The prime purpose of the project was to select and develop methods for constructing the horizontal adits required to convert dug-wells to collector wells of higher yield in unconsolidated material. After much experimentation two drilling techniques, telescoped jetting and moling, were developed. Both are capable of emplacing screens in such material. In the wells sunk in hard rock adjacent to the sand rivers of Botswana, air-hammer techniques had to be used before break-out into the unconsolidated sand.

jetting and telescoped-jetting

In jetting, water is pumped through a hollow drill string and bit, and returns via the annular space between the string and the hole. The water removes sand disturbed by the drill bit thus allowing steady advance of the string into the sand. A variant of this, telescoped-jetting, was used in the coarse sands of Malaysia, in the sand river beds of Botswana and in the alluvial plains of Zimbabwe. With this technique, four-inch diameter casing was jetted out to about 12 metres. Then, two-inch screen, encircling one-inch jetting pipe fitted with a loosely-connected sacrificial bit, was jetted through the casing and into the sands

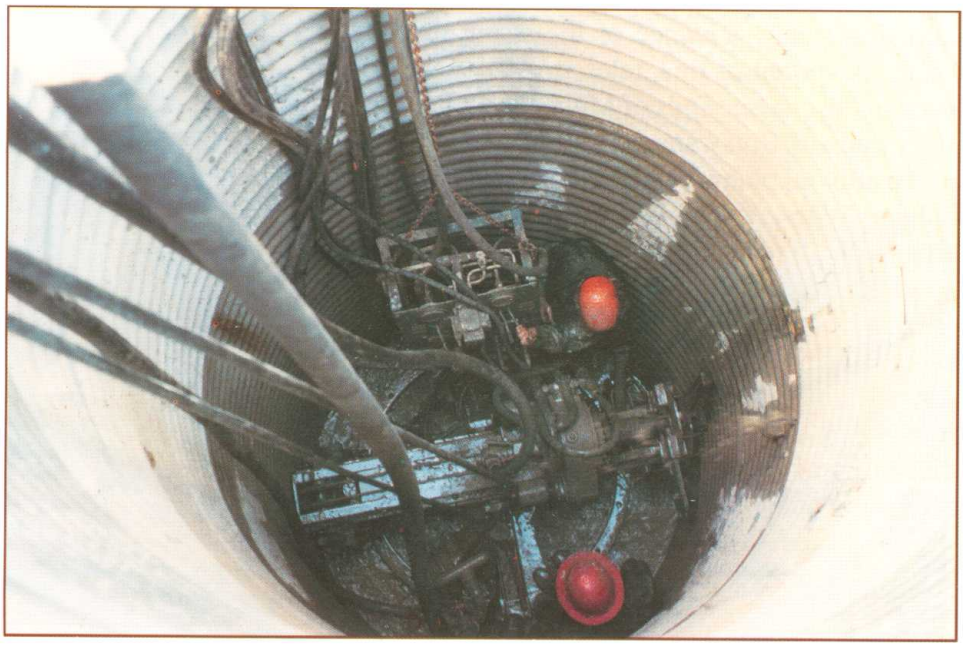
Inserting the jetting equipment, Malaysia

beyond. Eventually the jetting pipe and casing were removed, leaving about 20 metres of screen permanently in place in the aquifer.

moling

Moling is in regular use in the West for laying telephone lines etc, under roads. A hydraulic jack is used to push out a solid large diameter head in front of a smaller diameter drill string. The head creates a cavity by lateral compression of the material through which it is pushing. For this project a lightweight jacking rig pushed out a four-inch head using 1.5 inch push rods. These were surrounded by plastic-mesh-wrapped 1.5 inch screen and temporary, blank casing three inches in diameter. After reaching 20 or 30 metres, the three-inch casing and push rods were extracted leaving the screen behind.

Moling trials in the UK

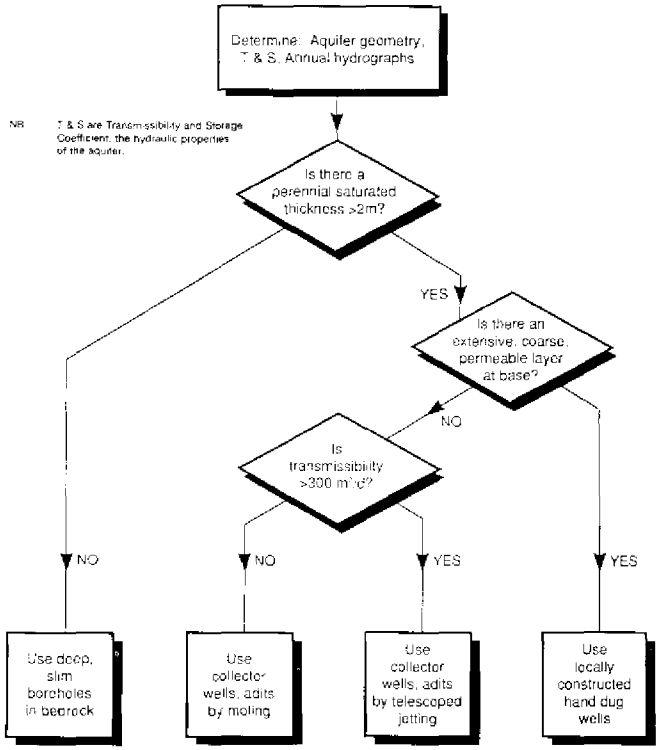


air-hammer drilling

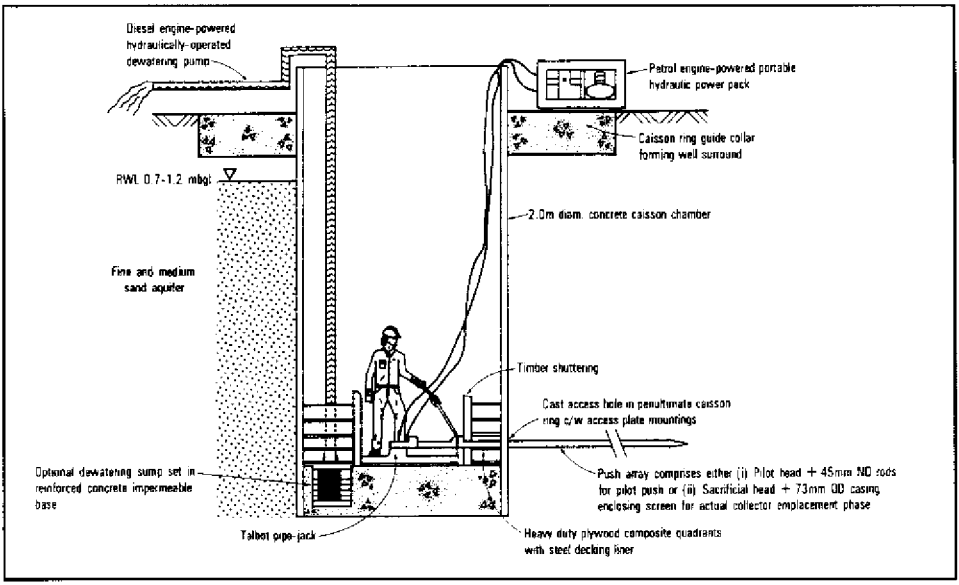
A hammer at the end of the drill string is driven by air which also blows the cuttings from the hole. This technique is ideal for hard rocks and was used in this project to drill through the hard rock banks of the Shashe sand river until the hammer drill entered the sands of the river. The technique used was routine and is in regular use world-wide.

selecting the best horizontal drilling technique

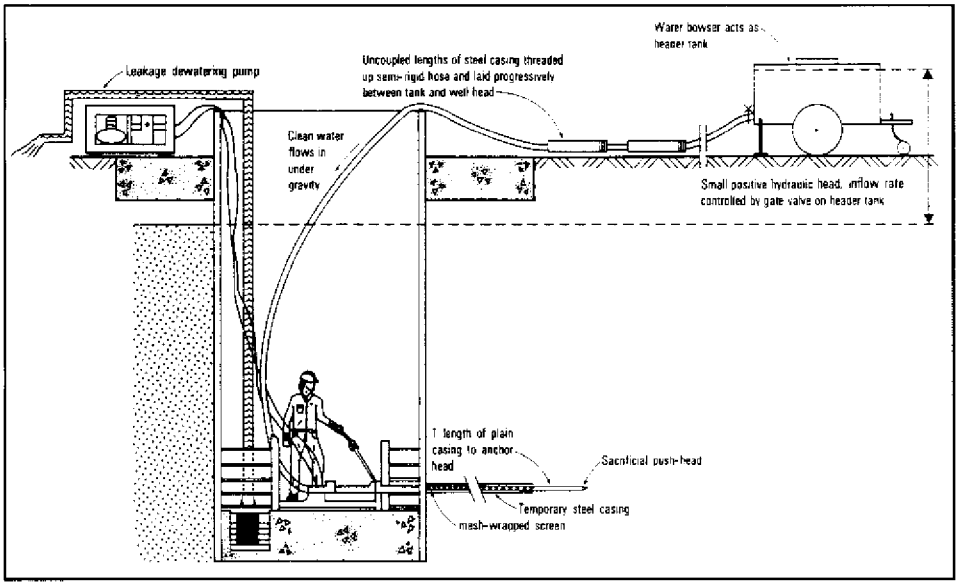
Adits created by moling are of smaller diameter than those created by jetting and consequently they can transmit far less water. The criteria for choosing which is best suited to a particular situation are outlined in the diagram below.



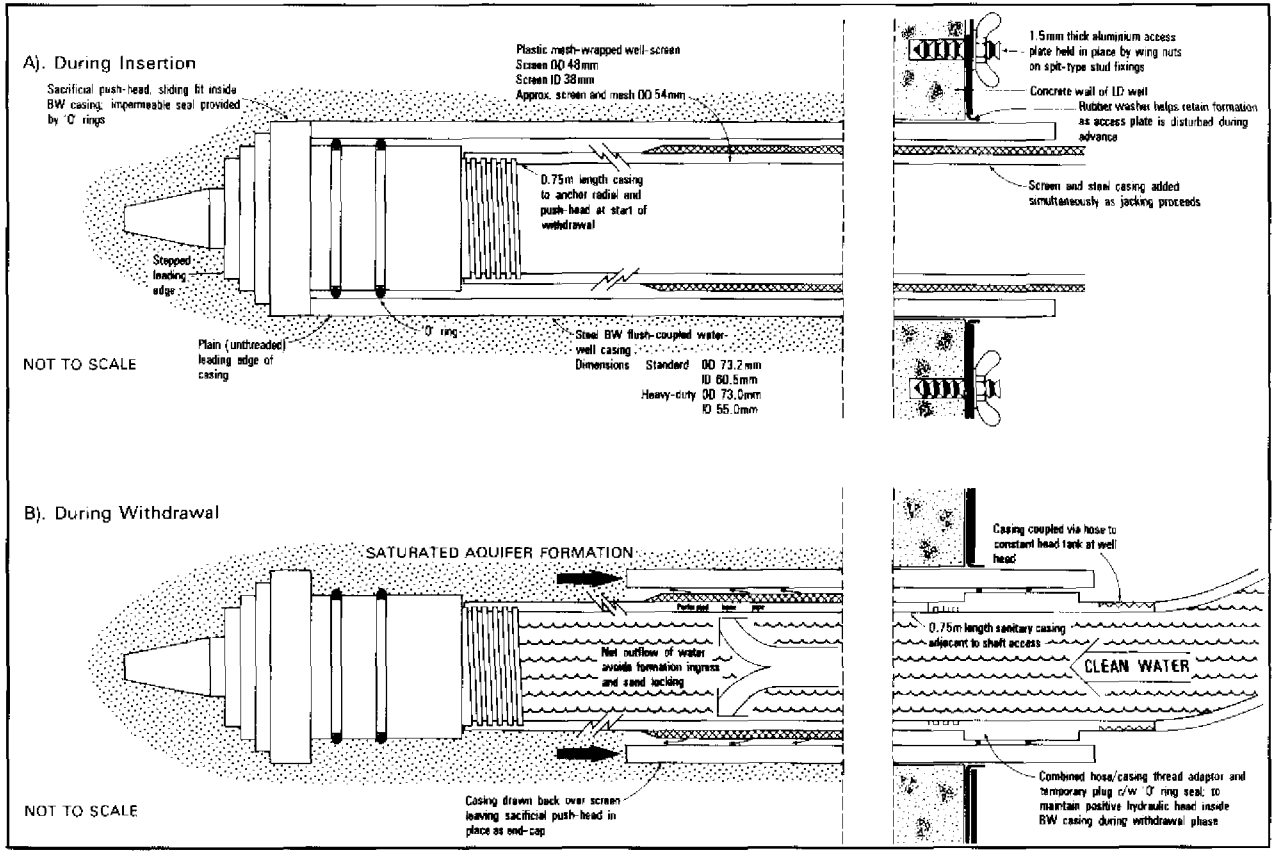
Selecting the optimum technique



Pilot push and emplacement of the screen



Withdrawal of temporary casing



Schematic diagram showing emplacement of the plastic screen

The thickness of two metres in the first decision-diamond (see page 13) is somewhat arbitrary. A widespread aquifer one metre thick would be sufficient for drilling of laterals. If the bedrock surface undulates however, the length of adit that can be drilled will be limited.

drilling costs

Detailed costs of drilling are given in Herbert (1992). To summarise, assuming that 20 wells are constructed per year each having four adits drilled out to 20 metres, the following drilling costs (£UK per well) were estimated at 1990 prices:

	Moling	Jetting
Capital cost of equipment purchased in UK	132	321
PV* of spares at 15 percent of capital/year at interest rate of 5 percent	153	372
Total	**285**	**693**

* the equivalent present value of the spares per well at 1990 prices.

In addition to the above, there will be local costs peculiar to each country. These will include staff costs (1 driller + 3 local labourers), fuel (marginal) and more importantly, about 90 metres of screen for the adits.

significance and application of the project results

1 The project has demonstrated that collector wells can be constructed cheaply and are an efficient means of extracting water from sand rivers and shallow, thin water-bearing strata of alluvial plains.

2 The work in Zimbabwe and Botswana was done during a severe drought and it was clear that even under such conditions, significant reserves of water are available in these shallow aquifers. These deposits represent a largely untapped source of water for many developing countries.

3 Two commercially available methods of drilling have been adapted by the BGS to allow the construction of collector wells and use of a decision diagram (page 13) allows selection of the optimum design of abstraction unit.

4 The Department of Water Affairs, Botswana is currently (1993) constructing six collector wells to supply villages near sand rivers using the techniques developed by the project.

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