elder writes at this time: "The Baths were like so many Bear Gardens, and modesty was entirely shut out of them; people of both sexes bathing by day and night naked."

1777–Hot Bath rebuilt to the design of John Wood the Younger.

1783-98–Cross Bath rebuilt and then enlarged.

1788–New Private baths (now demolished) built between King's Bath and Stall Street.

1790s–Great Pump Room built. While excavating the foundations for the new Great Pump Room, many of the first finds relating to the Roman Temple were made.

1798–The publication of "The Comforts of Bath," a satirical view of life in Bath, reflects the infamous lifestyle of elements of Georgian society. The Pump Rooms and the baths were the center of much revelry throughout this period when Bath became known as the "premier resort of frivolity and fashion."

VICTORIAN

1880–King's Bath excavated.

1889–The New Private baths were built over the Roman west baths–treatments included the Schnee Bath which used electricity (the New Private Baths were demolished in the 1970s).

20TH CENTURY

1900s–Bath spa water was bottled and sold as Sulis Water, promising relief from rheumatism, gout, lumbago, sciatica and neuritis.

1920s–Following the First World War, thousands of wounded soldiers rehabilitated in spa towns such as Bath. Construction of the public swimming pool at Beau Street.

1948–Following the establishment of the National Health Service, the health authorities of Bath made arrangements to provide water-cure treatments on prescription.

1970s–Roman Rendezvous–in the 1960s and 1970s, the Great bath was the setting for parties which mirrored the revelry of earlier spa culture.

1976–Withdrawal of NHS funding resulted in the closure of the Spa Medical Facility.

1978–Public health concern lead to the closure of the Beau Street and Cross Baths for bathing; though, the Roman Baths and Pump Room soon became one of the UK's leading tourist attractions.

1980s–Various bids led by commercial consortia to reopen the Spas for bathing failed due to the huge capital cost of restoration.

1983-5--Drilling of boreholes beneath the King's and Cross Springs ensured the supply of clean water.

1997–Successful bid to the Millennium Commission for a lottery grant which would enable Bath & North East Somerset council to reopen the baths and revitalize thousands of years of spa culture.

THE BATH SPA PROJECT

On 13 July 2000, Bath & North East Somerset council voted to commit itself to funding the £19 (US$ 28.5) million Bath Spa Project The decision signaled the end of a 22-year period in which Bath, which was founded and evolved as a City on the basis of its hot thermal springs, existed as a Spa in name only. No one has actually bathed in Bath's natural spa water since 1978, due to a withdrawal of NHS support for the medical spa and uncertainty over the purity of the source.

With the offer of a £7.78 (US$ 11.7) million Millennium Commission grant to support the Project already in place, building of a widely-acclaimed new Spa, designed by Nicholas Grimshaw & Partners, commenced in August 2000.

Various attempts - five in the 1980s and 90s - were made by the local council and by business concerns to reopen the baths, all of which ended in failure as it became clear that the capital cost of restoration was too great to allow profitable operation.

Throughout this period, local opinion has supported all efforts to restore Bath's historic spas and visitors to the city have remained frustrated and puzzled by the lack of Spa bathing facilities. Indeed, an area of the City, rich in culture, architecture and history - just a few hundred yards from the famous Pump Rooms - steadily degenerated.

Control of the hot springs was, in fact, entrusted to the Civic Authority in the Charter of Incorporation of the city of Bath (1590), it being the intention of Queen Elizabeth I that the thermal waters should be accessible to the public in perpetuity.

As the current guardians of the waters the Council's aspirations to make bathing facilities available on reasonable terms to all local residents are consistent with the aims and criteria for applications to the Millennium Commission.

An archaeological exploration of the Beau Street site has already been completed, and the construction programme and refurbishment of five buildings began in August 2000. The reopening of Bath's Millennium Spa is planned for spring 2002.

The Scope of the Bath Spa Project

Cross Bath	The Cross Bath will be restored as a working spa for bathing. Residents will have special access rights.
New Spa Building	The new spa building - a Bath stone cube, in a translucent glass enclosure - will be built on the site of the 1920s Beau Street swimming pool, and will house the main spa complex. From the rooftop pool and terrace bathers will enjoy views across Bath's skyline. Other pools within the spa will be located on different levels. Facilities will include whirlpools, steam room, exercise area, rest areas, treatment rooms and cafe.
Hot (or Old Royal) Bath	The Hot Bath will house the Preventorium, a medical treatment center providing preventative medicines and therapies such as massage, physiotherapy, hydrotherapy and acupuncture.
The Hetling Pump Room	The Hetling Pump Room will house an educational, research and interpretive center plus administrative facilities.
The Bath Spa Thermal Project	The Thermal Resource Project will research, explore and monitor the thermal waters to achieve greater understanding of their sources and ensure their protection for future generations.

THE ENERGY AND WATER SOURCE

Energy and water are available from three separate springs, each tapped by boreholes, and located quite close to the new development. These three sources are known as the Kings Spring, the Hetling Spring and the Cross Bath Spring. Each of these springs now have boreholes sunk to varying depths, to intercept the water at a lower level. All three sources were developed and used by the Roman inhabitants, but it is the Kings Spring which has been studied in most detail. Past estimates have indicated that the thermal output from the springs varied between 8 l/s and 27 l/s (127 and 428 gpm), and that the temperatures ranged from 40°C to 49°C (104 to 120°F). Much work was carried out during the 1980s to establish a number of new boreholes, and these sources will now be used to serve the new Bath Spa development. During this period there was extensive monitoring of the sources, which also considered the effect on these sources of extraction through new boreholes located elsewhere in the city. This research has formed the basis of the energy capacity used in analyzing the various systems options considered for serving the new development.

The Kings Spring

The Kings Spring is located under the existing Pump Rooms and rises naturally into the Kings Bath, at the center of the Roman Bath's Museum. The supply for the Bath Spa Project is brought to the surface through an inclined borehole, with its head located in the adjacent Stall Street. The borehole extends to a depth of some 76 m (250 ft) below the Stall Street datum, and the capacity of this source is limited to 0.50 l/s (8 gpm) at an average temperature of 43°C (104°F) and represents an energy source of approximately 65 kW. This source is located approximately 100 m (330 ft) away from the new main building, and will be connected to the new systems through new pipework.

The Hetling Spring

The Hetling Spring is located in front of the existing Hot Bath, in Hot Bath Street. This has the lowest output of the three springs, rated at approximately 0.42 l/s (6.6 gpm). This spring has potentially the highest temperature, yielding around 45°C (113°F). It is estimated that 50 kW of useful heat can be derived from this source.

The Cross Bath Spring

This is visibly the most interesting, in that the borehole termination appears above the surface of the exiting Cross Bath pool. The existing top of the borehole will be reconfigured to take the water into the new Beau Street plant area, but will maintain its presence in the redeveloped Cross Bath. The spring yields up to 2.39 l/s (38 gpm) at a temperature around 44°C (111°F). This gives the greatest capacity of up to 300 kW.

The Composition of the Springs

It is not only energy which is important to the development, but also the chemical composition. Again during the 1980s much investigation work was carried out on the chemical compositions, and these are summarized in the table below.

Summary of Water Analyses (from Kellaway, G. A. 1991)

Paramenter (mg/l)	Stall Stree Borehole	Hetling Spring	Cross Bath Spring
Sodium	187	195	183
Calcium	390	358	380
Sulphate	1010	1015	1050
Chloride	286	340	288
Bicarbonate	199	193	189
Magnesium	53	57	54
Silicon	21	21	–
Iron	1	0.5	02.

The analyses show that the thermal waters all contain sodium, chloride and sulphate ions in high concentrations. In addition, the iron content of the Kings Spring has the potential for staining, and it is this source which also has high suspended solid levels.

Since 1978, the hot spring spa pools at Bath have been closed following the identification of a free living pathogenic amoebae in the water. In order to establish safe supplies of the thermal water, lined boreholes were drilled into the Kings and Cross springs in the 1980's to abstract water from a depth and temperature at which the amobae can not exist. However, as part of the new develop-ment it is still necessary to provide treatment to the three pro-posed sources prior to their use in the new Bath Spa complex.

Building Systems and the Use of the Water

Original design development culminated in the release of an energy report which was issued in July 1998 as part of the initial scheme design. This report was based on an architectural scheme and building layout which has subsequently undergone various changes. The energy system at that time had been based on the principle that the spring water was initially passed through the pools to heat them and maintain the pools temperatures at 33.0°C (91°F). The water from the pools was then passed through a number of heat exchangers where the heat was extracted through a series of heat pumps to serve the heating load of the building.

This solution raised a number of concerns, mainly that there would be relatively high costs associated with treating all the available spring water required to maintain the heat balance in the pools. Following further design work, a flexible system was developed which allowed heat to be extracted from the spring water without the water being circulated through the pools. This ensured that the maximum heat capacity could be derived from the thermal water sources, without the need to treat large amounts of spring water. The option to take the water directly to the pools, through the water treatment system was maintained.

Design Criteria

The building has a wide range of uses, and therefore internal design conditions vary. However, the main areas within the pools and associated areas require internal temperatures of 29°C (84°F). The external design dry bulb temperature was set at –6°C (21°F), although the development is located in the center of the City of Bath, and is normally subjected to local temperature effects.

Building Loads

Building loads are incurred by heat losses from the building, due to fabric and infiltration losses, the need for hot water for showering and washing, and the requirement for maintaining the pools at the correct temperature. The overall building design heat load is approximately 620 kW at peak design condition. The pools require 300 kW to maintain a design condition of 33°C, and this in fact can be met extracting heat from the spring water, which in total has a capacity approaching 415 kW. However, the spring water alone cannot meet the whole building demand, and therefore supplementary energy systems are required. The building also requires fresh air to be provided to most parts of the buildings, and where possible these systems use heat reclaim in the form of run around coils.

System Design Options

Following discussions with the operator and Client, it was decided to investigate in detail the system options which would meet the thermal requirements for the building. However, the total energy consumption of the building is not limited to heating and thermal loads. The electrical consumption for the building also has to be considered. For the new Bath Spa building, the electricity costs will range between 3.7 p/kWh (5.5 ¢/kWh) and 7.0 p/kWh (10.5¢/kWh), depending on the time of year and usage, compared with 0.9 p/kWh (7.4 ¢/kWh) for gas. Also, from April 2001, the UK government intends to introduce a Climate Change Levy, which again will have the greatest impact on electricity costs. With these costs in mind, and taking into account recent experience on similar projects, it was decided to include the use of Combined Heat and Power in the system options, which is also expected to provide a benefit in taxation from 2001.

System Study Conclusion

The original proposals extracted as much energy as possible from the spring water supply. However, to do this heat pumps were used to extract the heat, which in turn use electricity as the primary energy source. Electricity is both relatively expensive, and has a high CO_2 production, when compared to gas as a primary fuel. However, the system does make a complete use of the spring water.

Systems were compared using energy and maintenance costs and CO_2 production. Financially a simple CHP and boiler combination is the best option with potential payback within 2 years and this is because there is no heat pump installation. However it has a higher CO_2 production because it is not making such effective use of the spring water. For limiting CO_2 production, a combination of CHP, heat pump and gas boilers gave a very low level, when compared to the other systems.

The building system design has now been developed to use as much of the spring water directly, and using a CHP and boiler combination. The warm thermal water is used:

- To preheat the incoming mains water, which is needed for showering and washing.
- To provide make up water to the pools to replace water lost be evaporation.
- To directly feed the pools if needed.

This system provides a good balance between costs, CO_2 production and spring water usage. Whilst the development is not wholly reliant on the continuing availability of the spring water, it is central to the day to day operation of the building, providing natural spa water to the pools and making an important contribution to the energy requirement of the building.