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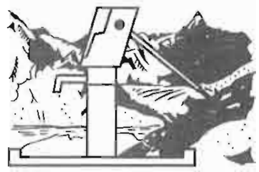
WATER, ENVIRONMENT AND MANAGEMENT



Cost recovery, charges and efficiency

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INTRODUCTION

This paper describes the water supply problems facing a large Indian city, some suggested technical remedies and a brief commentary on the economic and financial implications of the suggested improvement program. The technical remedies and data were investigated and researched by Indian engineers who participated in the Management for Public Health Engineers course at WEDC in the UK and field studies in Nagpur over the first quarter of 1992.

Nagpur is the second city of Maharashtra State and has a recorded population of 1,657,000 in the 1991 census.

THE SUPPLY SITUATION IN NAGPUR

The city has faced a water supply deficit since the early 1960s. At that time the water supply to Nagpur from all sources was 31.5 MGD. Most came from the aging Kanham water works (24 MGD) and Forewara (4 MGD). A further 3 MGD was potentially available from Wena water works but the prime role of this facility was to supply the Defence Establishment (Ambazari).

There has been a heavy dependence on surface water and the 31.5 MGD (ie 142 MLD) was inadequate for the 1971 population of 1.15 m. The supply problem has had two key aspects:
(i) Had everything worked absolutely effectively (including distribution) the supply would have provided approximately 120 LPCD. This falls short of the Govt of India's approved consumption figure of 130 LPCD, the amount to be available daily. In fact the wastage of water has been put at 25-30% of production. Thus the actual availability was about 85 LPCD. Moreover, the inadequacies of the distribution have led to gross inequities in supply.

The needs of industry were considered separately under arrangements of the Maharashtra Industrial Development Corporation.

In the 1970s when the existing water supply fell short of demand, the first phase of the Pench water scheme was planned to augment the supply by 25 MGD (113.5 MLD).
(ii) The Pench I scheme increased the stock of water but failed to provide adequately for its equal distribution around the city. The scheme cost Rs 7.74 crores and was started in 1974 and completed in 1982. By then the population had increased to 1.5 millions. Supply increased by 113 MLD to 225 MLD approximately. However, allowing for 27 MLD for institutional use, and up to 30% distribution losses, availability to the city was only about 150 MLD. This would yield 100 LPCD as a maximum. Thus because of population growth Pench I failed to provide for the approved consumption figure. Also because of the inadequate distribution system the water available could not be distributed on a fair basis. Sadly distribution needs were not considered as an integral part of the Pench I scheme though experience showed that a successful supply policy depended on its adequacy.

Projected population growth indicated the need to augment supply by new sources if the 'approved' consumption figure was to be met. Table 1 gives an indication of the expected future deficiency in supply in the absence of new works.

TABLE 1

SUPPLY SITUATION (MLD) WITHOUT NEW WORKS*

	1994	2009	2024
Population (m)	1.85	2.6	4.5
Domestic Demand	240.5	338	585
Non Domestic Demand	15.0	30	44
Total Demand	255.5	368	629
Existing Supply	256**	256	256
Balance needed	-	112	373

* Defined as Pench II and 'Improvement Program'
** Includes Pench I

To provide an initial contribution to the forecast requirements the government sanctioned development of Pench (Phase II). Work started in April 1990 and it is intended to increase Nagpur's water supply by another 113 MLD thus meeting the population's requirements at the approved consumption level of 130 LPCD. The scheme is estimated to cost R32.09 crores and is due for completion in 1993. Execution is by the Maharashtra Water Supply and Sewerage Board on behalf of Nagpur Municipal Corporation.

The previously alluded to inadequacies of the distribution system and the future required expansion of the supply system mean that distribution design has had to be given high priority,. To this end the Visveswarayya Regional

College of Engineering (VRCE) Nagpur has completed a computer based design study of the existing distribution and a planned program of expansion and improvement. In the light of adverse previous experience synchronization of water supply and the demand pattern with an emphasis on equitable distribution has taken precedence.

Table 1 indicates that by 1994, after completion of Pench I, there should be a balance of supply and demand. However, the supply figure makes no allowance for distribution losses and hides the record of uneven water coverage.

At the current time (April 1992) much publicity has been given to the poor supply situation. The press claims that the city faces a shortfall of 90 MLD, its requirement is 295 MLD during the summer but at best 205 MLD is supplied. The NMC counterclaims that 260 MLD has been maintained. It is generally the case that the burden of water shortage is generally imposed mainly on the poorer sections of society. Significantly, at the present time, richer residential areas have been affected and 1992 has seen the rare spectacle of high-income lady demonstrators taking to the streets in protest.

The response of NMC since 1986 to water distribution problems has been to provide ad hoc emergency water supply schemes. In 1992 Rs 85 lakhs have been provided for this purpose. The program consists of drilling boreholes, cleaning public wells, fitting electric pumps and additional tanker supplies.

POSSIBLE SUPPLY IMPROVEMENTS

Investigators defined the short term as 1994 and medium term as 2001. They suggested the means by which, over this period, sufficient water of good quality could be supplied in order to provide a target level of consumption of 180 LPCD by the year 2001.

Population data and assumed target per capita consumption allowed domestic demand to be calculated. Inclusion of bulk demand allowed total demand to be determined over the period (Table 2).

TABLE 2

NAGPUR DEMAND FOR WATER

	1991	1994	2001
Population (m)	1.622	1.824	2.4
Consumption (LPCD)	130	180	180
Domestic Dem (MLD)	210.86	328	432
Bulk Demand	44.7	45	50
TOTAL DEMAND	256	373	482

In addition to the completion of Pench II the investigators proposed a series of measures which could improve the Nagpur supply situation in such a way as to bring the 2001 total demand figure into balance with supply. Completion of Pench II would bring the total supply to 370 MLD thus requiring approximately 117 MLD to be gained from a program of improvements. Such a program might reasonably include the following measures.

a) An intensive wastage reduction program . In particular leak detection studies and remedial measures should be initiated. Currently some 25% to 30% of water production fails to reach the consumer.

b) Improvement of the efficiency of existing supplies, eg at Kanhan Plant only 95.3 MLD is being filtered and pumped against a design capacity of 105 MLD. This is partly due to accumulation of sand reducing water entry into the intake well. The plant itself could be improved with limited investment.

c) Implementation of the extension and improvement program to the distribution system as per VREC computer design with consequent removal of inequities in supply.

d) Exploitation of new sources, particularly groundwater which has favourably potential. It is estimated that 9.24 MLD are potentially available.

e) Reduction of the water loss due to illegal extraction, seepage and evaporation on its route from the Pench River to the treatment plant at Mahadula. At present a 48 Km canal is utilized but it is suggested that pipes might reduce losses by 20% or 70 MLD.

These measures and the impact upon supply are summarized below.

TABLE 3

SOURCES PRE AND POST IMPROVEMENT

	PRESENT (MLD)	POST IMPROVEMENTS AND PENCH II
OLD GOREWADA	19	19
KANHAN	95.3	105
PENCH I	135.5	135.5
BOREWELLS	1.61	9.24
OPEN WELLS	4.63	20.00
PENCH II	-	113.5
PIPE CONVEYANCE	-	70.0
ADDITIONAL GROUNDWATER	-	10.0
TOTAL	256.04	482.2

Thus the relevant increment of water is 226 MLD at a total capital cost of Rs 1370 m. Operating and Maintenance Cost is assumed to increase from Rs 90 m per year in year 1 (1992/93) to 320 over the assumed project life.

Project finance is assumed to be available from the same sources as that for Pench II and available on similar terms.

TABLE 4

SOURCE OF FUNDS

SOURCE	'IMPROVEMENTS'	PENCH II
HUDCO	200	-
OPEN MARKET	160	122.5
GRANT IN AID	320	74.9
LIC	690	91.4
PUBLIC CONT-RIBUTIONS	-	32.1
TOTAL	1370	320

MARGINAL COST PRICING FOR EFFICIENCY

On the grounds of optimizing resource allocation the general recommendation is that commodities should be supplied at a price reflecting Long Run Marginal Cost. Briefly the rationale of this is explained using Figure 1.

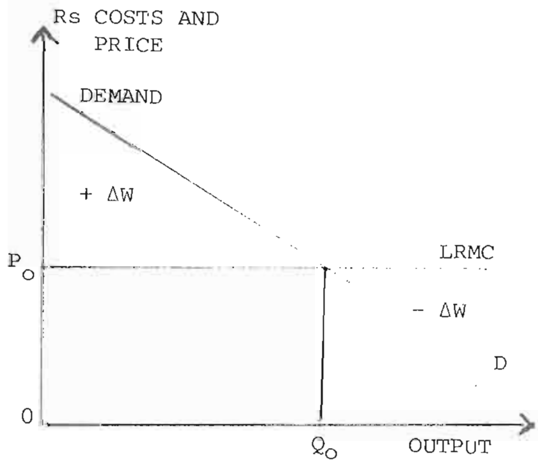

Figure 1

The demand curve shows the maximum in rupees that the community would be willing to pay for a unit of output rather than go with it. In short it records society's money valuation of each extra unit. The LRMC shows the full cost imposed upon the community of providing each extra unit of output. From zero output to Q_o there is a decreasing but positive net benefit by increasing output ie society values these units at more than they cost. Thereafter increasing output beyond Q_o the costs are greater than the valuation and welfare will fall. Thus the optimal output is Q_o and the optimal price is P_o, that is P_o = LMRC at which welfare is maximised.

The economist's definition of Long Run Marginal Cost requires that the addition to Total Cost of producing a small change in output be measured. However, the indivisibilites associated with such projects as water supply, sewered sanitation or power generation mean that an approximation to LRMC be found. The accepted approximation is the Average Incremental Cost, in this case the AIC of water produced from Pench II and the improvement programme.

In effect, the formula for AIC calculation uses the output of the project as a proxy for benefits:-

$$AIC_t = \frac{\sum_{t=1}^{T} \frac{C_t + O_t + M_t}{(1 + r)^t}}{\sum_{t=1}^{T} \frac{Q^t}{(1 + r)}}$$

where C = Capital Cost, O = Operating Cost, M = Maintenance Cost, Q = Output and r = discount rate.

Application of this formula shows that on the cost assumptions made, water from the defined project will cost Rs 4.2 per 1000 litres. This is somewhat lower than the often cited cost of 'new' water in India of about Rs6.0 and is attributable to the use of water from the existing Pench source and its already provided civil works.

It can readily be seen that a price based on AIC will recover the full cost incurred in expanding Nagpur's water supply. Economic break-even requires that the PV of revenues should equal the PV of the costs incurred.

$$\Sigma P_tQ_t/(1 + r)^t = \Sigma C_t + 0_t + M_t/(l + r)^t$$

Where P = Price and other notation is as defined above.

The Constant annual price which will ensure this is P* :-

$$\Sigma P^tQ_t/(1 + t)^t = \Sigma(C_t + 0_t + M_t/(1 + r)^t$$

Hence P* can be used as an indicator of the price which will lead to cost recovery for a 'lumpy' or indivisible investment:

$$P^* = \frac{\Sigma(C_t + 0_t + M_t/(1 + r)^t}{\Sigma Q_t/(1 + r)^t}$$

which in our case yields P* = Rs 4.2 per 1000 litres.

Based on an average household income of Rs 15,000 per year, a family of 5 persons consuming

180 lpcd, would need to spend about 9% of household income on water. This is high relative to the often cited rule of 5% of income but low relative to expenditure of citizens elsewhere in the world dependent on water vendors. At a reduced target consumption of 150 LPCD the percentage of income falls to 7.6%.

The burden of recovering cost could be reduced on the poorest by subsidized payments by the rich or acknowledging that until incomes grow sufficiently, only a proportion of capital costs would be recovered. In addition an increasing block tariff could be designed with zero price charged for initial consumption and higher rates for successive additional consumption. Luxury water at very high levels of consumption could be charged for at punitive high rates and justified on the grounds that such levels of consumption are the prerogative of the rich.

WASTE REDUCTION AND COST RECOVERY

It is interesting to note that the investigating engineers recommended predominently engineering solutions. Measures to increase capacity received attention whilst wastage reduction of the existing supply was assumed to be an implicit result of improving distribution.

Economists would argue that wastage reduction should be viewed more explicity as an alternative investment project to additional construction. This economic approach has two facets. Firstly, the price based on AIC and cost recovery will constrain demand at high levels of consumption. Of course, the tariff system must ensure that basic and reasonable demands are affordable. However, prudent use of the valuable resource water may be fostered by facing people with the real cost of their consumption. A prerequisite of a successful policy of charges to allocate water efficiently is volumetric recording of consumption. It is worthy of note that it was variously reported that between 60% and 90% of Nagpur's meters were tampered with, defective or damaged.

Secondly, at least 25% of treated water never reaches the consumer. Interestingly this order of wastage is typical of much of the developing and industrialised world alike. What other industry would allow upwards of a quarter of its finished output to be wasted?

Clearly, just as the production of new water incurs costs so does the conserving of existing output by metering and waste reduction. It is worth enquiring how much it is worth spending on wastage elimination. For the Nagpur situation it is possible to arrive at an approximate answer to this question.

To do this one needs to know the annualised cost of increasing supply ie the cost of Pench II plus the Improvement Program. The annualised cost is that sum of money which would have to be put away each year to recover the full costs of the project plus accumulated interest charges.

The PV of costs of the program is calculated at approximately R2,800 m. The annual cost is PV of costs x Capital Recovery Factor = Annualised Cost at 10% over 30 years

2,800 m x .1061 = 297.08 m

This annual cost each year provides 226 MLD of treated water. Given at least 25% is wastage then 226 - 4 = 56.5 MLD incurs cost but earns no revenue. Annually this cost is 297.08 - 4 = R74.25 m. In short it would be worth spending at least this sum of money to conserve existing supplies rather than to invest in new capacity.

The importance of waste control is that it can help cost containment and thereby reduce the AIC of future water supplies. In turn, this will reduce costs to consumers and aid cost recovery. Only when utilities are allowed to operate commercially with tariffs reflecting costs and freedom from central control in operation can one expect the generation of revenue sufficient to recover costs and to ensure adequate operation and maintenance. Until such time the ladies of Nagpur will take to the streets and express their displeasure at inadequate service.

AIC COST CALCULATION

$$AIC = \frac{\text{Rs } 27975 \text{ m}}{1791.38 \text{ m} \times 365}$$

$$= \text{Rs}4.2 \text{ per } 1000 \text{ litres.}$$