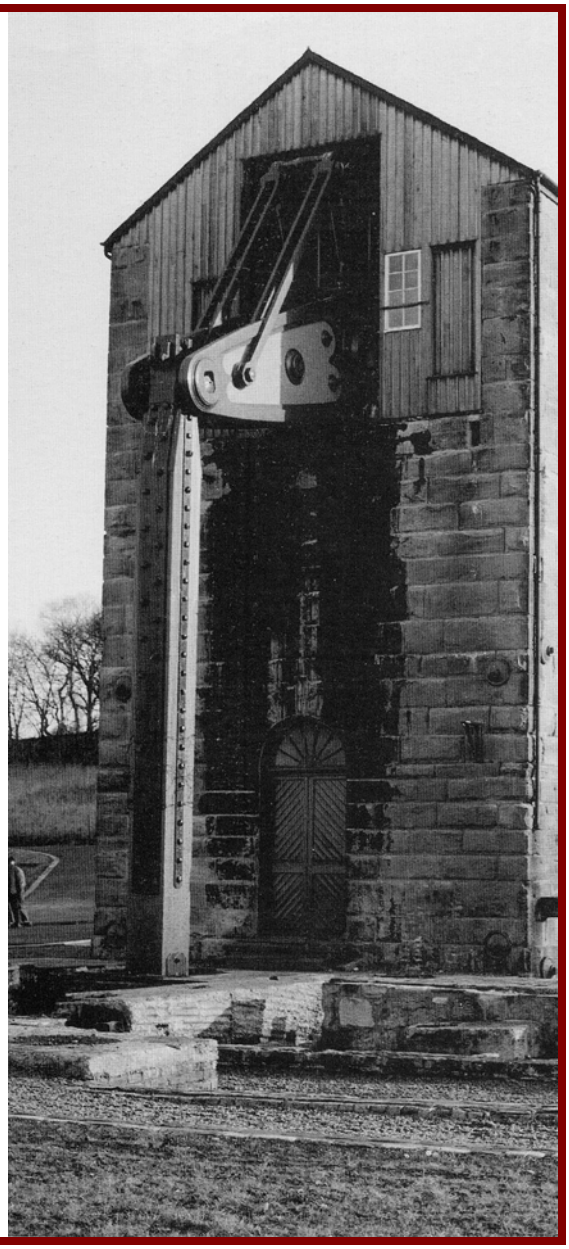
Water at Prestongrange and pumping it out
A resource pack for teachers and students

***This Resource Pack** is one of a series offering an introduction to local history while fulfilling National Curriculum targets across a number of subject areas. It has been designed for the 5-14 age range and mixed abilities.*

Contents



1. A brief history of water drainage at Prestongrange

The major factor limiting coal mining at Prestongrange has always been drainage and the key to intensive mining at Prestongrange in the 19th and 20th centuries was the Cornish beam engine. To understand its importance is to understand the impact of steam power on the coal industry.

Digging ever deeper

Over the centuries, from 1184 onwards, mine workings grew deeper as surface coal was exhausted. Salt and coal were both extremely valuable resources and industry flourished throughout the 17th and 18th centuries, thanks to nearby commercial markets and the sea trade at Morrison's Haven. But, by 1749, Prestongrange mine was closed due to underground flooding.

Prestongrange Re-opens

The advent of steam power offered a solution and, in 1830, Matthias Dunn re-opened Prestongrange, sinking a new shaft, the 'Great Seam Pit'. The impact of steam power on mining was revolutionary, allowing access to enormous supplies of minerals and fossil fuels, especially in Cornwall, where the depth of its tin mines encouraged the early development of machines and equipment. However, all through the 19th century, flooding was still a major issue at Prestongrange.

The Cornish Engine

These engines utilised high pressure steam, combined with the doubled up power strokes of the 'parallel motion' innovation of James Watt. This produced an enormous fuel saving on previous engines. A steam engine located at the top of the mine shaft powered the beam which, together with the heavy pump rods (weighing up to a hundred tons) operated a pump located at the bottom of the mine shaft. Through a series of intermediate tanks and pumps every few hundred feet, the water was removed from the shaft, often into a tunnel or 'adit' which drained some distance away.

Thomas Newcomen (1663-1729)

It was Thomas Newcomen who first harnessed the power of steam in what became known as the 'fire engine'. This was essentially an upright cylinder filled with steam, which was then cooled so that it condensed, using atmospheric pressure to generate power via a piston. However, these engines were massive in size and extremely expensive to install and, although some were in use during the second half of the 18th century, their enormous cost generally made them unavailable to individual mine owners.

John Smeaton (1724-1794)

Smeaton's wide experience in iron forging gave him the understanding to improve the efficiency of early steam engines, both in terms of power and control. By standardising the measure of a steam engine's capacity, he created a more practical, scientific approach making it possible for buyers to identify in advance the type and capacity of machine suitable for their needs.

James Watt (1736-1819)

By 1765, when James Watt introduced the concept of a separate condenser to keep the cylinder constantly hot, instead of repeated heating and cooling, the beam engine had been in existence for over 60 years. Additional changes to the way in which the piston was attached eventually resulted in the 'rotative engine'. These modified steam engines could operate at double the power of

previous engines and required far less human involvement in the operation. Moreover, they were smaleer and more easily transportable than previous engines. When Watt, and his partner Boulton's, patents expired in 1800, other manufacturers were eager to make use of their designs. This resulted in the first appearance of what was known as the Cornish Engine.

Richard Trevithick (1771-1883)

Trevithick's 'Cornish Boiler', built of riveted wrought iron, could produce steam at a pressure rate of fifty pounds per square inch. Previously, the maximum pressure achieved was only four pounds per square inch. Furthermore, it could be mounted on wheels and therefore had a capacity for mobility.

The Prestongrange Beam Engine

The 'adit' system which came into use in the 16th century used separate shafts for mining and for drainage. Even so, by 1749, the volume of water flowing through the tunnels at Prestongrange made further mining impossible until 1829, when Mathias Dunn installed a twenty-inch cylinder pump and auxiliary pumps. These, along with Dunn's system of cast-iron 'tubbing' or lining to prevent water seeping into the shaft, allowed access to the 'Great Seam' 420 feet below the surface. However, the pressure of water on these cast-iron 'tubs' was enormous and the pumping engines could barely cope with such a volume of water.

In 1874, Prestongrange Colliery purchased a Cornish beam engine, designed by engineers Hocking and Loam. It was built in 1853 by JE Mare at the Plymouth Foundry for a silver-lead mine in South Devon. In 1873, Harvey and Company of Hayle replaced the existing beam and lengthened the piston rod, before selling it to Prestongrange Colliery in 1874, where it was erected by Matthew Loam of Liskard. According to local lore, the engine was shipped in parts via Morrison's Haven harbour and assembled on site. Once erected, the beam engine pumped water at a rate of 650 gallons per minute.

In 1905, the Summerlee Company installed further pumps and new pump rods of orgeon pine to increase the capacity of the water pumping equipment. A steam-driven winch helped with this work and was then left in place in case of future repairs. The larger pumps also required a strengthening truss added to the beam, which was no longer capable of bearing the increased load resulting from the new pumps. The improvement work was carried out by Messrs. Andrew Barclay Sons & Co. Ltd., and the strengthening truss designed and manufactured by the Summerlee Company.

The work of the beam engine allowed many years of mining to be carried out at Prestongrange, with greatly reduced levels of flooding. As a result, mining operations deepened even further. However, this took its toll on the beam engine which, in 1916, suffered a fractured piston rod. As the rod fell, it broke the bottom of the cylinder and cracked the cylinder wall. The mine was closed while repairs were carried out, a costly exercise for both owners and workers. Similarly, in 1938, the mine closed while repairs were once again made to the beam engine.

By 1952, the beam engine was suffering the stress of so many years of continuous working and the pump fractured. In 1953, the discharge valve burst and was repaired. By 1954, a fracture had

appeared in the pipe which supported the vertical column. The cost of casting and producing a replacement pipe was prohibitive and the Cornish pump was replaced by a number of smaller, more efficient electrical pumps. Increased drainage problems with seams below the Firth of Forth, competition from alternative power sources and the establishment of open cast mines meant that drainage costs at Prestongrange were prohibitive. By 1962, the mine was permanently closed.

2. Summary

Digging ever deeper
Coal was mined at Prestongrange for centuries, but as mines grew deeper, more and more water flowed into the **workings**. By the 1749 the **volume** of water flowing through the tunnels at Prestongrange made further mining impossible.

Prestongrange re-opens
In 1830, Matthias Dunn sank a new **shaft** at Prestongrange, the 'Great Seam Pit'. This shaft was possible thanks to a new source of power to pump water out the mine - steam power.

The Cornish Engine
Steam powered **piston** engines for lifting, hauling and especially, at Prestongrange, for pumping water away, meant that coal could be mined once again. It was Thomas Newcomen who first **harnessed** the power of steam and James Smeaton who developed a machine which was more powerful and easier to control, but it was James Watt's idea of a separate **condenser** and his design for a '**rotative engine**' which allowed inventors to increase the power of these engines. Richard Trevithick's 'Cornish Boiler', produced steam at a **pressure** rate of fifty pounds per square inch. The maximum pressure of previous boilers was only four pounds per square inch.

The Prestongrange Beam Engine
In 1829 Mathias Dunn installed a series of steam driven pumps. However, the water pressure was enormous and the pumping engines could barely cope.
In 1874, the Prestongrange Company purchased a Cornish **beam** engine. A steam engine at the top of the mine shaft powered the beam. This, together with the heavy pump rods (weighing up to a hundred tons) operated a pump located at the bottom of the mine shaft. For 80 years, until 1954, this beam engine pumped water out the mine at a rate of 650 gallons per minute. However, by this time, drainage costs at Prestongrange were prohibitive and in 1962, Prestongrange Mine was closed.

3. Glossary

Workings
The area underground where coal is being mined

Volume
The measurement of how much space is taken up by a quantity of liquid, solid or gas

Shaft
A mining tunnel dug from the surface, often straight down into the earth

Piston
A moving cylinder. A rod attached to a piston can move machinery

Harnessed
To bring something under control

Condenser
A container in which air is heated until it forms steam

Rotative engine
An engine with a beam or rod attached to a circular crank

Pressure
The amount of force created by one thing pushing against another. In the case of a steam engine, the weight of steam pressing against the inside of the boiler

Beam
A long, thick bar, often made of wood. A beam engine uses steam power to move the beam to and fro, which in turn moves a pair of rods which operate a pump

4. Timeline

1150s - Charter grants the Cistercian monks of Newbattle Abbey by Seyer de Quincy, Earl of Winchester to establish a coalworks and quarry between Whytrig Burn and the boundaries of Pinkie and Inveresk.
1308 - Act of Parliament forbids the use of coal in London due to smoke and fumes. Coal is used to heat large monastic and nobles' houses in Scotland whilst being associated with trade and industry.
1300s - James V allows construction of Acheson's (now Morrison's) Haven. The Abbey is granted the right to transport coal from the workings beside the River Esk for shipment in small boats. Packhorses make the return journey with salt and with goods traded for the salt and coal shipped at the harbour.
1450s- Accessible supplied of coal diminish while demand for coal increases.
1500s - Scottish coal output is approximately 40,000 tons, but still from small scale workings. However, 6 tons of coal were needed to produce one ton of salt (salt was very profitable).
1609 - Export of coal forbidden.
1606 - Law reduces colliers to a form of slavery (serfdom).
1700 - Annual output of coal c4 million tons
1705 - Thomas Newcomen patents the steam engine.
1707 - Union of the Parliaments of Scotland and England sees the decline of the Prestonpans salt industry.
1722 - Tranent and Cockenzie Waggonway laid.
1741 - Evidence of the use of horse gins at Prestongrange.
1743 - Morrison's Haven harbour ceases trading.
1746 - Mining temporarily ceases at Prestongrange due to flooding.
1780 - James Watt successfully modifies Newcomen's design.
1800 - Total coal output for Britain is 10 million tons
1812 - William Murdoch perfects a method for extracting gas from coal for lighting.
1814 - Sir John Hope's Pinkie Railway between Pinkiehill and Fisherrow is constructed.
1815 - Tranent and Cockenzie Waggonway replaces wooden rails with cast iron.
1830 - George Grant-Suttie leases land at Prestongrange to Matthias Dunn
1830 - No 1 shaft sunk, re-opening the mine after more than 65 years.
1831 - Edinburgh and Dalkeith Railway ('Innocent Railway') constructed.
1838 - Waggon road at Prestongrange runs from pit bottom to working. Bearers replaced by wheeled rails.
1838 - Matthias Dunn gives up the lease of Prestongrange.
1840 - No. 1 shaft flooded.
1850s - Turnpike System is introduced in Scotland.
1850 - The Prestongrange Company takes over the Prestongrange lease.
1850 - Opening of the mineral railway junction links Prestongrange Colliery with the main East Coast line.
1870 - Total output of coal in Scotland is 15 million tons.
1874 - The Cornish Beam Engine is installed at Prestongrange.
1878 - The Mining Institute of Scotland is established.
1893 - The Prestongrange Company fails.
1895 - The first mechanical washer for cleaning coal in Scotland is installed at Prestongrange.
1900 - 439 employed at Prestongrange Pit: 61 above ground and 378 below.
1905 - The Cornish Beam Engine has its pumping capacity improved.
1910 - 873 employed at Prestongrange: 153 above and 720 below (including many Irish immigrants).
1910 - An electric turbine pump is installed to pump water from Prestongrange.
1913 - Total coal output for Scotland 42 million tons.
1915 - total coal output for Scotland 35.25 million tons.
1945 - Total coal output for Scotland less than 20 million tons.
1946-7 - Nationalisation. The government takes over the coal mines.
1962 - Prestongrange Pit closes.

5. Curriculum Target: Knowledge and understanding of people in the past

STRAND	LEVEL C	LEVEL D	LEVEL E	LEVEL F
People, events and societies of significance in the past: Developing an understanding of distinctive features of life in the past and why certain societies, people and events are regarded as significant	**Describe** the diversity of lifestyles of people in the past, eg the life of a peasant as opposed to a landowner	**Describe** some features of societies, people and events of the past and suggest why they might be considered significant	**Explain** the motives or actions of people in particular historical situations Explain the values or attitudes that characterised various societies in the past **Explain** why particular societies, people and events from the past are thought to be of significance	**Apply** knowledge and understanding of the motives or actions of people in particular historical situations and/or the values and attitudes of particular societies in the past to reach conclusions on a given historical issue or question
Change and continuity, cause and effect: Developing an understanding of change and continuity over time and of cause and effect in historical contexts	**Make** a comparison between present and past lifestyles/circumstances/features. What is different? What is the same? **Give** some reasons for differences and for aspects of continuity	**Identify** important features of a development that have changed over an extended period of time eg transport, role of women **Explain** in simple terms why these features were important and describe what effects they had on people's lives	**Demonstrate** a detailed knowledge and understanding of the main features of a particular event/development/attitude with regard to change and continuity **Give** some reasons to explain why a specific historical event/action/development took place and what the specific consequences were	**Apply** knowledge and understanding of the process of cause and effect to provide detailed explanation as to why a particular development/event took place and give balanced assessment as to the significance of its consequences
Time and historical sequence: Developing an understanding of time and how events in the past relate to one another in chronological sequence	**Put** a series of events with their dates in chronological order **Use** the words 'decade' and 'millennium correctly	**Explain** the meaning of the terms 'bc' and 'ad' **Place** a number of events from a specific historical development on a timeline that crosses BC/AD divide	**Explain** the relationship between specific dates and the relevant century **Name** and place significant historical periods in chronological order	**Compare** and contrast timelines from a significant historical period in different parts of the world
The nature of historical evidence: Developing an understanding of the variety of types of historical evidence and their relative significance	**Describe** ways in which people remember and preserve the past, eg war memorials and suggest reasons why they should do this	**Suggest** a variety of sources of information about the past and what use they might be to someone studying a particular topic **Explain** the meaning of the term 'heritage' and give some examples, eg castles, literature	**Suggest** ways in which society's awareness of its own past can affect its present and future development eg devolution in Scotland, conflict/peace in Northern Ireland	**Describe** how heritage and evidence can be used in both positive and negative ways eg to promote social, economic or political ends

5. Curriculum target: skills in social subjects

STRAND	LEVEL C	LEVEL D	LEVEL E	LEVEL F
Preparing for tasks: **Planning** tasks in a systematic and logical way **Identifying** appropriate sources of information	**Plan** a sequence of activities for tackling an enquiry, class or homework task **Suggest** relevant sources of information that might assist in a particular task	**Plan** a sequence of tasks or procedures, adapting as required **Identify** a variety of straightforward sources from which relevant information might be collected	**Plan** appropriate strategies, resources and sequence of tasks or procedures, adapting as required **Identify** a variety of sources from which relevant information might be collected and give reasons for choice	**Plan** appropriate strategies, resources and sequence of tasks or procedures, adapting as required **Identify** a variety of sources, including complex ones, from which relevant information might be collected and give reasons for choice
Carrying out tasks: **Selecting** relevant information and/or equipment. Observe, measure, find, select, record **Processing** information in a variety of ways **Evaluating** the usefulness and reliability of information	**Select** and record specific information for a given purpose from a variety of sources available in the school or local community **Select** simple techniques to process/classify straightforward information in a variety of ways **Distinguish** in an elementary way between fact and opinion, fact/truth and fact/fiction	**Select** and use known enquiry methods and/or equipment to access, select and record relevant information from a variety of straightforward sources **Select** techniques to process/classify information in a variety of ways eg the results of a questionnaire Make simple judgements about usefulness/reliability of information/evidence	**Select** and use methods and/or equipment to access, select and record a range of relevant information from a variety of different types of sources **Select** techniques to process/classify information in a variety of ways, justifying choice Make judgements about what evidence is relevant/reliable, eg by reference to bias, exaggeration and selective use of information	**Make** independent use of suitable methods and techniques to access, select and record information from a range of sources, including complex ones **Make** independent use of techniques to process/classify information in a variety of ways, justifying choice **Recognise** when information is likely to be irrelevant, biased, or unacceptably inaccurate
Reviewing and reporting on tasks: **Presenting** findings in an appropriate and coherent way **Presenting** conclusions that are relevant to the purpose or issue	**Present** findings in a report, communicating key points clearly **Present** conclusions giving reasons	**Present** findings in an organised and appropriate manner **Present** conclusions and justify these with reference to evidence	**Present** findings in report (orally or in writing) showing clear organisation and appropriate specialist vocabulary **Present** conclusions that are well supported by reference to presented information	**Present** an extended report (orally or in writing) showing a clear and coherent argument or analysis **Present** detailed conclusions, or conclusions on more complex issues, that are well supported by reference to presented information

6. Activities

Activity 1: Atmospheric Pressure

Use a bicycle pump to pump air into a bicycle tyre. As the tyre fills with air, what do you notice about the amount of effort you make to push the pump?

Answer_____

_____

_____

Why do you think this is?

Answer_____

_____

_____

Activity 2: Calculations

1. A piston driven by a steam engine revolves once every 3 seconds. How many revolutions does it make per minute?

Answer_____

2. If the pressure in a condenser is five pounds per square inch, by how much is it multiplied if the pressure is raised to 50 pounds per square inch? Tick the correct box:

3 times
5 times
10 times

Activity 3:

Using lego and/or junk, invent a machine which can lift or lower, push or pull an object from one place to another.

Once you have made your machine, think about what changes you might have to make if you were trying to move water

Changes_____

_____

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_____

7. Further Investigations

For more information on the Prestongrange Estate, especially the Industrial Heritage Museum, try the following websites:
www.eastlothian.gov.uk/museums/index.html
www.prestoungrange.org

For images from Scottish history:
www.scran.ac.uk

For an explanation of how a steam engine works:
http://www.howstuffworks.com/steam3.htm

For an explanation of how a beam engine works:
http://www.bbc.co.uk/history/games/beam/beam.shtml

For more information about Thomas Newcomen and James Watt:
http://www.technology.niagarac.on.ca/courses/tech238g/newcomen.htm