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REMEDIATION OF THE OLD MEADOWS GRAVITY MINEWATER DISCHARGE

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ABSTRACT

The gravity minewater discharge from the abandoned Old Meadows Adit results in major contamination of the receiving water due to its high iron loading. It is a priority site in schemes recommended by the Environment Agency for the implementation of remedial measures. IMC Consulting Engineers were commissioned to design and supervise construction of a major treatment scheme to restore the river water quality.

The paper describes the works necessary in the mine adit to collect the water and the pumping regime necessary to discharge to the remote site for treatment. The treatment system comprising the addition of Sodium Hydroxide followed by settlement in lagoons and tertiary treatment on a wetland is also described.

INTRODUCTION

Old Meadows minewater discharges into the River Irwell at Broad Clough some 1200 metres north of Bacup in Lancashire. It is one of most significant gravity discharges in the UK and is a priority scheme for implementation of remedial measures to improve river quality.

The adit is located in the bottom of a steep sided valley adjacent to the River Irwell. The only suitable site available for the proposed treatment plant is situated on a sloping plateau above the River Irwell. The landscape is of a rural nature, the upland pasture being used for the grazing of sheep and cattle.

The discharge emerges from a 2.1 m x 0.9 m abandoned mine drainage adit, and flows directly into the River Irwell. The heavy total iron load of up to 50 mg/l in a flow of 50 litres/sec results in 'ochre' staining of the bed which can, on occasions, be seen up to 24 Km downstream.

MINEWATER FLOW & QUALITY DATA

Monitoring undertaken over a short period and was carried out by a university on behalf of the client during a relatively protracted period of dry weather. The maximum flow rate recorded during the monitoring period was 50 litres/sec. However, because of the short data base an additional 15% was allowed in the minewater treatment plant design, and a discharge rate of 57.5 litres/sec has been used.

In respect of minewater quality, the highest discharge analysis obtained in respect of total iron contained 37 mg/l and this figure has been used to determine the treatment plant design. The discharge contained a cold acidity (to Phenolphthalein) of 70 mg/l as calcium carbonate. No other notable level of contaminants was contained in the minewater discharge. The discharge and receiving water data are summarised as follows;

Parameter	Required EQS	Value in Discharge	Value in Watercourse	Discharge Flow Rate	Watercourse Flow Rate	Loading Kg/day
pH	6 - 9	5.9	6.6	57.5 l/s	364 l/s	-
Total Iron	1 mg/l	37 mg/l	-	57.5 l/s	364 l/s	304
Acidity	-	70 mg/l	<2 mg/l	57.5 l/s	364 l/s	575

Table 1.

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The Environment Agency desire the treated minewater to be returned to the River Irwell with a total iron of <1 mg/l to achieve a EQS of 2 mg/l. However, the consent to discharge is a descriptive consent related to an agreed method of operation of the site that should allow the desired water quality standards to be achieved.

METHODS OF TREATMENT CONSIDERED

Two principal methods were considered for treatment of the discharge:

- By chemical neutralisation, settlement and tertiary treatment.
- By neutralisation and sedimentation using a wetland.

The area required for wetland treatment (Heldin et al 1994, Younger 1995) is 3 Ha. for a net alkaline water at an iron loading of 10 g/m^2. To remove acidity at a loading of 3.5 g/m^2, the recommended area would be around 16 Ha. Such an area is not available in the steeply sloping valley topography making the use of wetland alone not viable. Were the minewater to be first neutralised and then passed onto a wetland, the area required would be about 3 Ha, which again, is not available.

A further disadvantage with primary treatment using a wetland only is the potential sludge loading, which is estimated at 8 m^3 per day. It is considered that this loading would rapidly cover the wetland and inhibit plant growth before they could become established. It was, therefore, concluded that a reliable and established treatment of chemical neutralisation and sedimentation of the discharge should be the preferred option. However, in order to maximise compliance with a discharge standard of 1 mg/l total iron, a tertiary treatment in the form of a surface flow wetland was considered to be a necessary adjunct.

RISK OF FAILURE OF THE SCHEME

The main risk of failure of the project lies in the potential underground blockage of the minewater discharge routes resulting in rise in level of minewater he workings. It could then outflow at other higher adits or crop workings in which case the minewater treatment plant could remain viable if new pipework connections were constructed. However, build up of sufficient head behind the blockage could release the constriction rendering the treatment plant viable.

CONSTRUCTION DETAILS

Figure 1 shows the layout of the treatment system constructed at Old Meadows.

The Adit

Testing carried out by the construction of a temporary timber wall across the mouth of the adit failed to raise the internal water level because of the high rate of leakage occurring

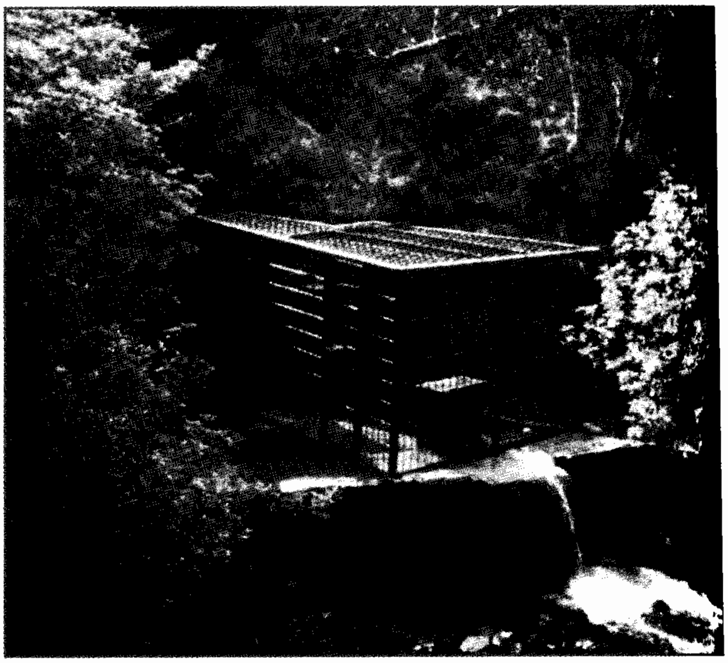

Figure 1. Plan and section on the Old Meadows Site.

through the dry stone lining of the adit. Efficient operation of the proposed pumping system required that an effective flowbalancing element be constructed at the adit to minimise stop/starts of the pumps.

The dry stone lining in the adit extended 12 metres from the portal, beyond which was solid sandstone strata. It was decided to seal this area by the insertion into the adit of GRP channel sections designed to be a close fit into the adit and secured by grouting the residual void and into the random stone lining. The section extending onto the solid strata was also grouted to secure a watertight seal. The open channel thereby created was successful in providing the flowbalancing element required by allowing fluctuation in water level of about 1000 mm. The installation works were carried out as a mining operation under the supervision of a Colliery Manager. This proved vital in maintaining the safety of operatives because of the rapid deterioration in the atmosphere that occurred on many occasions due to egress of mine gasses and oxygen deficiency.

The flow balancing storage volume in the adit connects to the pump suctions. Twin 300 mm diameter suction ranges lead 200 metres downstream from the adit to the pumphouse. Control of the pumping regime is by electronic level detectors in the adit which are set to maintain a depth of water of around 750 millimetres by varying the pump speed and consequently the output discharged to the treatment site. Sudden surges of minewater due to collapses or other features in the underground workings are discharged by an emergency overflow directly to the river. Instances of high rate discharges due to underground phenomena occur on average once a year.

Figure 2 shows the adit area and security cage with an overflow directly to the river prior to commissioning of the chemical treatment system.

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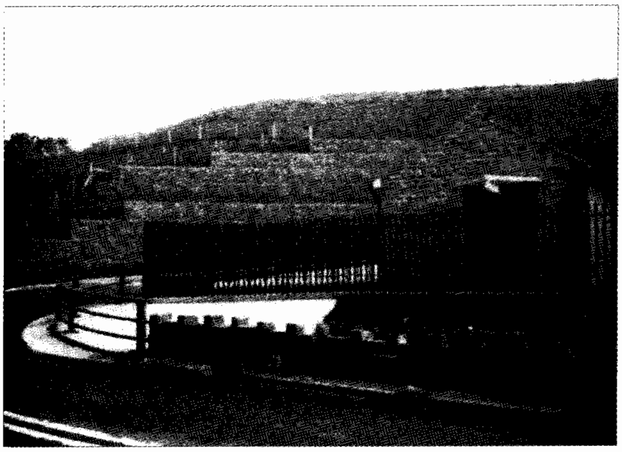

Figure 2. The adit with minewater overflow before completion of works.

The Pumphouse

The Pumphouse contains two duty and one standby pump. Each has the capacity to discharge 40 litres/second through twin 160 millimetre diameter delivery ranges which connect to the chemical treatment building located on the high plateau about 300 metres distant. Monitoring of the operation of the treatment plant is from the pumping station by means of a PC with modem link.

Adjacent to the pumphouse at the entrance to the site, a large stone gabion wall has been constructed to retain the earth slope which it was necessary to excavate to provide access to the site. The gabion wall is six metres in height comprising two three metre sections with an intermediate ledge to allow planting to take place which will help to blend the structure into the landscape. Adjacent properties to the entrance, including a large mill building, are constructed in stone compatible with the structure of the wall. Figure 3 shows the entrance area including the pumphouse and gabion wall.

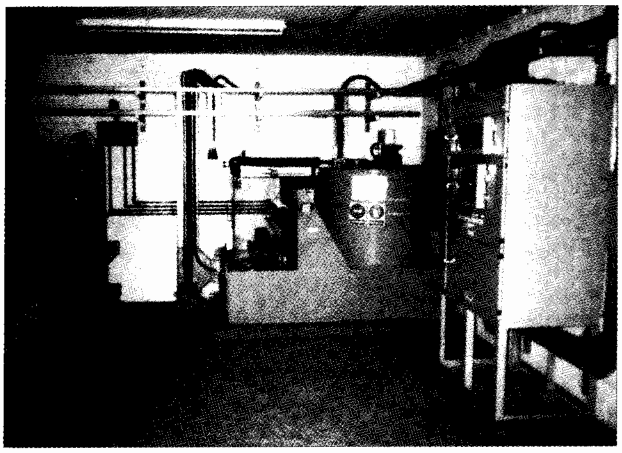

Figure 3. Site entrance showing pumphouse and gabion wall.

The Chemical Treatment Building

The chemical treatment building is located immediately adjacent to the settlement basins and the wetland on the high plateau about 40 metres above the Adit. The use of hydrated lime fed from a silo was precluded because of the high visibility of the silo in the landscape of the area and consequently, the use of Sodium Hydroxide selected.

The Sodium Hydroxide dosing plant consists of a bulk storage tank with a minimum capacity of 18,000 litres with an anticipated usage of 6,000 litres per week. The tank is installed at ground level inside a bund of 110% capacity of the tank. A transfer pump linked to level probes in the dosing tanks delivers to the caustic solution plant on demand. The bulk storage tank, transfer pipe range and dosing building are to be heated when the ambient temperature falls to 10 ºC. to ensure that the Sodium Hydroxide does not freeze during the severe winters which can be experienced on this exposed site.

A flow measurement device detects delivery of minewater and switches on the treatment system. This is a precautionary measure to cater for pump failure situations when caustic soda is not required in the system. The volume of injection of chemical into the minewater flow is controlled by the pH probe which measures the acidity of the treated minewater and determines the quantity of caustic required by relaying appropriate instruction to the dosing injectors.

Treatment is by the injection of caustic soda solution using four dosing pumps. These are mounted in pairs over two 100 litres bunded plastic storage tanks situated inside the dosing building. Dependant upon demand one or all of the pumps can be in use at any one time.

Safety paramount and the requirements for decontamination in the case of accidental spillages and the restrictions on storage and filling by the chemical supplier have been incorporated.

Figure 4 shows the chemical dosing equipment, reaction tank and electrical controls housed in the treatment building.

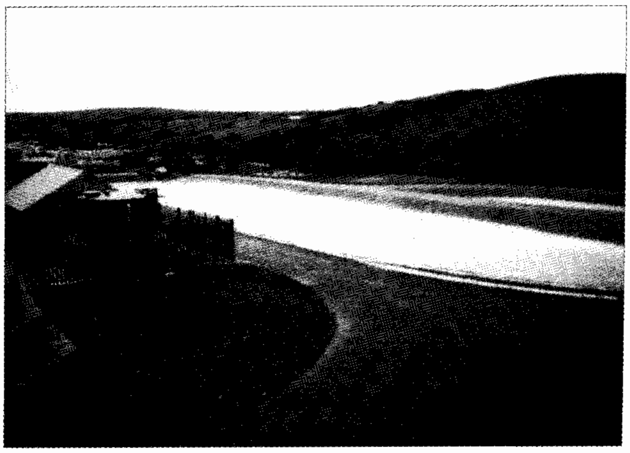

Figure 4. Interior of chemical treatment building.

Sedimentation Basins

The basin design ensures that the appropriate overflow rate is provided at normal flowrates, maximising sedimentation efficiency so that the treated effluent meets discharge quality

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requirements. A further consideration has been to maximise sludge retention capacity to minimise the frequency of desludging by constructing as large a pond as possible within the available site area.

Twin sedimentation basins have been excavated on the plateau area following a cut fill balance exercise. The ponds are not identical in size because of topographical constraints but they operate in parallel with flow being proportioned in relation to their surface area. The larger basin is approximately is 100 m x 28 m and 3 m deep which equates to a capacity of some 6200 m^3. The second basin is 60 m x 28 m and 3 m deep giving a volume of 3500 m^3. Inlet and outlet weirs on both lagoons spread uniform flow of water through the basins.

The base and sides of the ponds are essentially in coal measure sales that are impervious although a minimum of 300 mm of clay has been placed and compacted on these surfaces to ensure that water does not leak into sub-strata. This clay which has low shear strength is unsuitable for embankments construction but is ideal for sealing purposes and this solves the problem of ensuring its effective use.

Wetland

The wetland is a surface flow system using soil recovered from the site to form the planting substrate. Surplus clay materials have been placed and compacted to form a level impermeable base to the wetland which will be 1600 m^2 in area. A minimum of 250 mm of soil excavated from the site has been placed over the clay to provide a growing medium for the wetland plants. Because of the exposed location of the site, plants known for durability and suitability for metal laden waters have been utilised. The principal species are *Typha Latifolia* and *Juncus effusus* although some *Scirphus lacrustis* has been planted in deep water areas and Iris Pseudacorous at margins to give a decorative quality.

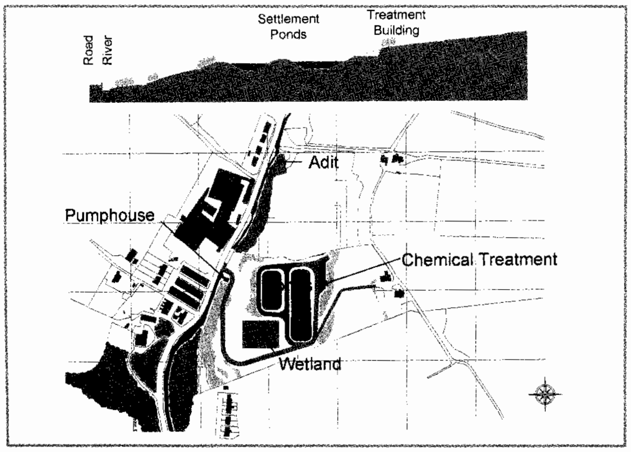

Figura 5. Overview of the minewater treatment site.

The wetland provides tertiary treatment only and it is expected that the inflow should not exceed a total iron concentration of 5 mg/l, but it is likely that these solids will be very fine. Passage of the minewater through the plants will result in detention of fine iron solids on the plants and the leaf letter to enable a final discharge quality of around 1 iron to be achieved. Discharge of the final effluent from the wetland is by gravity pipeline directly back into the River Irwell.

Figure 5 shows an overview of the site illustration the layout of the treatment building, sedimentation ponds and wetland.

MAINTENANCE DESLUDGING

General M&E maintenance of the pumps and caustic dosing plant are undertaken on a regular basis by contractors. Other minor maintenance such as checking caustic soda level in the bulk storage tank, cleaning pH probes, grass cutting and the general security of the site are also undertaken by contractors.

Desludging of detained ochre solids is expected to be necessary once per year and will be undertaken by using road tankers fitted with suction equipment to remove the 'ochre' from the ponds. It is probable that this 'ochreous' sludge will be transferred from the Old Meadows site to sludge drying beds that are proposed to be constructed at a further minewater treatment site in the locality. This will allow the sludge to thicken by dewatering in the drying out bays and will significantly reduce the volume of material requiring disposal. This will minimise the costs of disposal of the sludge to licensed waste disposal sites. However, trials are at present taking place in UK at water treatment works using ferric chloride manufactured using 'ochre' solids as a coagulant. The trials appear to have been successfull.

OPERATION OF THE SITE

Full scale operation of the site commenced in June 1999 and as a consequence, little experience of operation has yet been accumulated. However, adjustments of the pH level at which the treatment is being maintained along with analysis of the resultant quality of the discharge is being undertaken to achieve the desired water quality along with economical use of chemicals.

ACKNOWLEDGEMENTS

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