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CLEAN RIVERS TRUST
Registered Charity Number 103 7414

MINEWATER UTILISATION PROPOSALS FOR LOCAL HEATING SYSTEM AT QUEENS MEDICAL CENTRE, MEDIPARK AND NOTTINGHAM UNIVERSITY CAMPUS



In over 20 years of involvement with control and treatment of minewater, the Trust has built up a fund of knowledge and experience which has equipped it to explore the various possibilities for harnessing this hot water 'resource' for wide ranging benefit. Whilst minewater is a pollutant but it can be viewed as a hugely valuable resource. The mere control of water from abandoned coalfields in the UK already requires an expenditure of many £millions annually and this cost is growing as the Coal Authority install new plants to remediate or protect more and more locations from pollution. A recent report (Atkins 2011) for the Department of Energy and Climate Change estimated that the cost of protecting the environment.from mettalliferous mining sites would be in the region of £300 million. Use as a means of heating will turn a negative issue into a positive benefit.

In conjunction with 'Invest in Nottingham' the Trust seeks to explore the feasibility of a thermal heat from minewater energy centre to serve Queens Medical Centre, Medipark and Nottingham University campus which sit adjacent to each other above a suitable abandoned coal mine. Our experience, collaborating with both the Coal Authority and UK Coal over treatment proposals in abandoned mines, has given us the insight to be able to assess the opportunities in any potential location for district heating and volume usage. We have experience of working closely with universities over treatment methods for polluted waters from metalliferous mines which also have great potential both for hot water utilisation and the economic recovery of minerals. The Trust has given mining related advice extensively to the British Government and to and foreign government sponsored organisations.

In order to use its ability effectively the Trust has set up 'Minewaters Consultancy' to provide advice and project development services to prospective energy developers and consumers to help make minewater utilisation widely available as a matter of urgency exploiting the potential within controlled and safeguarded parameters. In practical terms the Trust will provide the following services: Scoping Report, Feasibility Study and Grant assessments, Geological and Operational site assessments, Mobilisation Proposals.

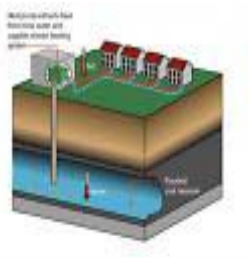
In the majority of new projects we expect to introduce a district heating or a local distribution proposal alongside an Energy Centre and to extend the facility by incorporating absorption chillers for cooling. A characteristic of hot minewater utilisation will be as a simple and robust heating facility reliable for many decades providing stable low cost and low carbon heat. Where appropriate systems can and should be complimented by Combined Heat and power generation and the technology to ensure adequate electrical backup in the event of power grid shortages. Well thought out and capitalised solution to utilising a naturally occurring energy source will both help the environment and attract government financial support and capital allowances.
The Trust has already located minewater resources for chemical, pharmaceutical and food manufacturers in the UK.

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The resource value of hot minewater from abandoned workings is a proven asset. There have been positive uses made of in Canada, Holland and, to a limited degree, in the UK. In Canada a large factory was built in 1988 using energy, heating and cooling supplied using hot minewater from abandoned mine workings beneath the site. The pay back was very early on, and the system has proved successful and been greatly extended in the locality.









In the Netherlands a highly acclaimed scheme has been completed that utilises water from a mine to supply heating and cooling for a large new commercial and residential development in the municipality of Heerlen together with a district heating scheme for 350 houses.

Five new wells were drilled in various locations around town to access the underground mine shafts. Each well is 700 meters (2,300 ft) deep and can pump out nearly 80 cubic meters (2,800 cubic feet) of water per hour. The water temperature at the bottom of the well is 32 C (89 F) and gradually cools to 28 C at the surface. In a system similar to that proposed for Nottingham, hot water from the mine is brought to the surface where a heat pump extracts the heat in order to supply hot water to households in the area. Meanwhile the minewater is pumped back down 450 meters to be reheated. In the summer, to provide cooling, water will be pumped from a much shallower depth of 250 meters, where it exists at a lower temperature.

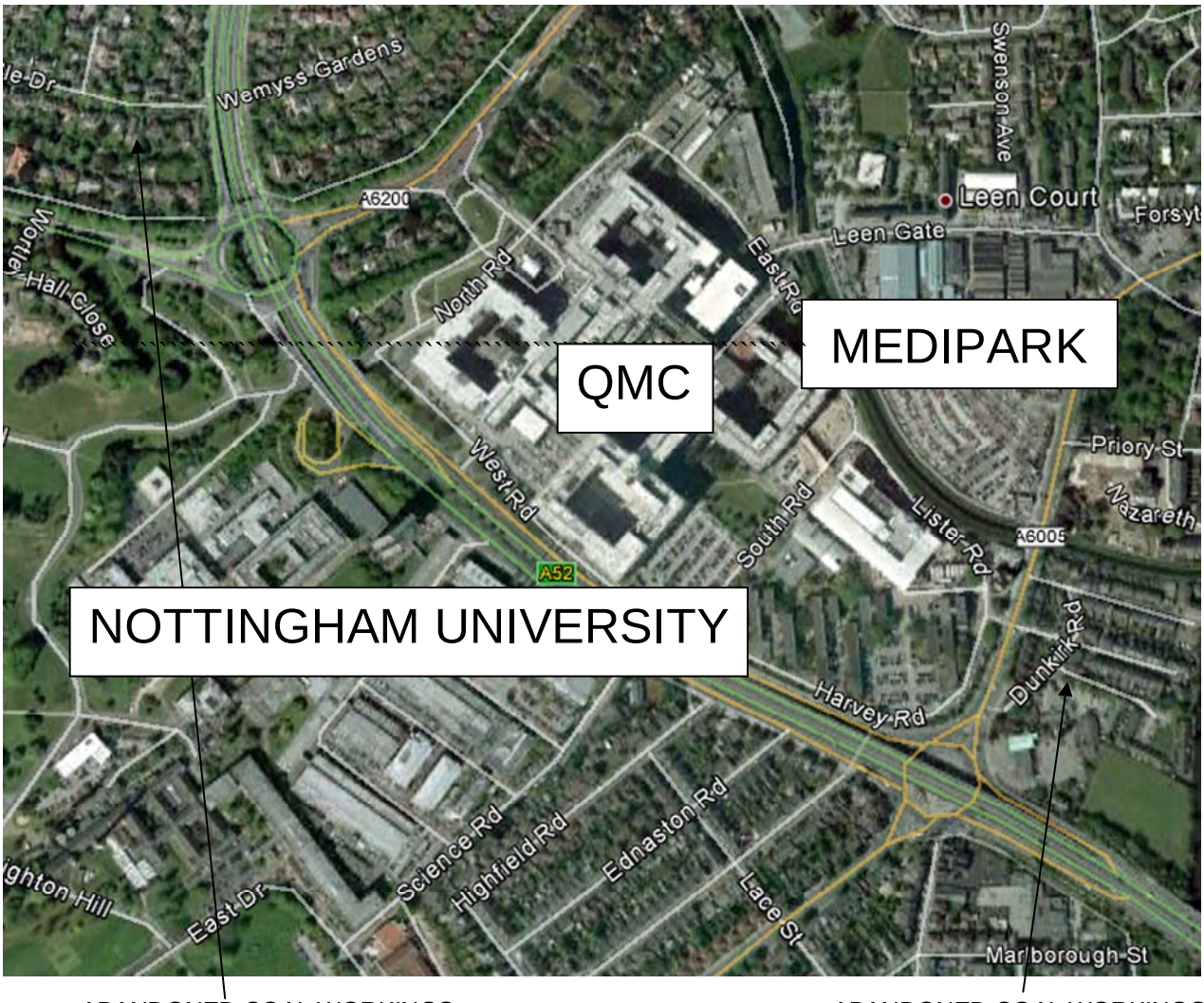
Similar schemes are now being planned in Slovenia, Austria, Germany, France and Belgium where such plants are likely to be installed. The Coal Authority is presently using thermal heat from minewater at one of its pollution control sites in the north east of England to heat its own offices. Whilst ground sourced heat exchange, district heating schemes and deep geothermal heating systems are becoming commonplace, The economic utilisation of hot minewater at relatively shallow depths has only become available as a result of the move to abandon mines and reliance on coal in the late 20thC.

Nine out of ten houses in Iceland are heated geothermally, and 17% of Iceland's electricity comes from geothermal power. The availability of hot springs has been of huge benefit to Iceland and now the availability of hot minewater in the UK is on offer. It is an opportunity not to be missed. Users particularly suited to hot minewater utilisation are those with a high demand for heat including hospitals, universities, hotels, schools, industrial, offices and residential projects.



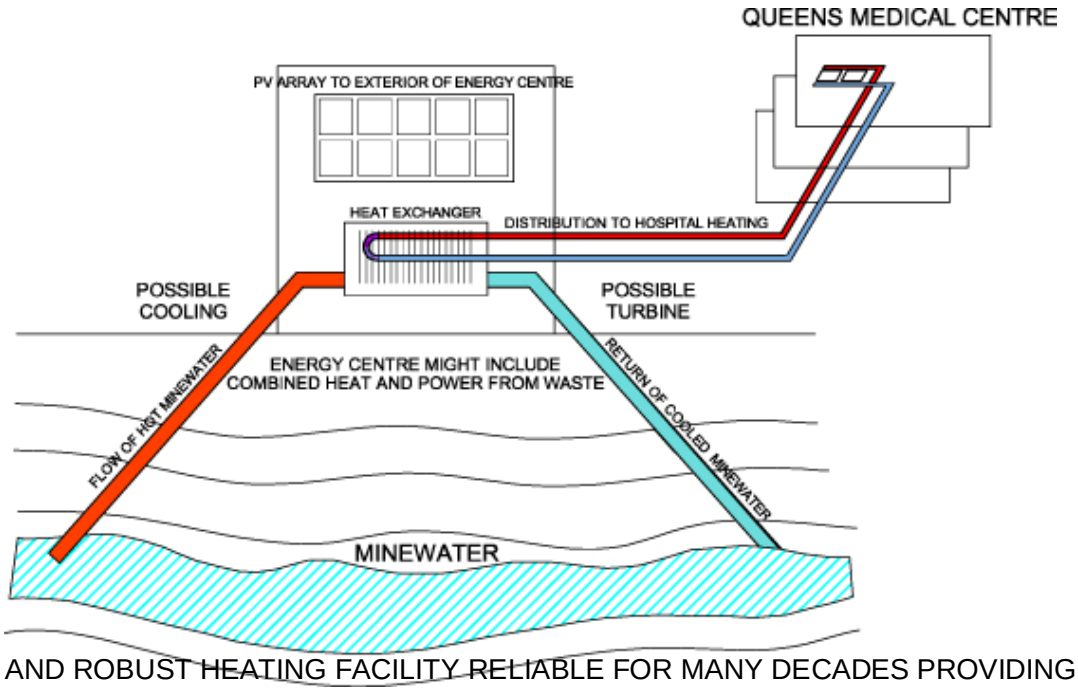
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ABANDONED COAL WORKINGS

ABANDONED COAL WORKINGS



A SIMPLE AND ROBUST HEATING FACILITY RELIABLE FOR MANY DECADES PROVIDING STABLE LOW COST AND LOW CARBON HEAT

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INTRODUCTION TO WORKING WITH MINEWATER

CRT have been working with minewater for more than twenty years and have built up an expertise in many ways of managing and utilising it., both during active mining operations and after mineral extraction has ceased.

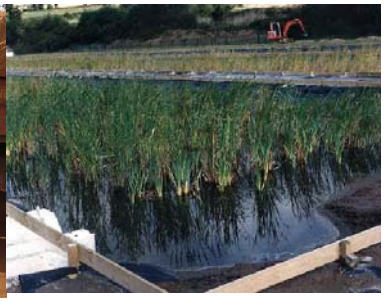
The irregular flows and appearance of abandoned minewater pollution has taxed the rump of the coal and metal mining regulators as to its cost effective treatment and in many cases volume management both in the UK and Europe since mining for many metals and minerals; particularly coal have ceased to be mined on any major scale. This has been due to the legislation and lack of realisation as to the future scale of the issue, particularly with the development of water quality legislation and in particular the Water Framework Directive.

Minewater since 1991 when the large water pollution incident that took place at the just closed Wheal Jane tin mine in Cornwall where the Fal Estuary was considerably affected by millions of gallons of ochreous arsenic and copper wastewater that rebounded to surface. This incident itself; with the ongoing water treatment and the ongoing management of water levels within the small area has cost over the last twenty years many millions of pounds alone.



Minewater issues from abandoned coalmines are being managed by the Coal Authority effectively and in conjunction with the Environment Agency in England and Wales, the Scottish Environmental Protection Agency in Scotland is prioritising its modest budgets to develop water treatment and management schemes that curtail, pre-empt or reduce pollutions across Britain. The agency has in place over 60 schemes at present and is looking to install a similar number more to cut pollution to a total of over 400km of water courses and protect some of the country's important aquifers.



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Metalliferous minewater pollution in Britain has recently been tasked to the Coal Authority to bring about a management scheme that is achievable; a report (Atkins 2011) states that the cost of schemes is estimated at over £320 million to bring the present pollution problems in hand. There is ongoing discussions with the regulators and other interested parties as to a acceptable program of works to begin what can only be a long-term agenda.

The negativity that the issues of minewater engender are remarkably strong, but there are aspects to the whole issue that can be seen as positive. The nature of the beast is that vast reservoir areas across much of the industrialised and populous regions the country that have reserves of water; markedly of variable quality, but in an island that is concerned with the issues of global warming, drought and a growing shortfall in water resource generally there is a certain glimmer of hope.

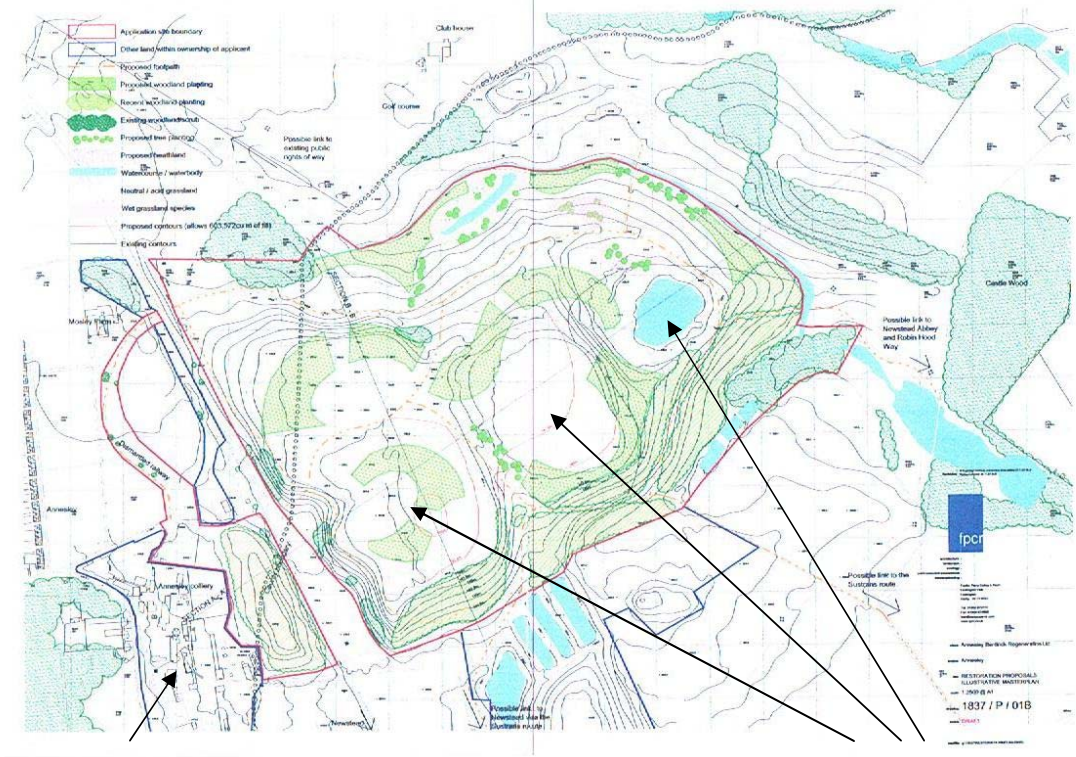
The CRT Experience

The Trust has been involved with the treatment of minewater for over twenty years, from both closed and active operations. Our experience of the management of water emanating from active operations include most notably Annesley Bentinck Colliery in Nottinghamshire between 1992 and 2000, when the colliery shut and Silverdale Colliery in Staffordshire between1995 and 2000 when again the winning of coal ceased is encyclopaedic.



These operations dealt with millions of gallons of water being pumped to the surface annually: at Annesley Bentinck the average was 1.2 million gallons per day plus surface water management issues of the sites that covered nearly 1,000 acres. The harvesting of which was achieved as a viable and valuable environmental and economic bonus for the site.

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PITHEAD ANNESLEY RESTORATION PLAN LAGOONS

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After mining ceased at Annesley Bentinck the Trust was retained to aid the site decommissioning, draining lagoon infrastructure and the maintenance of environmental protection measures and standards
The Trust has always considered what the uses to which minewater could be put; the development of several concepts such as basic resource: heating or cooling water, treated to bespoke standard of need, household mains supply or process water. All these have been investigated and have been proved to be economically viable.

In the west of England the Trust identified an old iron mine minewater pumping shaft as a suitable resource that was utilised to supply minewater as process water for a major pharmaceuticals and drinks manufacturer at rates above 100,000 gallons per day (36.5 million gallons of water per annum). With some treatment to remove bacterial risk the water was developed as the resource to manufacture a range of internationally popular sports and lifestyle spring water based drinks and a range of infant formula preparations. The project proved over the lead-in period to be financially sound: it further safeguarded the factory and engendered the expansion of the factory and increased the workforce by over 150% to over 1200 employee in an area of job scarcity.

In West Cumbria an international chemical and phosphate company wished for a large volume supply of water for cooling towers for its power plant and acid works. A search

of likely or potential sources identified two sets of mine operations adjacent to the factory which were potential resources. The shallower mineral seams; those of an abandoned anhydrite mine were chosen to investigate as they were closer to the surface and overlay the coal working that were potentially the other source.

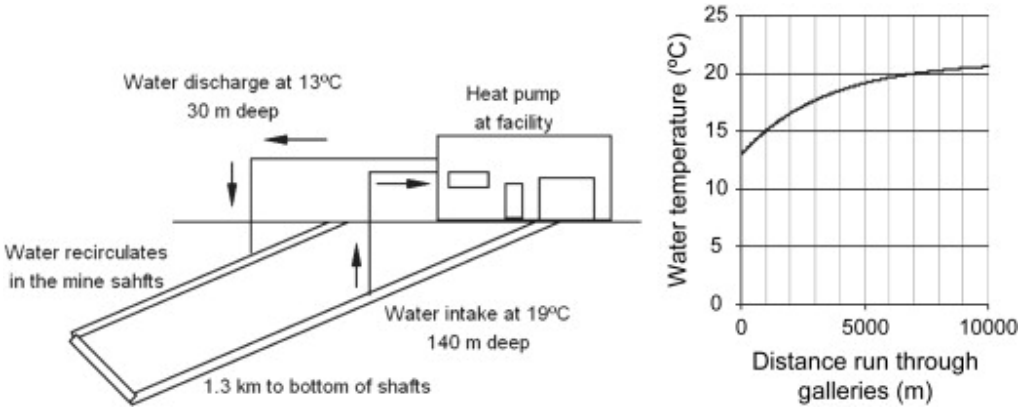


Over a prolonged period of trials and the licensing of an abstraction licence with all that that entailed. The water proved to be less costly by 99% for the product and cost 20% less to make suitable for the industrial uses that they were specified for. With the development costs and licensing fees payback was achieved within 12 months.

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Concepts of Minewater as an Energy Resource

There are three operating facilities that use minewater from abandoned mines operational globally. The longest lived operational scheme being located in Canada.

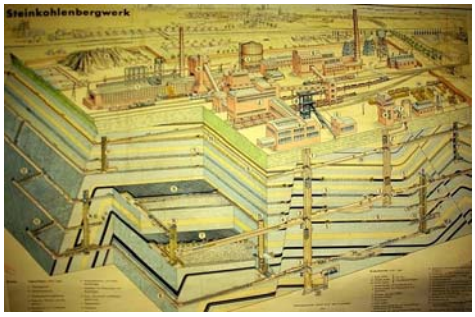


Minewater has been used since 1988 in Springhill, Nova Scotia in Canada to heat, cool and dehumidify a large packaging manufactory. American Canners, later know as LynPak have developed the concept to include community and private dwelling heating programs across the town. The costs of the project were such that the project saved money on initial completion. The principal is still functioning satisfactorily today.

Due to laws pertaining to abandoned mine access, even remote drilling and pumping, in other states within Canada the project has not been replicated elsewhere in the country; though the British Columbia legislature is at present looking to alter its legislation to allow similar projects in the mining areas of that state.

The second scheme is located in Heerlen in the south east Netherlands. The operation was originally planned to be a joint venture with a Scottish local authority; which due to political and fiscal constraints pulled out of the venture. The municipality of Heerlen though continued in 2008 and have now an industrial and residential heating and cooling scheme functioning across the city.





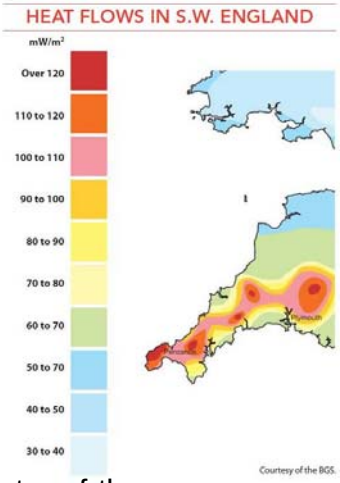
The third operation is a small project run by the Coal Authority in the UK. The minewater pumping scheme at Dawdon on the coat of County Durham takes a small part of the water from that is pumped to protect the local aquifer and passes the untreated flow through a heat exchanger. The heat generated by the process heats the offices and laboratory on site.

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CRT Minewater to Energy Background



In 1992 Clean Rivers Trust held meetings with British Coal to discuss the use of minewater for heating and a possible sustainable future for some then operational mines that were being considered for closure. The discussions were fruitful in that the Trust was able to look at minewater temperature at the pumping lodges that were operational at the time. There was though no take up of the idea and after the President of the Board of Trade in November announced the closure of the major part of the coalmining industry and the reprivatisation of the other operations the idea of using minewater was not appropriate till after the formation of the two companies that took on the residual mines; RJB Mining plc and Coal Investments plc.



At this time CRT was collaborating with Camborne School of Mines on the West Cornwall 'Hot Rocks' geothermal project that was funded by the Department of Energy and Dti.
In 1995 the International Energy Agency researched a report on the abandonment of coal and metal mines across Europe and the possible repercussions for the water environment. Clean Rivers Trust is cited in their report on the subject. The Trust worked with the Agency to look at the uses of thermal water from the mines, but at the time gas and nuclear generation capacity were the favoured energy sources across the continent and minewater was considered to be not much better than refuse incineration or wind turbines.

RJB Mining had discussions with the Trust, but the mining director of the company was unable to interest the financial backers of the company. Similarly the same was true with Coal Investments; they as a company collapsed and Midlands Mining took on their mantle. The directors were interested to explore the various options that were available to utilise their sites for other forms of energy generation. Clean Rivers Trust were detailed to consider these options and set up a small research group including some researchers from Nottingham University and part of the post doctoral research group at Camborne School of Mines.

There were proposals to use water for a small industrial estate close by Annesley Colliery to utilise water with temperatures up to 40 degrees C but informal planning discussions blighted the proposal. At the end of 1999 Midland Mining ceased trading to keep within the law and the legal framework with regard to future liabilities with regard to minewater and pollution from abandoned workings that came into force on 1st January 2000.

Water Resource Potential

The water resources that are available from within the abandoned mineral mines of the UK are large and remarkably evenly placed around much of the country. The historic industrial centres are centred about the coalfields of the mainly 19th Century workings

that are closer to the outcrops of coal and its shallower workings and developed as this reserve was worked out to the deeper workings. As this following of the coal strata down dip the quality of coal encountered became better due to the non oxidised nature of the product.

It took till the Georgian and Victorian age to be able to follow these coals deeper for the water that is commonly attendant with mining became harder to remove at depth. Mining has always found water a nuisance and it took the pumping engines, originally developed to dewater the tin and copper mines of Cornwall and Devon to be made available to the coalmining industry by companies such as Bolton and Watt.



Water was a problem in all mines to one degree or other and few found any disposal route apart from discharge to the local streams and rivers of the coalfields. By the nature of many of the waters this coursed widespread pollution from iron staining and coal dust (Royal Commission on River Pollution, 1874), though the same report also notes that some mines supplied communities with water as a resource for industry and human consumption.

Now that the coal industry as the metal mines had previously closed down the workings below ground have flooded in the main. In many coalfields as this inundation has taken place minewater has found its way to the surface to drain into the natural environment resulting in pollution of the receiving water courses. The Coal Authority as an independent agency of UK government manages the remediation of waters from the coalmines of the nation and have been made the agency to oversee the remediation of metalliferous mine discharges that are polluting as well (2012).

The waters that are at present treated by the Coal Authority are known to be of elevated temperatures but as these waters are primarily for pollution control the thermal value has not been of significance. At Dawdon this attitude is changing; at the minewater

treatment facility in County Durham the Authority has installed a research installation of a heat exchanger to glean the waste heat to be used at their premises on site.





This is the total response at present to the known value of minewater as a geothermal resource that has been proven in Nova Scotia, Canada (1988) and Heerlen in the Netherlands (2010/11).

Overview of Nottingham's Minewater Resources

The minewater resources of Nottingham are located around the City edges coal being present beneath the city centre but left as a conserved pillar to avoid the city dropping due to subsidence after the removal of coal. The main coalmining operations that worked the coal seams beneath the city's periphery included Wollaton, Clifton, Gedling, Newcastle, Babbington and Radford. The mines located to the eastern edge of the area worked originally from the outcrop and gradually mining operations moved east following the dip in the coal strata.

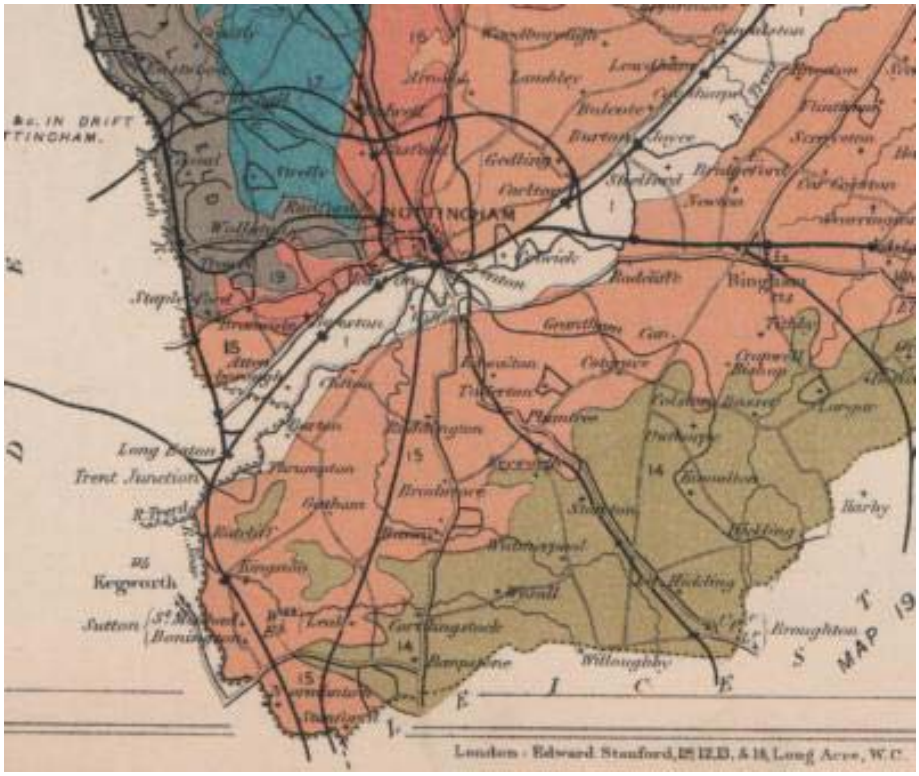
The south western part of the Nottingham coalfield is dominated by workings of two collieries, Wollaton and Clifton; the whole area is known to have been mined from very early times with many of the workings unrecorded (pre 1887).

The knowledge that the area was known for wet working goes back as far as the 16th Century where the accounts of the Willoughby family and their estate of Wollaton detail the costs of constructing drainage adits or soughs to lead water away from the coalface workings in the area.

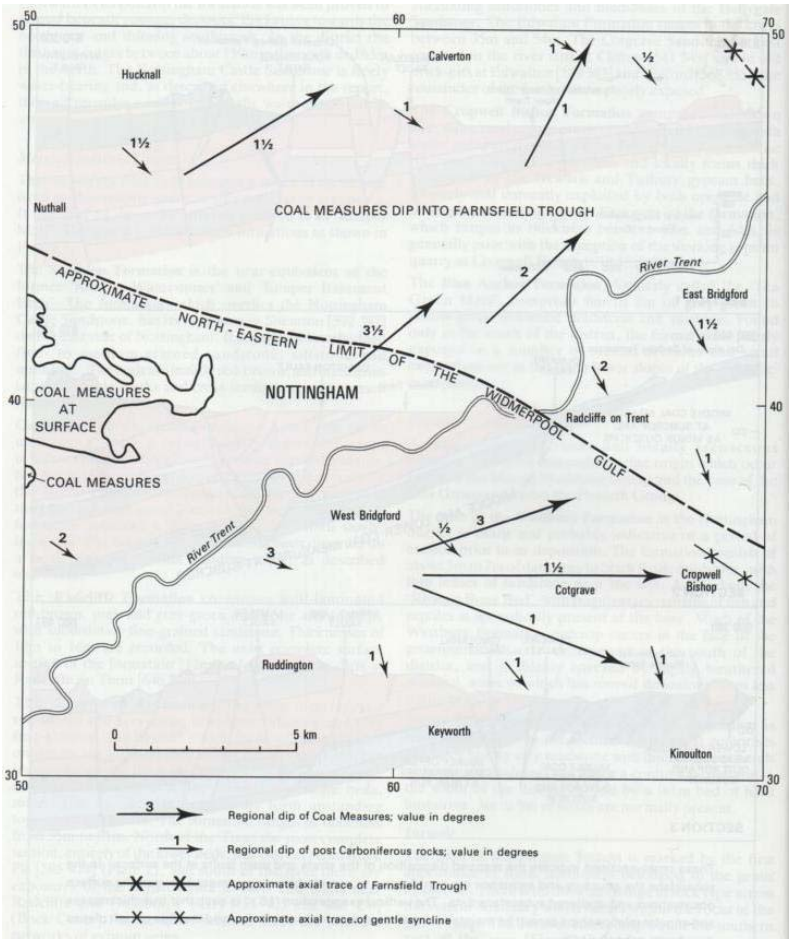
Geology / Hydrogeology conditions of the South Western Nottingham Coal Area

The coal seams that have been worked in the area outcrop across the lands between Beeston and Wollaton and ark round the area in a northerly direction. The coal measures being sandwiched between the Carboniferous limestones below and the Sherwood sandstone atop allowed for wet coal workings. These were influenced by waters from the aquifer above, the secondary aquifer below; allied to the strata that allowed precipitation at the outcrops of the coal seams and by their proximity passed into active workings down dip. Though much of the coal workings have subsided since mining in the area ceased in the 1960s, there is still permeability and large water availability within the goaf areas.

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The Geology of the Nottingham Area.



Dip of the Coal Measures.

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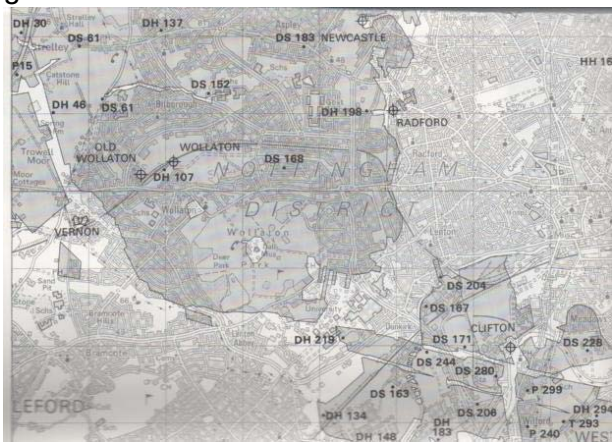
The mine configuration about the target area of the Queens Medical Centre and projected Nottingham University development site are interesting; the outcrops of the coals mined in the area are only a few miles distant but the coal mines in the area mined coals at depths in the locality of 500 feet and more showing a sharp dip in the strata towards the east.

The target area is located between the two colliery workings on what is best described as a buffer zone that protected the integrity of the two as entities. The strip between was not meant to have been linked and on inspection of the basic worked coal plans at the Coal Authority office at Mansfield no drivage link was noted. There being no plans either of pre 1870s mineral workings in the area; though they are known to have been extensive.



Location of Near Surface Workings and Unknown Early Coal Excavation Shafts.

The drainage soughs of some of the Wollaton mines in the 1500s were known to take water away towards the northern Trent streams in a south or south-eastern direction towards our sites of interest. Their actual routs are now near lost though estate plans give some indications.



Workings in the South West of Nottingham Shafts and Coal Boreholes.

Techniques

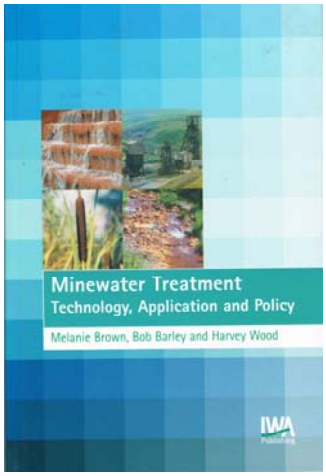
Generally the methods of taking water from a mine is to enter it by the open shaft if such access is available or to place boreholes to enter the workings at their most robust and permanent void areas; pit bottom, main drivage or haulage roads. These locations being the most assured to hold reservoirs of water. This accounts for the location of a pumped water supply rising main. The return injection well is less of an issue so long as the

cooled water is returned to the mine workings in not too close a proximity to the take out point. If it is to close there is the probability that it might influence water temperatures to a negative degree. The reinjection well may only need to place the water at a level where gravity can lead it to the main water body below.

The technical aspects of gaining access to the water from the mine systems of Clifton or Wollaton collieries from a site such as Queens Medical Centre or the proposed 'Medi Park' may be considered as somewhat out of the ordinary. Both colliery workings are known to be close to the sites but not directly below them; this leads to the development of the project with the use directional boreholes.

As has been noted previously in Canada and the Netherlands, the boreholes have been targeted vertically for the placement of the rising main; this is though unnecessary as in many other forms of subsurface development, such as in the oil and gas industry these methods are common and regularly used.

It may be possible to considered generating electricity as part of a self contained system by using low grade heat to stimulate gases of low temperature boiling to drive a steam turbine in a sealed environment. Similarly it might be possible to utilise an inboard turbine in the return phase of the operation. The selection of a suitable target extraction point and the execution of the bore requires both the skill, knowledge and experience which CRT Consult possesses and wishes to develop through further application.



The team also wish to develop further applications to use alongside the utilisation of minewater. We already have a body of knowledge and many years experience in Minewater remediation which in the appropriate circumstances will help to be able to devise suitable ways of removing pollutants and enabling the effective use of minewater

in water related processes. Dr Harvey Wood's books about Minewater are the Standard references on the subject.

We would like to exploit the potential for self containment and back up systems as it will be important to monitor and keep to an even flow rate. We have already undertaken innovative research into the generation of power by use of CHP technology in conjunction with anaerobic digestion and sewerage utilisation. Our work on this technique has had specific reference to health issues in Ethiopia and Uganda but, subject to permitting there could be widespread applications for this technology in the UK and Europe.

As an alternative power system which might be deployed in conjunction with a Minewater installation, we seek to examine the linkage of a PV array in conjunction with battery technology. As well as improving battery storage technology for cars Panasonic have produced and industrial storage arrangement suitable to power with PV.
It will be possible in conjunction with the minewater heat exchanger to introduce a cooling mode to installations where this would be valued.

It may also be possible to adapt the minewater installation for use with industrial processes. Whether treated or untreated, as a supply and resource, water is already a significant economic asset.

Today it is in use in various locations across the UK. There are many reasons:

- Independence of supply
- Cost, the price of water abstracted under licence from beneath the ground is considerably less than any water company can supply
- Removing the need for potable water supply from a water company to be used for purposes for which there is no need for its quality
- Helping to protect major aquifers from over exploitation
- Helps to protect the regions surface waters from pollution by abandoned minewater pollution
- Can limit industrial sites' carbon and water footprints

All the above singularly are attractive in times of increasing prices and mounting environmental regulation but as combinations they become even more attractive. For industrial users except in the food and drink industry process waters can be acceptable in a relatively 'dirty' condition. Even when the water needs to be pure companies can and do find these resources cost effective.

Minewater as an area of growing potential has been kept out of the industrial spotlight by the environment regulators and the statutory water companies for these reasons.

- Water company revenue loss
- Contaminated ground and water issues
- Licensing procedures; their costs and complexity
- Prospect of long-term in-house management issues
- Regulators' lack of enthusiasm
- Local authority environmental health and planning departments lack knowledge regarding these areas of their responsibility

Many industrial users need substantial supplies of water and are told in most parts of the country that if they do not have an operational well or borehole on site that is already consented that there is no available water to be abstracted from their area. This is the case with aquifers that are regionally or nationally important such as most of the Sherwood sandstones or the chalk aquifer of Kent or Sussex. In the mining areas of the English Midlands there is a shortage of aquifer supply. The existing surface water supply from Wales is over subscribed, but beneath the sandstone aquifer are large volumes of water that are not touched.



Legal issues

The legal and licensing issues are important and need to be addressed at the outset of any proposed project where ever it is planned. In the UK the situation is relatively straight forward. The water that is the target of the enterprise is the property of the state. That said the purpose in the initial proposal; that is to gain heat from the water does not require abstraction licensing as it is not being removed from the strata for other uses and is being returned to its source in the same chemical state as it was when brought up to the surface.

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The regulators for any groundwater based activity that might be carried out is the Environment Agency for England and Wales, till 2013 when Wales will be covered by the newly constituted Welsh Environment Agency and in Scotland the Scottish Environmental Protection Authority. In whichever area a project is envisaged there needs to be liaison with the regional groundwater teams.

The local authority planning department needs to be involved from the outset to minimise issues of borehole placement and the permissions that a development to use the heat will engender. There are other organisations that have some jurisdiction into access to mines in some areas of the country; the Deputy Gavellor's Office in the Forest of Dean for example, though there are now few other local controllers of minerals left in the UK by extant Local Acts of Parliament.

COAL MINES
The authority that needs to license any activity appertaining old coal workings is the Coal Authority which is much interested in this area of development. Their main issue is that they have signed indemnities from the exploratory operator before any mechanical intrusion is made into their workings. Apart from the regulatory stance they have a self imposed role to encourage the uses of minewater.

METALLIFEROUS MINES
From 2012 the Coal Authority has been given the responsibility to clean up the water and land pollutions from metalliferous mines in England and Wales and the Scottish Government are expected to pass on similar responsibilities to them shortly.

It is unclear as to the Coal Authority's role with regard to accessing minewater from abandoned metalliferous workings, but the logic of involving them at the outset precludes any issues that might arise later. Local planning authorities are the main regulators in the area though with few issues to regulate beyond the basic planning proposal. Mineral rights landlords may feel that they have a financial interest but as water is not of their ownership and the water is being returned to the strata no mineral is effectively being interfered with.

RESEARCH
Mine plans for the collieries of Wollaton and Carlton need to be accessed at the Coal Authority as do mine plans that may be lodged with the Nottingham County Records Office and the Willoughby Archive at Nottingham University.



Demand Requirements

QMC is heated by a central generating set and we anticipate being able to utilise the existing distribution system. It is anticipated that there will be a huge saving over conventional energy generation.

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Medipark's hitec medical science specialisms have yet to be realised and developed. The park would be an appropriate location for a central energy installation where distribution will be via a district heating scheme. The University Campus may also be a most effective target for a minewater installation.











Stakeholders

Nottingham University Hospitals NHS Trust

Nottingham City Council

Nottingham Regeneration Limited

INVEST IN NOTTINGHAM
www.investinnottingham.co.uk

NDE

medilink EAST MIDLANDS

Technical Partners

Geldards law firm

ADDC Architects

Drilling Company

Derry Mechanical and Electrical Services Provider

Feasibility and Grants

Application is to be made to the Technology Strategy Board for the Greenius Award

Mobilisation and Program

Medipark is in a special Planning Zone and application will be made to the City Council for consents during the first phase of the competition.

It is anticipated that work in phase two – the development of a first working prototype in its Energy Centre on site at either QMC, Medipark or the University can be accessed during June -November 2013. There after it should be possible to provide turnkey solutions based on the prototype across the UK Coalfield and further afield on a commercial basis.

Prepared by Dr Harvey Wood FRSA, FRGS, FGS, FLA, FRSM Dip AD October 2012