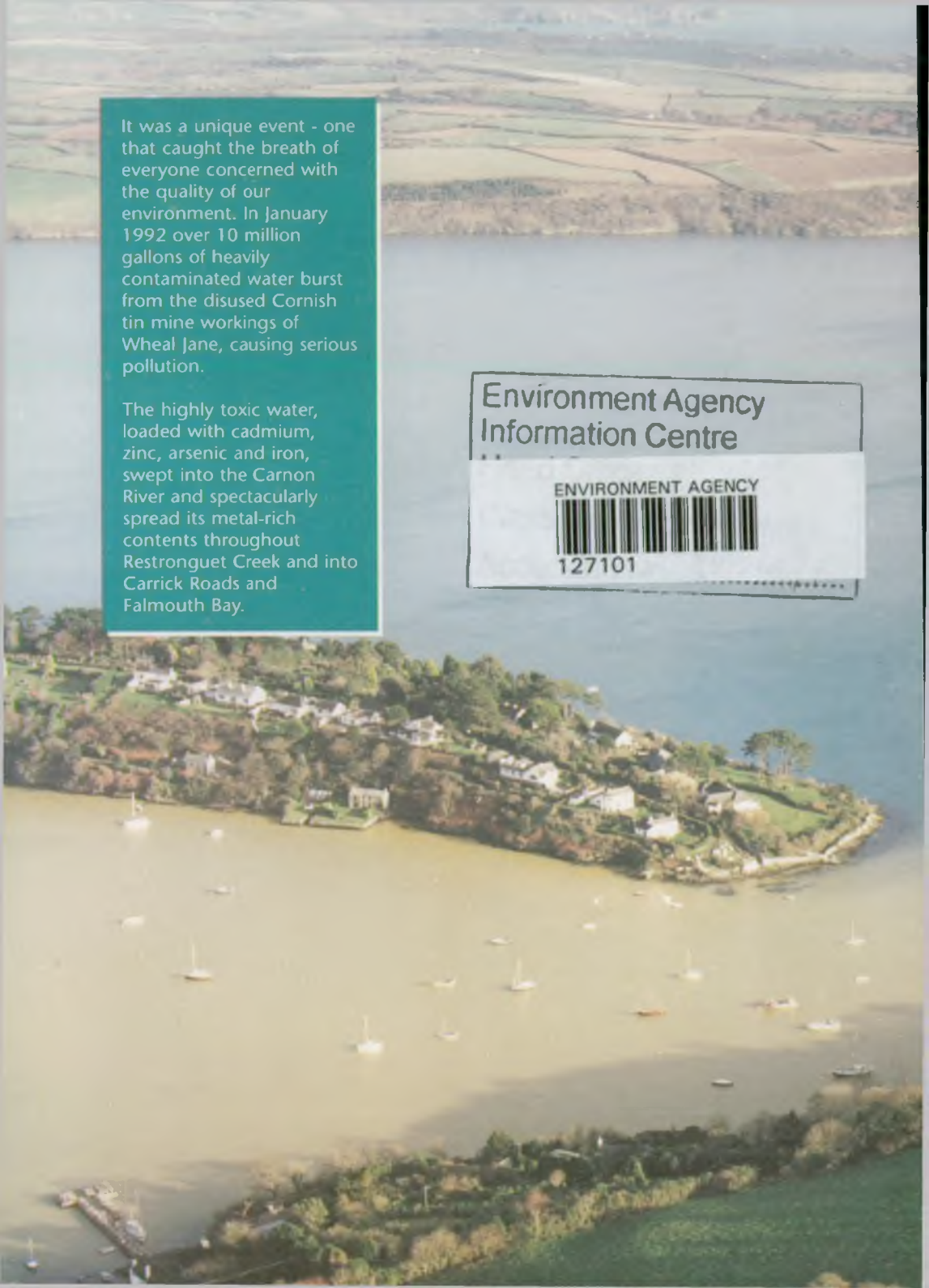
Wheal Jane

A Clear Improvement

ENVIRONMENT AGENCY



It was a unique event - one that caught the breath of everyone concerned with the quality of our environment. In January 1992 over 10 million gallons of heavily contaminated water burst from the disused Cornish tin mine workings of Wheal Jane, causing serious pollution.

The highly toxic water, loaded with cadmium, zinc, arsenic and iron, swept into the Carnon River and spectacularly spread its metal-rich contents throughout Restronguet Creek and into Carrick Roads and Falmouth Bay.

The response by the National Rivers Authority (NRA) - which subsequently became part of the Environment Agency on 1 April, 1996 - was swift and effective in first controlling and then treating the worst elements of the contaminated minewater.

A complex engineering and scientific project began, with challenging objectives to:

- Minimise the polluting effect of the contaminated minewater discharge from Wheal Jane;
- Monitor changes in water quality and the effects on the aquatic environment;
- Determine the most cost-effective long term treatment strategy.

In recognition of the unprecedented scale of the problems, the Government initially pledged over £8 million for this pioneering work.

A new three year project - supported by a further £6 million from Government started in April 1996 under the management of the Environment Agency. The new project will build on the work already carried out and, with some further studies, assess the best long term solution for Wheal Jane.

This leaflet details the response and action in meeting this undoubted challenge.

THE POLLUTION CHALLENGE

Cornwall is famous for its tin mines, but the decline of this once flourishing industry has left a legacy of pollution as old mine workings have become flooded.

In the case of Wheal Jane, regular pumping during its productive life depressed the water table by about 400 metres. The mine was closed in 1991 and pumping operations ceased.

As the water level in the mine began to rise, and in anticipation of a heavily contaminated discharge of minewater polluting the Carnon River, a temporary treatment system was instigated.

Minewater reached the surface in November 1991, but then events took a turn for the worse.

The dramatic burst at Wheal Jane arose when a plug in the underground Nangiles Adit unexpectedly failed in January 1992. The plug failure resulted in

A diver survey of the ecologically important maerl (calcified seaweed) beds in the estuary was part of the impact assessment.

the sudden release of highly acidic water which contained large quantities of dissolved heavy metals, more than 5000 parts per million at its peak.

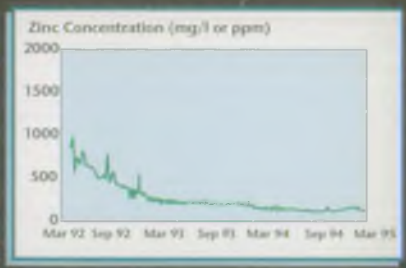
Monitoring has demonstrated that the effects of the minewater release on both water quality and discolouration were short-lived. There appears to have been no major adverse effects from the incident on the biota (flora and fauna) of the estuary. Subsequent treatment and the fact that the biota that existed in the system had already been affected by centuries of mining reduced the eventual impact.

However, recent scientific investigations indicate that the initial spill and continued metal inputs from Wheal Jane and the Carnon River may have resulted in zinc toxicity in swans on the Fal Estuary.

Due to increasingly efficient treatment systems the concentrations of metals discharged to the Clemows Stream and then to the Carnon River have declined rapidly since 1992. Metal concentrations in the Carnon River are now at pre-incident levels.

The Wheal Jane complex, together with the County Adit, are the major sources of contamination in the Carnon River. However, significant amounts of metals are also contributed from other tributaries and non-point or diffuse sources, such as spoil heaps and other disused mines. For this reason there would still be a significant metal loading in the Carnon River even if the two major point sources (Wheal Jane and County Adit) were treated.

Metal concentrations have declined in the untreated minewater since the initial flushing (see Figures 1 and 2) and should continue to do so, albeit at a much slower rate. This decay in untreated minewater concentrations may mean that at some point in the future no treatment will be necessary.



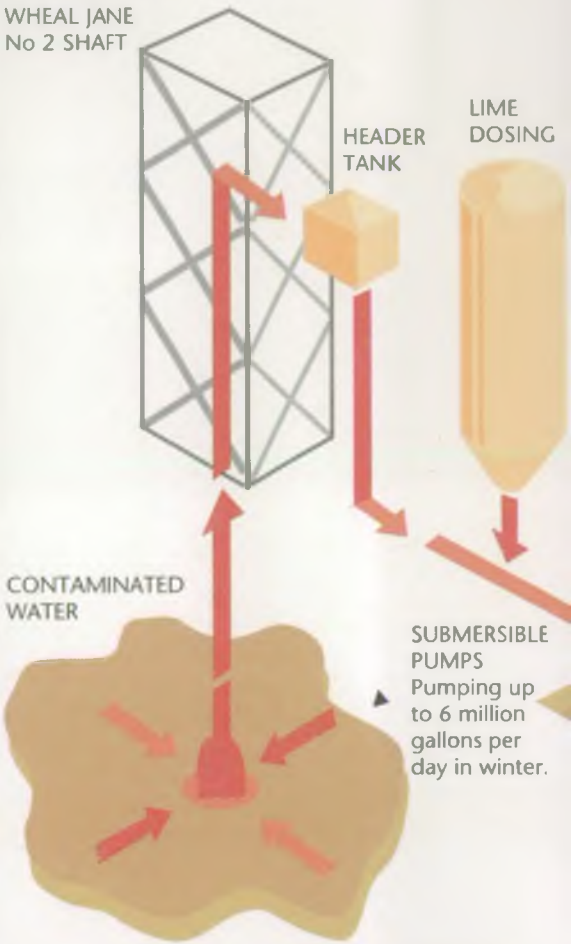
Figures 1 and 2: Decreasing metal concentrations in Wheal Jane minewater.

CURRENT CHEMICAL TREATMENT (A Co-operative Venture)

Minewater from Wheal Jane is processed by chemical treatment arrangements instigated by the Environment Agency in conjunction with South Crofty plc - who own the site and use it for processing ore from the mine at South Crofty - and consultants Knight Piésold Ltd.

Between February 1992 and summer 1996 treatment has prevented over 13,000 tonnes of heavy metals from being deposited in the estuary and has been responsible for minimising the environmental impact on the Fal Estuary.

In parallel with carrying out temporary treatment operations, a comprehensive system to monitor the flow and quality of the river and minewater has been installed at key locations throughout the area.



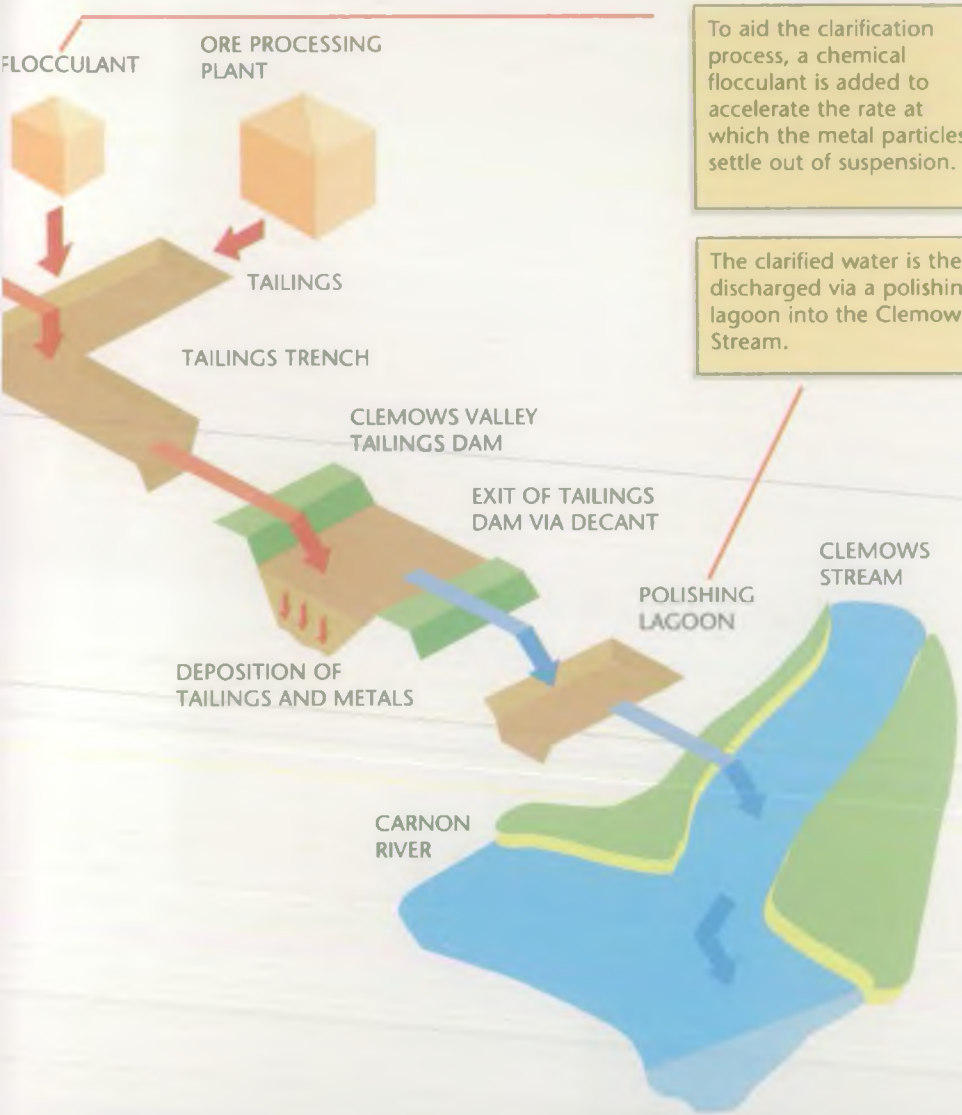
The metalliferous sediment settles into the Clemows Valley Tailings Dam which is designed to store mine tailings arising from milling operations carried out on the site.

Lime is added to the pumped minewater to neutralise acidity and render the metals insoluble.

The addition of lime transforms the water from a clear liquid to a dark blue-green liquid containing finely dispersed metal hydroxide particles.

To aid the clarification process, a chemical flocculant is added to accelerate the rate at which the metal particles settle out of suspension.

The clarified water is then discharged via a polishing lagoon into the Clemows Stream.



PASSIVE TREATMENT

Passive treatment allows for the removal of metals and the neutralisation of acidity using a combination of physical, chemical and biological mechanisms similar to those found in many natural wetlands.

The Environment Agency has undertaken pioneering work by constructing three pilot passive treatment schemes in the Carnon Valley. The schemes involved the construction of a series of shallow lined lagoons (or cells) within which a combination of aerobic (containing air) and anaerobic (excluding air) environments were created.

Aerial view of the three pilot treatment schemes.

PILOT TREATMENT SCHEME 3

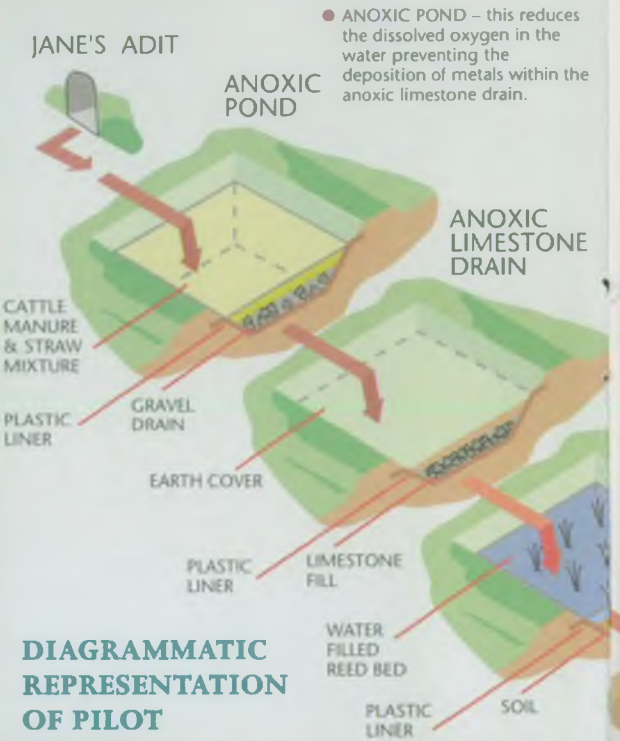
No effluent from the pilot plant is currently discharged to the river. Although the potential to discharge to the river exists all water is returned to the mine site.

EARLY RESULTS

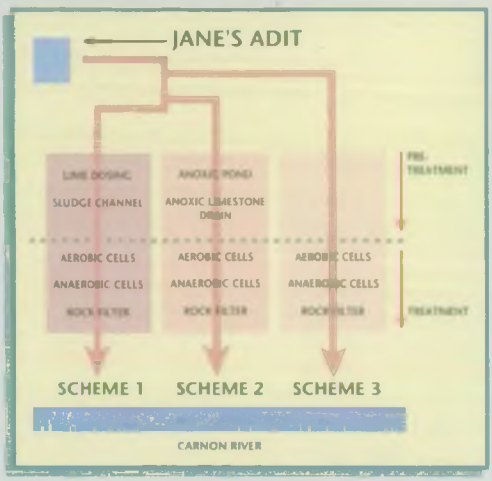
The aerobic cells (see diagram) have been shown to remove iron successfully (65 to 90% of the incoming iron) and arsenic (90 to 95% of the incoming arsenic).

All three anaerobic cells have been shown to remove zinc, copper and cadmium and also to decrease the acidity. The anaerobic cell which has the anoxic limestone drain pre-treatment (see scheme 2) has performed the best so far and has removed up to 95% of the incoming zinc, cadmium and copper.

However, although the pilot plant has demonstrated that metals can be removed using these systems, further work is required to evaluate its applicability for the discharge from Wheal Jane and other polluting discharges in the valley as a whole. It is doubtful whether passive processes will be the most cost-effective treatment method for the minewater from Wheal Jane, with its large flow and particularly acidic and metal rich waters, within the land available in the valley.



DIAGRAMMATIC REPRESENTATION OF PILOT TREATMENT SCHEME 2

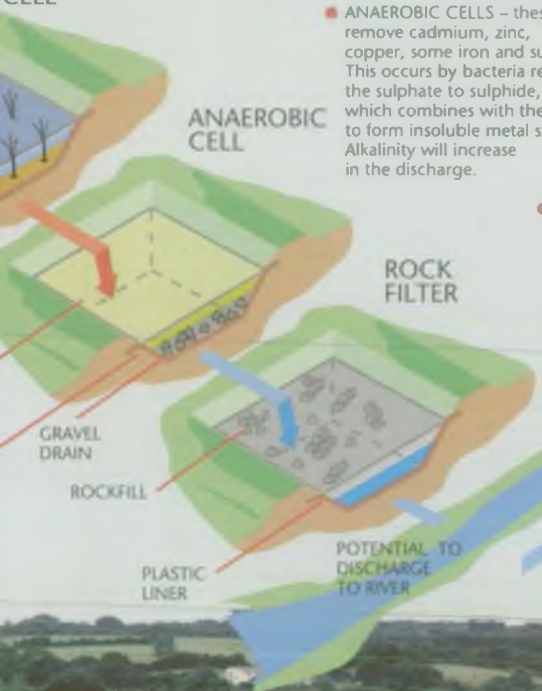


- ANOXIC LIMESTONE DRAIN (ALD) – this consists of an enclosed limestone layer which adds alkalinity and thereby allows a reduction in the size of the aerobic cells.

- AEROBIC CELLS – these remove iron as iron hydroxide. Arsenic will be removed by co-precipitation with the iron hydroxide.

- ANAEROBIC CELLS – these remove cadmium, zinc, copper, some iron and sulphate. This occurs by bacteria reducing the sulphate to sulphide, which combines with the metals to form insoluble metal sulphides. Alkalinity will increase in the discharge.

- ROCK FILTER – these rocks provide a large surface area on which algae grow. These generate a high pH micro-environment which allows manganese to be removed. The filter also removes the organic loading - Biochemical Oxygen Demand - produced as a result of bacterial activity in the anaerobic cell.



LONG TERM TREATMENT

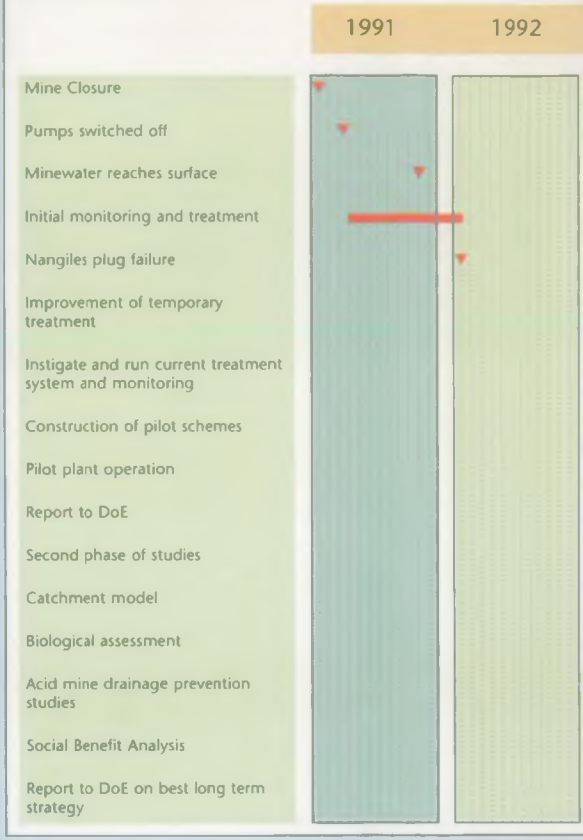
The current active chemical treatment scheme will not offer a long term solution for Wheal Jane due to the limited storage capacity left (approximately 5 years) in the Clemows Valley tailings dam.
A research project was set up to establish the most effective method of long term remediation of the problems. This study examined the performance and cost-effectiveness of both active and passive methods of treatment to establish their potential for future use on the site.

The first phase of the project finished in March 1996 and its recommendations were:

- The current treatment system should continue until the best long term solution is established.
- The treatment plant should be operated to achieve no deterioration in water quality.
- The pilot passive treatment trials should continue.
- The following studies should be carried out to determine future treatment needs:

- Collection and appraisal of water quality and flow data.
- Develop a model to simulate the decay in the concentrations of metals in the untreated minewater.
- Identify the diffuse sources of contamination eg spoil heaps.
- Further develop an integrated water quality model for the Carnon River and Fal Estuary.
- Assess the long term impact of minewater on the estuary biota.

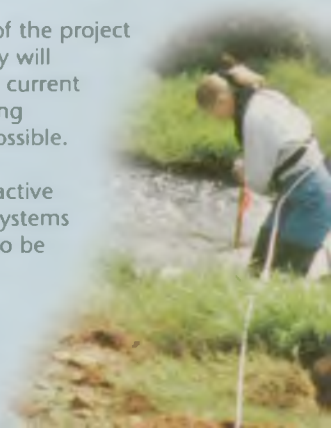
WHEAL JANE MINEWATER PROPOSED TREATMENT PROGRAMME

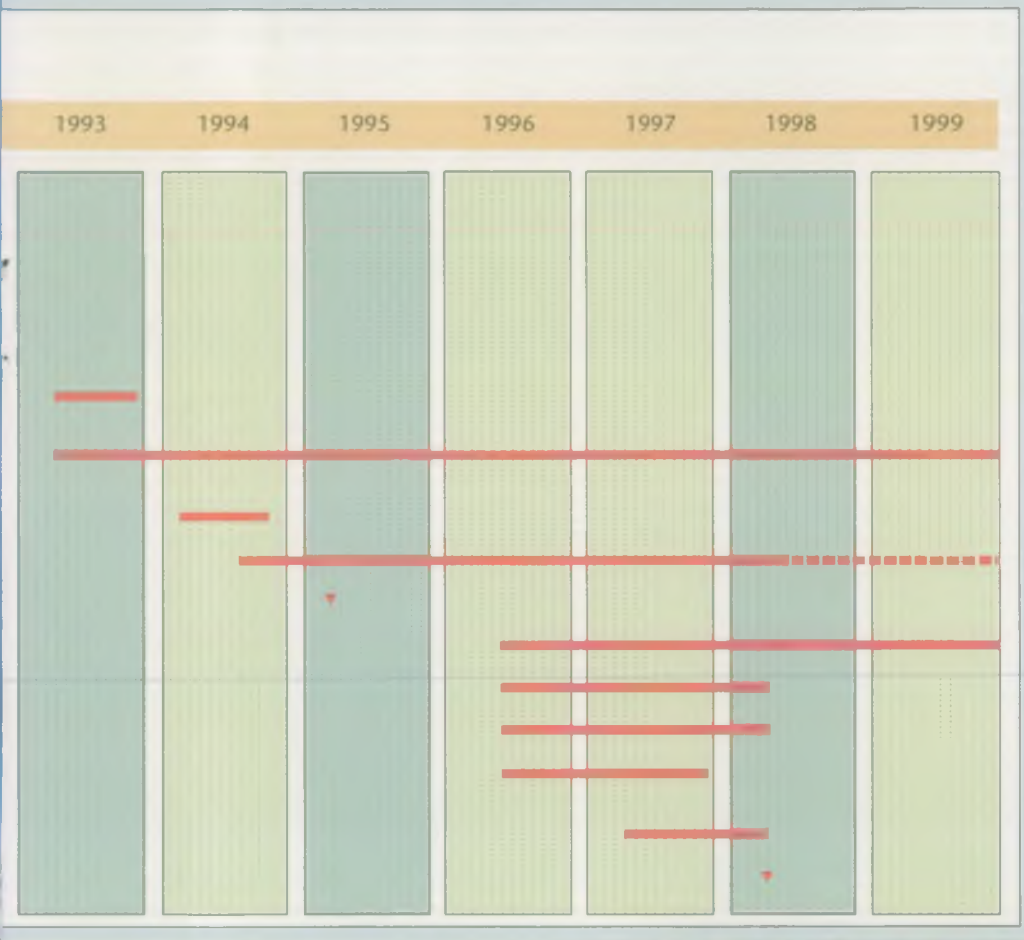


These recommendations were accepted and culminated in funding for a further three year phase of study.

Within this next phase of the project the Environment Agency will continue to operate the current treatment system, making improvements where possible.

The suitability of other active or chemical treatment systems in the long term will also be assessed.
Investigations into the efficiency and feasibility of passive systems at





the pilot plant will also continue. Investigations into these passive techniques will enable the Agency to determine their suitability for treating the minewater at Wheal Jane or even other discharges within the valley, Cornwall, elsewhere in the UK or even the world at large.

A mathematical model will be used to simulate future minewater quality and the impact of metals in the Carnon Valley and in the Fal Estuary and to assess the likely effect of the different treatment options on the environment. A biological assessment of the Carnon Valley and the Fal Estuary (Restronguet Creek and the Carrick Roads) will make predictions of likely impact from the various treatment options based on the outputs from the model.

Pilot plant reed beds at Wheal Jane


Clemows Valley Tailings Dam
N
Polishing Lagoon
Clemows or Baldhu Stream
Areas of Landscaping
Bissoe flow and water quality gauging station
Bissoe Bridge

CONSERVATION AND RECREATION

Construction of the pilot schemes in the valley has enabled a stretch of bridleway to be improved from Devoran Bridge to above Bissoe Bridge. A new footbridge has been built at Devoran with a second to be built at Bissoe, which will form part of the Mineral Tramways Project to link North and South Cornwall by bridlepath.

Areas of natural wetland have been created, existing lagoons in the valley have been retained and made safe and extensive landscaping carried out around Jane's Adit.

Principal Consultants of the Wheal Jane Minewater Study:

Knight Piésold Ltd in association with
WS Atkins Water
Plymouth Marine Laboratories
RTZ Consultants Ltd
Henry Butcher Smith Vincent
Risk & Policy Analysts Ltd

External Reviewers:

Dr P. Younger, Newcastle University
Dr A.J. Monhemius, Imperial College

An eight minute video explaining the Wheal Jane Project is also available, and can be borrowed free of charge from the Environment Agency.
Contact Public Relations in Exeter

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ENVIRONMENT AGENCY
GENERAL ENQUIRY LINE
0645 333 111

The 24-hour emergency hotline number for reporting all environmental incidents relating to air, land and water.

ENVIRONMENT AGENCY
EMERGENCY HOTLINE
0800 80 70 60

Bissoe flow and water quality gauging station

THE ENVIRONMENT AGENCY

The Environment Agency, which began operations on 1 April 1996, brought together the National Rivers Authority, Her Majesty's Inspectorate of Pollution, the Waste Regulation Authorities and several smaller units from the Department of the Environment.

The Agency provides an integrated approach to the protection and management of the land, air and water environment. Its main functions include pollution prevention and control, waste regulation, flood defence, water resources, fisheries, recreation and conservation.

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