CHAPTER XII

WATER RESOURCES MANAGEMENT

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BACKGROUND INFORMATION

Groundwater, forming one of the facets of the water resources system in the hydrological cycle, has a most remarkable feature in its being a renewable resource, getting periodically replenished largely from rainfall. The rapid pace of development in the study area has resulted into unprecedented increase in demand for groundwater. Rainfall being the only source of recharge, its erratic and deficient input in conjunction with adverse geoclimatic conditions has created precarious conditions of availability of water. Scarce rainfall input, highly permeable stratum (aeolian plains) and considerable evaporation losses have made water resources very meager and localised with high variation in their chemical content.

PROBLEM PROFILE

The availability, potentiality and potability of water are three major components generally responsible for various developmental aspects as well as socio-economic fabric of any area. The problems of the study area and their magnitude can be briefly summarised as under :

1. The study area constitutes a part of semi-arid terrain characterised by high insolation, aridity and evaporation.
2. Rainfall input to groundwater recharge is seasonal and erratic.
3. Adverse physiography in combination with climatic factors has made this area rainfall deficient.
4. The incipient recharge to the groundwater regime through the drainage network getting lost at the fringe areas of the desert margin is considerable. However, it is restricted to a very narrow strip and is localised.
5. The study area, due to the presence of vast cover of aeolian sand sheets, has high infiltration capacity. But due to high insolation, aridity, winds, etc., the area witnesses high evaporation losses.
6. High evaporation losses and lack of surface/sub-surface flushing are responsible for enriching salts in the groundwater and also the sediments.
7. By and large, the groundwater is contaminated and not suitable for drinking purpose.
8. The availability of potable water is highly restricted, witnessing an unforeseen over exploitation.
9. The lead, i.e. distance to the source of potable water is more and causing much hardship to the inhabitants.
10. Although the area has got innumerable surface water storage structures, majority of them are rendered useless or affected by siltation, due to their improper maintenance.
11. On account of the sporadic distribution of population and settlements, the implementation of any major scheme on cost benefit ratio is non-viable.

Due to the above given factors, large number of villages/towns in the study area have been identified as 'No Source Villages' or 'Hardcore Villages'.

WATER MANAGEMENT PRACTICES

In the study area, the practice of storage, conservation and utilization of water resources has been observed since early times. Number of such traditional and conventional structures used for water storage, *viz.*, tankas, jodas, nadis, etc., are testimony to the above fact.

Till the early fifties and sixties the water demand and its availability was not a very concerning issue, as the water need for livelihood was broadly restricted to drinking purpose. Agricultural practices were dependent on the monsoon, hence people used to have only kharif crops.

The late sixties and seventies period had started witnessing unprecedented water demand, owing to fast development, *viz.*, roads, electrification, easy accessibility to urban centers, agricultural practices, industrialization, high population growth, etc. This has necessitated to look into the problem and find out ways and means to meet the ever increasing demand for water.

The problem of water resources management in the study area can be resolved by way of:

- Development of groundwater resources and recharge conditions.
- Development of surface water resources.
- Conjunctive use of surface and sub-surface water.

INVENTORY OF EXISTING PRACTICES

The existing modes of utilization of water resources in the study area include surface water structures like village ponds, storage tanks, tankas or cisterns, percolation tanks, etc.; groundwater structures like dug wells, dug-cum bore wells, hand pumps, bore wells, etc., and combination structures like check dams, gully plugs, subsurface dams, etc. A summary of these different types of water harvesting structures is given in Table 12.1 and briefly described below.

Groundwater Harvesting Structures

Extraction of groundwater is the main purpose of these structures and the common types of such structures seen in the study area are:

i) Dug wells: The open dug wells ranging in diameter from 2 to 10 meters with a 10 to 60 meters depth range, tapping phreatic aquifers, usually have a circular outline, sometimes oval, square or rectangular and supply water for drinking, domestic and irrigation purposes. These are mostly found in hardrock terrains, pediment plains and alluvial plains. In the alluvial plains the dug wells are lined and water is extracted by electrical/diesel pumps. Shallow dug wells excavated on the river bed are common in the study area, especially along the Luni river channel (Plate XII.1 & 2). The village wells used for drinking water generally have constructed platform and cattle water troughs (Plate XII.3).

ii) Dug-cum-Bore wells: The problem of low yield and short duration supply of dug wells in many parts of the study area has been countered by tapping the deeper aquifers as well as the lateral extension of aquifers. This is achieved by radial horizontal boring and vertical boring at the bottom of the dug well (Fig. 12.1).

iii) Hand Pumps: Hand pumps are the common and very popular structures for drinking water, tapping the consolidated and semi-consolidated aquifers *viz.*, quartzites, phyllites, schists, sandstones, limestones, etc. Schematic hydrogeologic conditions of a common type hand pump is shown in Fig. 12.2. The yield of the pump depends on the aquifer types and also the seasonal recharge.

iv) Bore/Tube wells: Bore wells and tube wells are mostly found in the crystalline hardrock terrains, the pediment plains and alluvium areas (occasionally in the aeolian plains), and vary in depth from shallow drilled wells to as deep as 60 meters or more. In the study area, such wells are concentrated more in the Kantli watershed. A schematic diagram of the hydrogeology of a bore well is shown in Fig. 12.3.

Surface Water Harvesting Structures

Various surface water structures used for rainwater harvesting and conservation of surface water include traditional or conventional structures like village ponds or tanks (nadis) for domestic purposes, farm ponds and percolation tanks (khadins) for irrigation, tankas (cisterns), joda nals, etc., and modern anicuts, check dams, etc.

Plate XII.1 A view of lined dug-well in the alluvial plains of Luni river. Location: Alniyawas

Plate XII.2 Extraction of water by means of diesel pumps from shallow dug-wells excavated on the Luni river bed. Location: Alniyawas

Plate XII.3 A view of typical village well in the semi-arid terrain of Merta-Pipar.

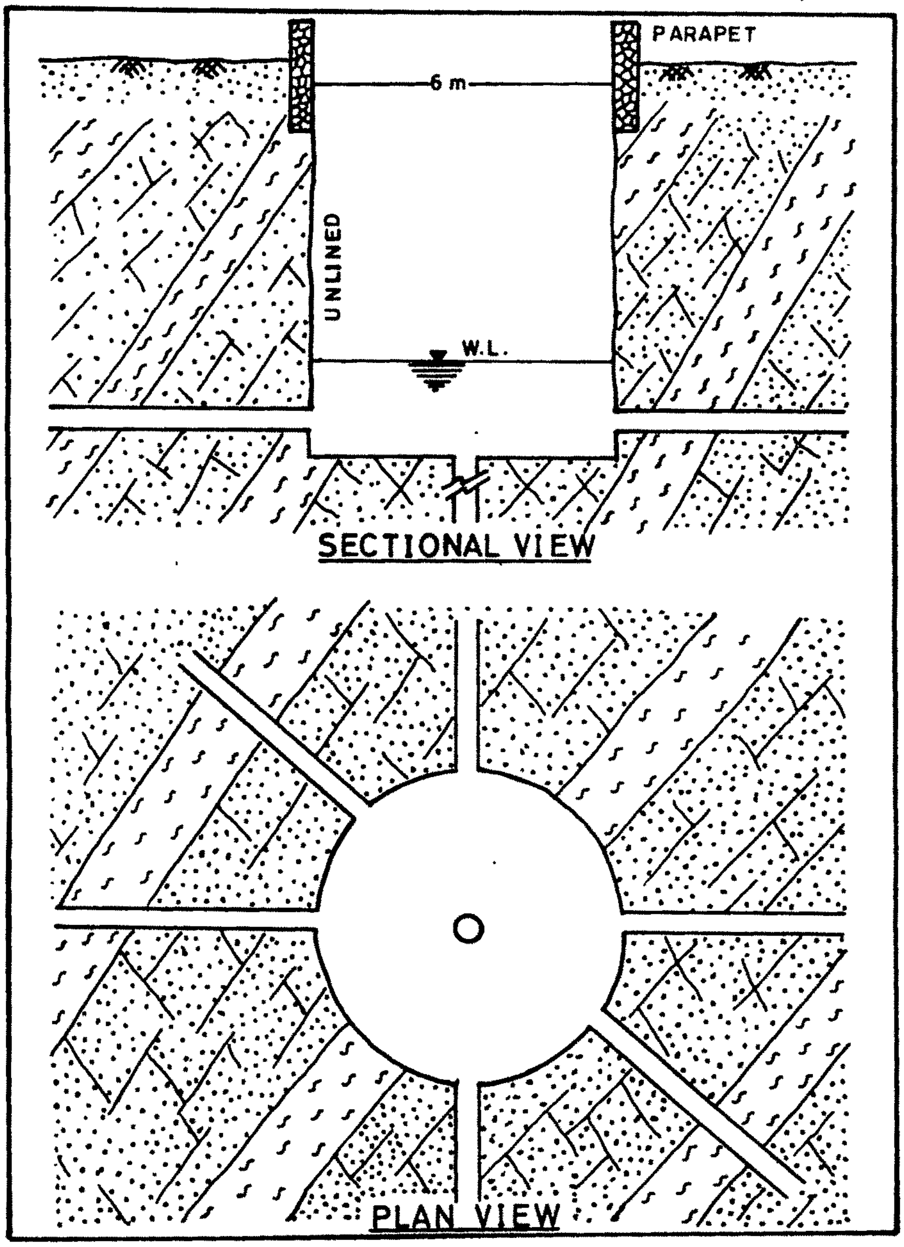

Fig. 12·1· SCHEMATIC DIAGRAM OF DUGWELL WITH RADIAL BORES

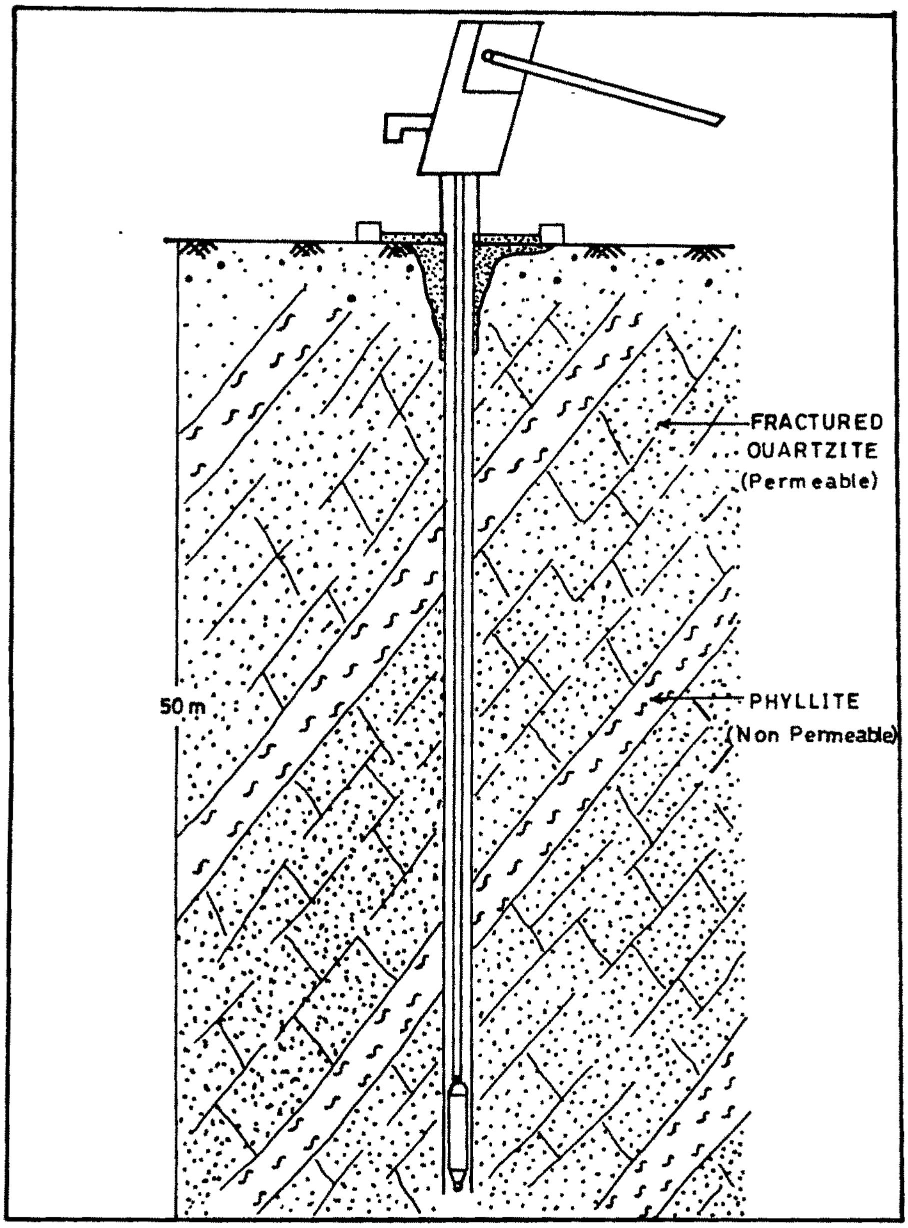

Fig. 12.2. SCHEMATIC DIAGRAM OF HANDPUMP BUILT UNDER APPROPRIATE SUBSURFACE CONDITIONS

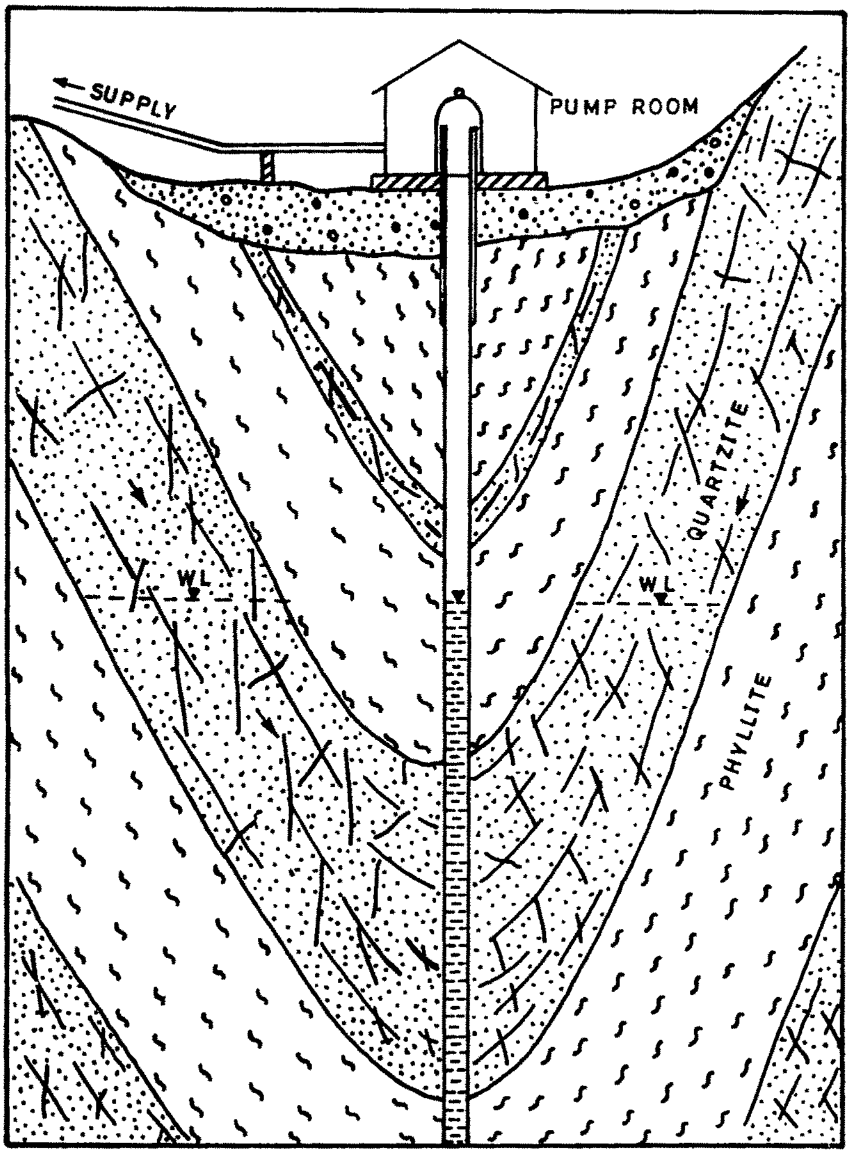

Fig. 12·3· SCHEMATIC DIAGRAM OF BORE WELL

i) Village Ponds: Village ponds, locally called '*nadis*', are common surface water storage structures being used for domestic needs and cattle drinking. One or two wells dug on the bank of such a pond are solely used for drinking water supply. A schematic diagram of the village pond and pond wells is shown in Fig. 12.4. Improper maintenance and upkeeping has caused deterioration in the quantity as well as quality of water in these ponds in the recent years. High rate of evaporation, siltation and pollution are the major problems in the nadis.

ii) Storage Tanks: The storage tanks, similar in structure and function to the village ponds, are common man made structures in the alluvial, aeolian and pediment plains of the study area. A schematic diagram of typical storage tank is shown in Fig. 12.5. Storage tanks, locally called as '*Joda Nals*' occur in large numbers in the aeolian terrain covering northern parts of the study area around Taranagar, Sardarshahar, Surajgarh, etc. (Plate XII.4). Figure 12.6 shows a schematic diagram of a typical *Joda Nal*.

Modified forms of storage tanks as designed to work in the arid lands od Australia have been suggested by Hollick (1982) after Burton (1965). Schematic diagram of such typical storage tanks or excavated tanks and their variations is shown in Fig. 12.7.

iii) Cisterns or *Tankas*: These are covered underground tanks for storing water commonly sited in the interdunal depressions of the aeolian terrain in the northern parts of the study area around Taranagar, Sardarshahar, Melasar, Ranadisar, Gogasar, Baliya, Rajgarh, Pilani, etc. The traditional form of the tankas consists of a large circular to semicircular pit or pond of about 3-4 m diameter and 3 m depth, excavated in the sloping ground of interdunal depressions. The inner walls of this pit are generally plastered to avoid downward percolation of water. Due to the general slope of the ground towards the central pit, the surface runoff during rainy season flows into this tank and gets collected there for later use. To prevent evaporation losses the tank is covered by a domal structure made up of dried twigs and thorns. A schematic diagram of the traditional tanka is shown in Fig. 12.8 and Plate XII.5 shows such a tanka located in the interdunal depression near Surajgarh.

Plate XII.4 A view of typical storage tank 'Joda Nal' located in the interdunal depression in aeolian sandy terrain. Location: Doliya

Plate XII.5 Traditional tanka (Cistern) for water storage located in the aeolian terrain around Taranagar-Sardarshaher.

Plate XII.6 Typical tanka (Cistern) made up of concrete structure. Location: Taranagar

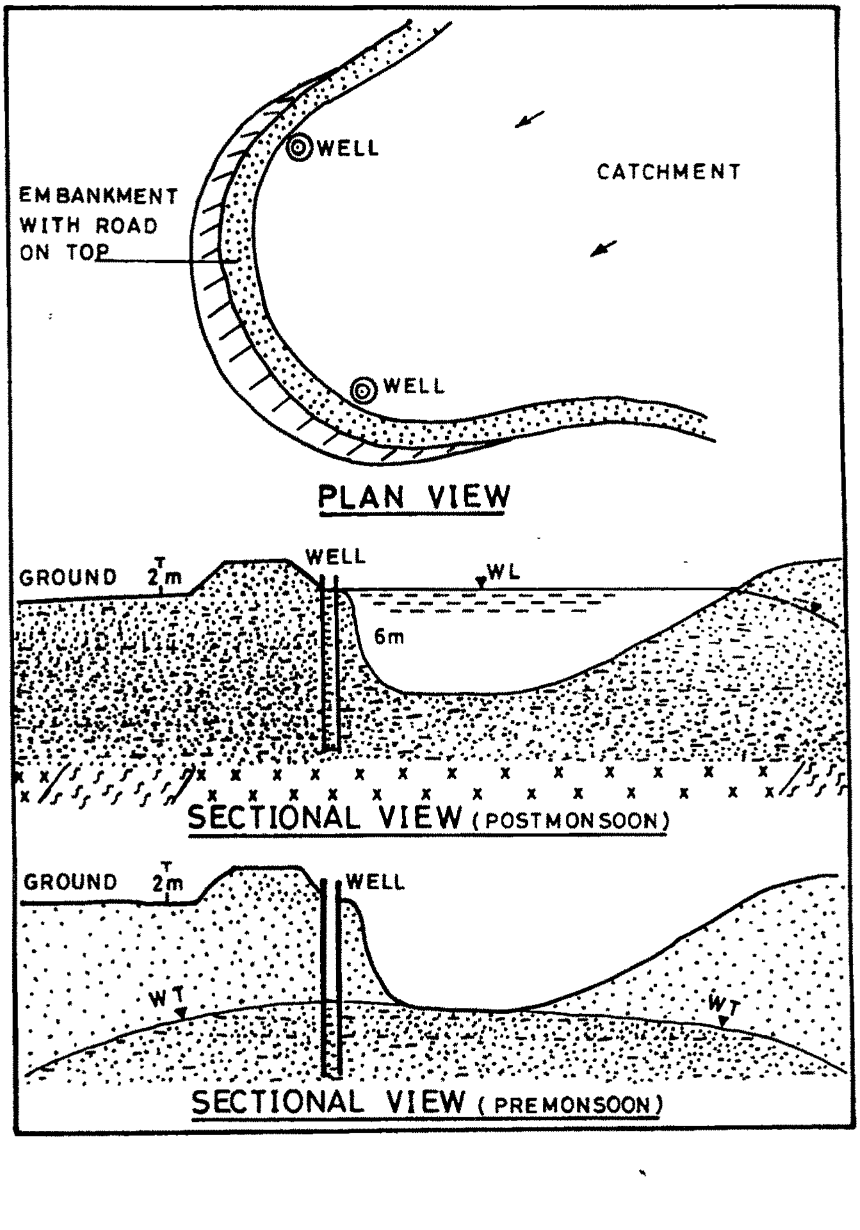

Fig. 12·4· SCHEMATIC DIAGRAM OF VILLAGE POND

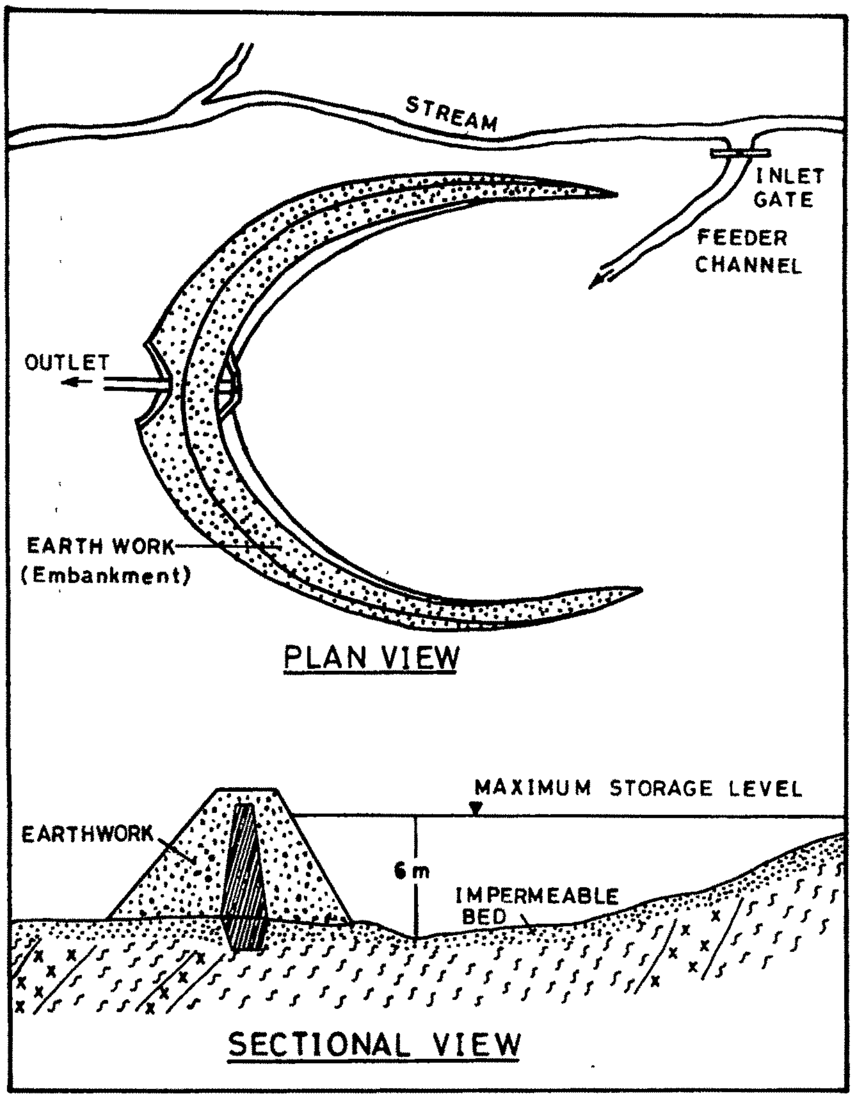

Fig. 12.5. SCHEMATIC DIAGRAM OF STORAGE TANK

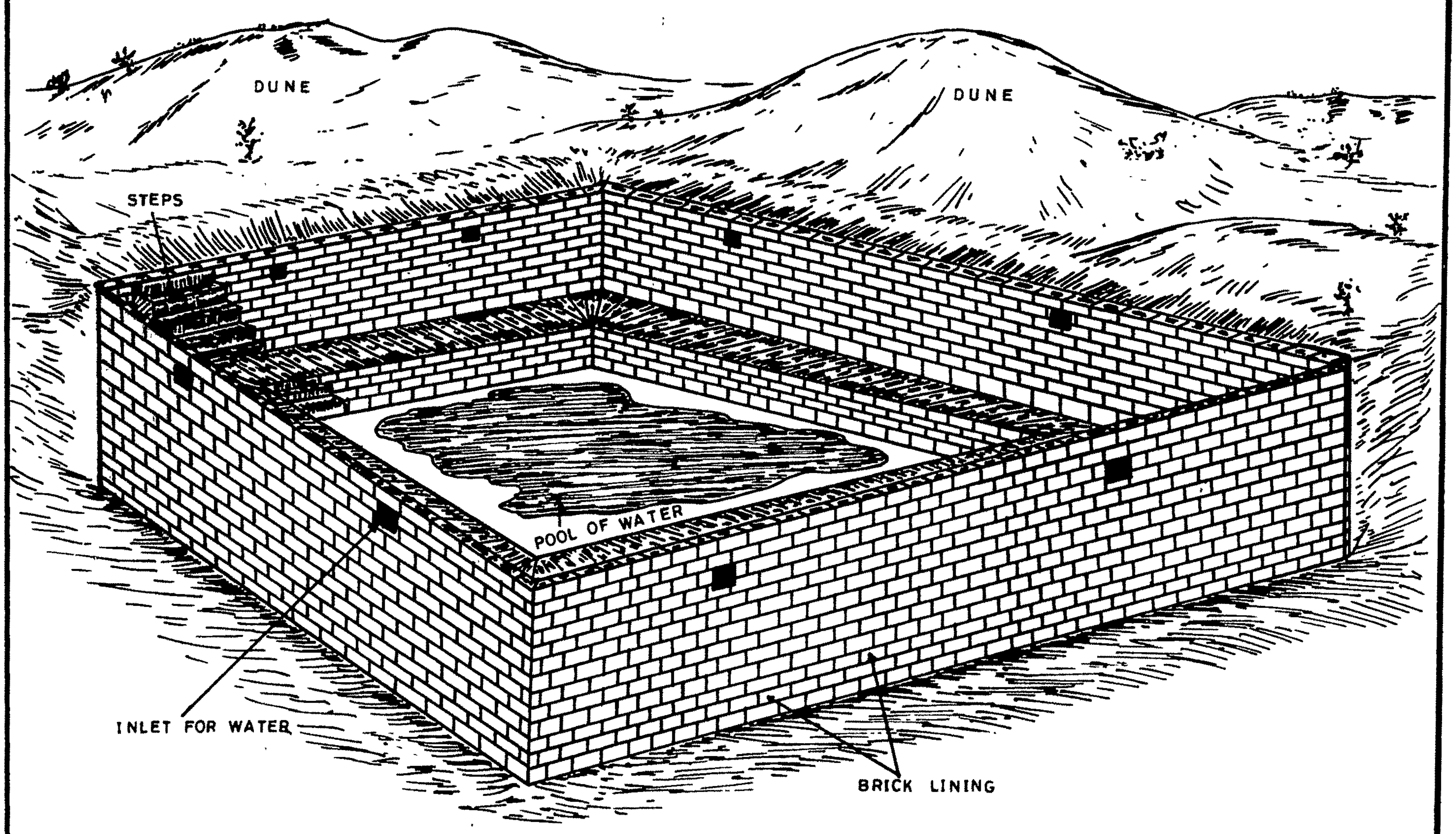

Fig. 12.6. SCHEMATIC DIAGRAM OF A JODA NAL IN A DUNAL TERRAIN

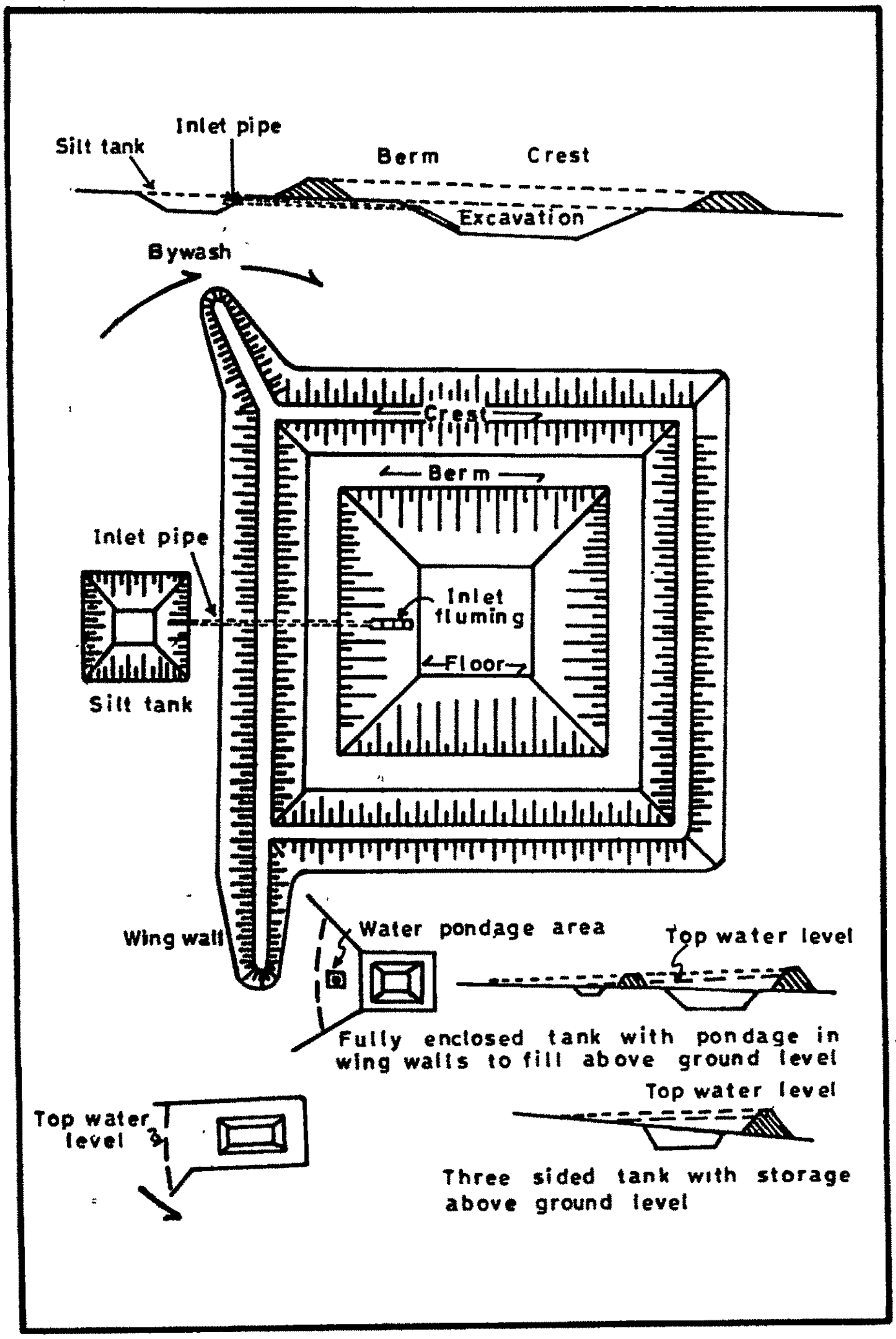

Fig. 12·7. SCHEMATIC DIAGRAM OF MODIFIED FORM OF TYPICAL EXCAVATED TANK AND VARIATIONS
(After Burton, 1965)

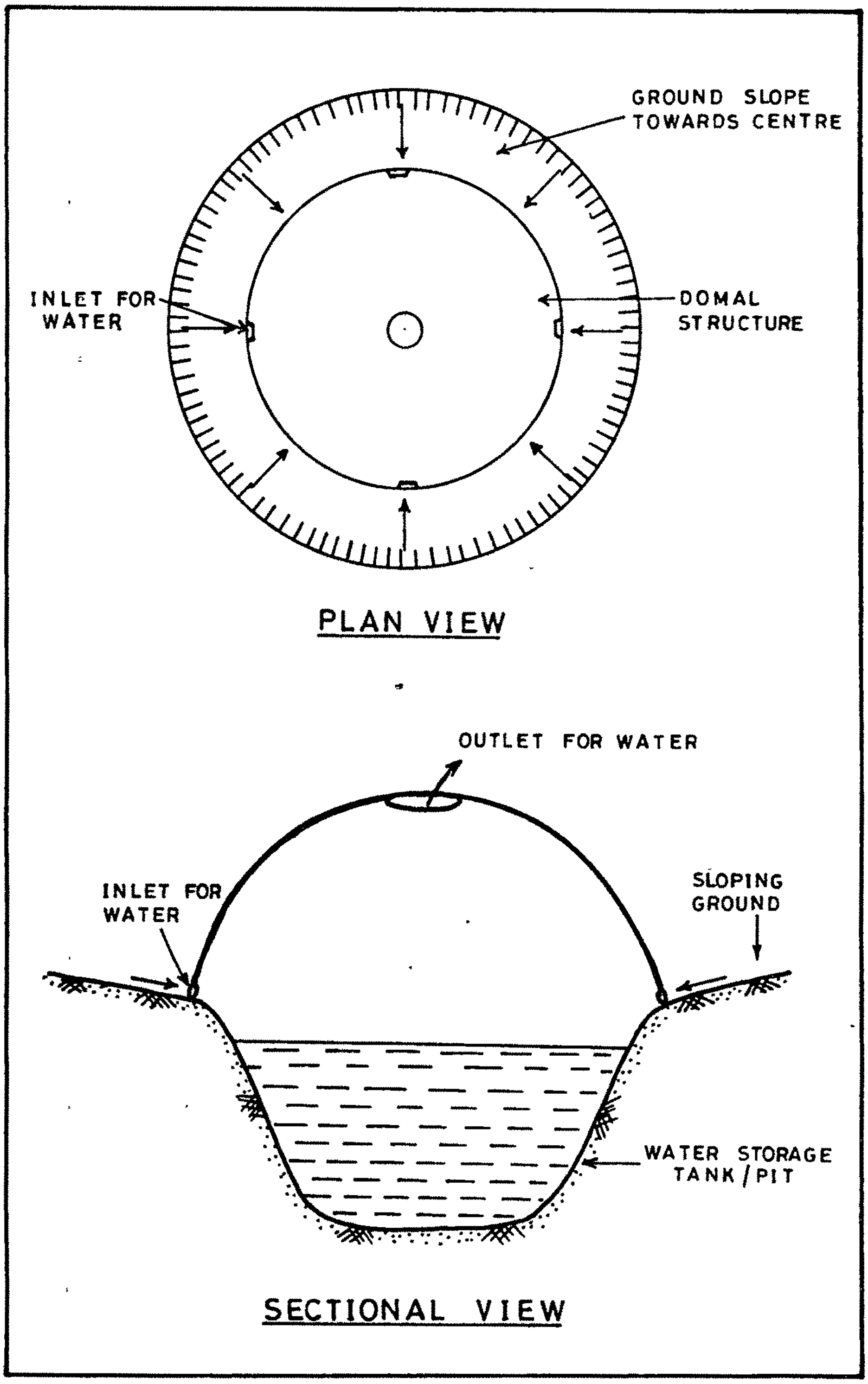

Fig. 12·8· SCHEMATIC DIAGRAM OF TANKA (CISTERN)

The modified structures of traditional tankas consist of domal covering made up of concrete (Plate XII.6) and is provided with an outlet for drawing out water. The major problem in these tankas is that the water storage capacity is reduced considerably by the large scale sedimentation from the adjoining unstable landforms.

The Central Arid Zone Research Institute (CAZRI) at Jodhpur is involved in carrying out numerous experiments to reduce seepage and evaporation losses from the water bodies and to counter the sedimentation and pollution in the nadis, tankas and jodas. A number of ameliorative measures have been suggested and new improved designs of tankas have also been prepared to avoid such problems. These tankas have been considered to be the most popular rainwater harvesting structure in the Thar desert.

iv) Percolation Tanks: A storage-cum recharge structure, locally called as '*Khadin*', the percolation tank is usually located nearby stream channels and agricultural lands. The overburden material above the bedrock is excavated and a large pit or tank is made. Bund is constructed using the excavated material. The exposed rock having high infiltration rate recharges the surrounding aquifers and the seepage from the bed of the tank enhances recharge to surrounding wells. A feeder channel from the nearby stream is usually constructed to augment the water supply to the tank (Fig. 12.9).

Combination Structures

These are dual purpose structures acting as surface water storage as well as recharge to the aquifers. The combination structures are used less frequently in the study area and include check dams, gully plugs, subsurface dams, contour bunding, etc.

i) Check Dams: These are surface barriers constructed across the rivulets to store water, which cause flooding of the stream channel during waning phase of monsoon. These small masonry structures constructed at appropriate parts of the channel have the provision of sluices or overflowing design. The study area, particularly the pediment zones and rocky peneplains around Harsore-Ras-Tiwri-Khimsar are ideal places for such types of structures. In the study

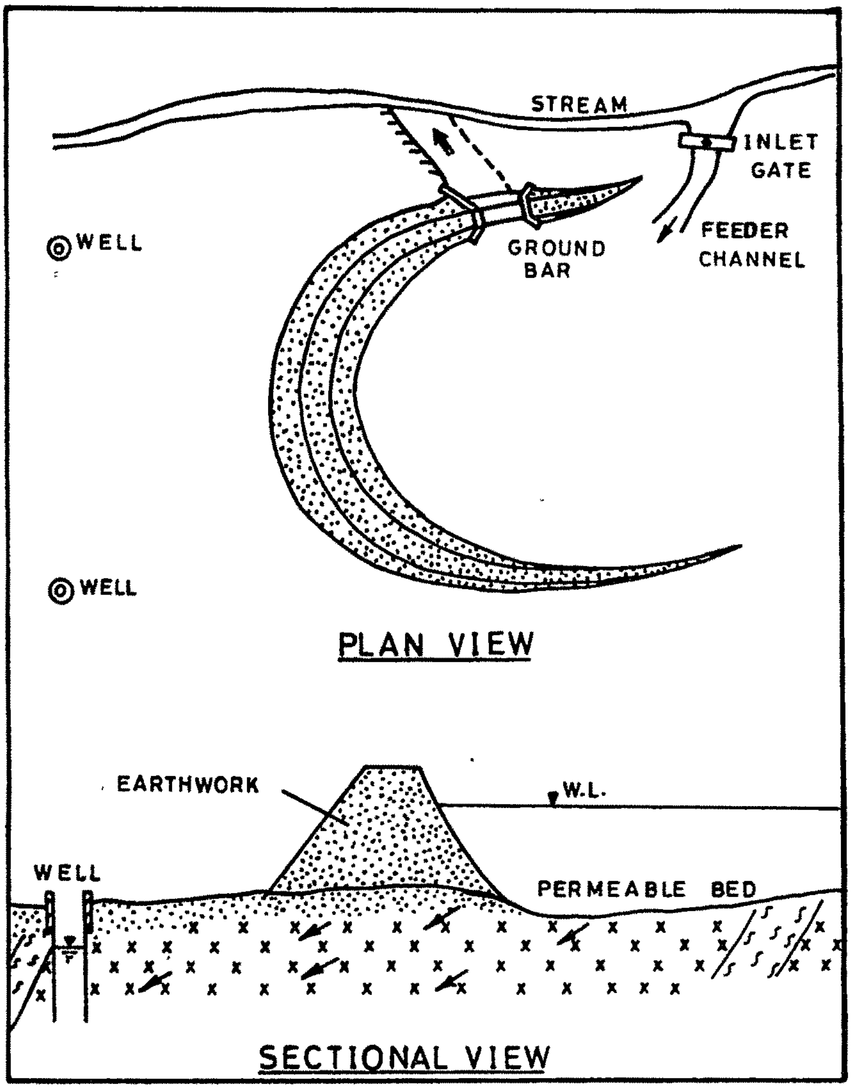

Fig. 12.9. SCHEMATIC DIAGRAM OF PERCOLATION TANK

area number of structures are already existing, constructed by the government, however, due to faulty site selection, substandard construction and lack of maintenance, they have been rendered unfruitful. A schematic diagram of typical check dam is given in Fig. 12.10.

ii) Gully plugs: These structures, of overflow type weirs, are constructed on the bedrock across the gullies and are used mainly for augmenting groundwater recharge. The plug blocks the flow of water and creates a small water pool along the channel and the stored water recharges the groundwater in the vicinity. A schematic diagram of typical gully plug is shown in Fig. 12.11. Modified versions of gully storages as constructed in the Australian arid lands have been suggested by Hollick (1982), after Burton (1965), which may be applicable to the set up of present study area.

iii) Subsurface Dam: These structures check the underflow/ baseflow of the river and store it within the sandy bed. A trench of about 1-2 m width is excavated up to the bedrock depth across the identified river bed section. This trench is backfilled with impervious soil over which a sand bed or protective rubble cover is provided. The subsurface impervious clay barrier acts as a dam storing water within the sandy bed, thereby preventing evaporation losses considerably. Figure 12.12 shows a schematic diagram of a typical subsurface dam.

iv) Contour Trenching: The contour trenching or bunding techniques on gently sloping ground of rolling topography help to increase the rate of percolation of surface runoff, thereby increased water retention in the area and also check on soil erosion. Seepage of water downwards all along the length of the trench and the delayed recharge help in prolonged retention in the soil, sub-soil horizons. A schematic diagram showing contour trenching and bunding is shown in Fig. 12.13.

v) Reservoirs: In addition to the numerous surface/subsurface water structures, the study area harbours number of reservoirs constructed across the ephemeral Luni and its tributaries (Saraswati and Sagarmati) and the Kantli. In the Upper Luni basin, a few earthen dams, *viz.*, Meera Dam near Kurki and Barra Dam near Barr, both on local nalas; Girri Dam near Girri on Lilri river, Raipur-Deepawas Dam near Raipur on Raipur-Luni river; Sardar Samand reservoir on Sukri river, Jaswant Sagar Dam on Luni river, etc., have been constructed to store storm

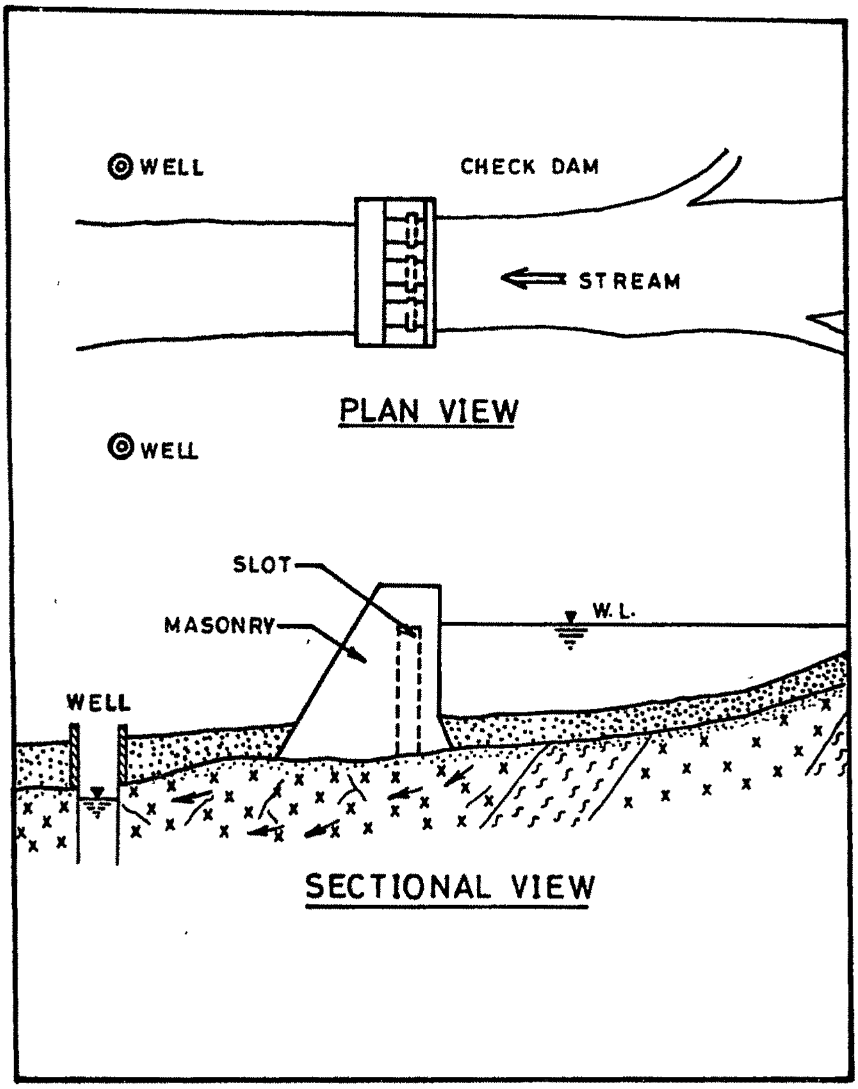

Fig. 12.10. SCHEMATIC DIAGRAM OF CHECK DAM

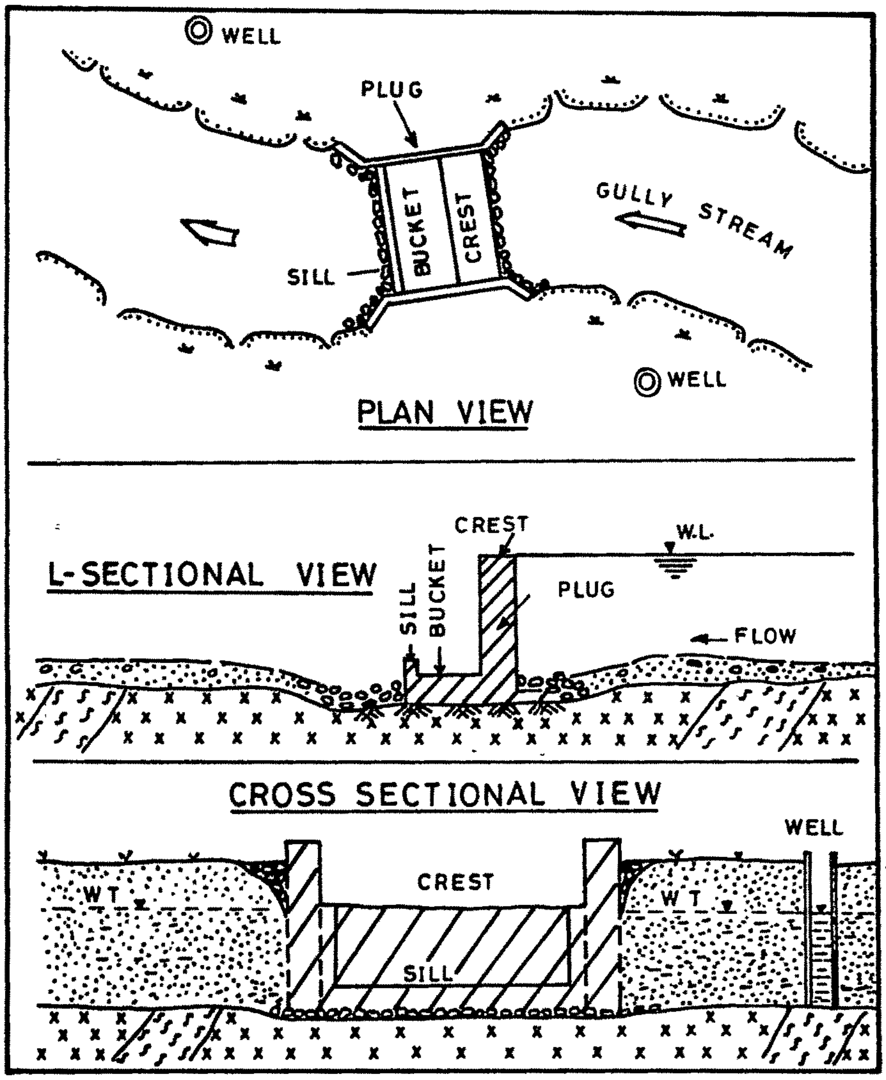

Fig. 12.11 SCHEMATIC DIAGRAM OF GULLY PLUG

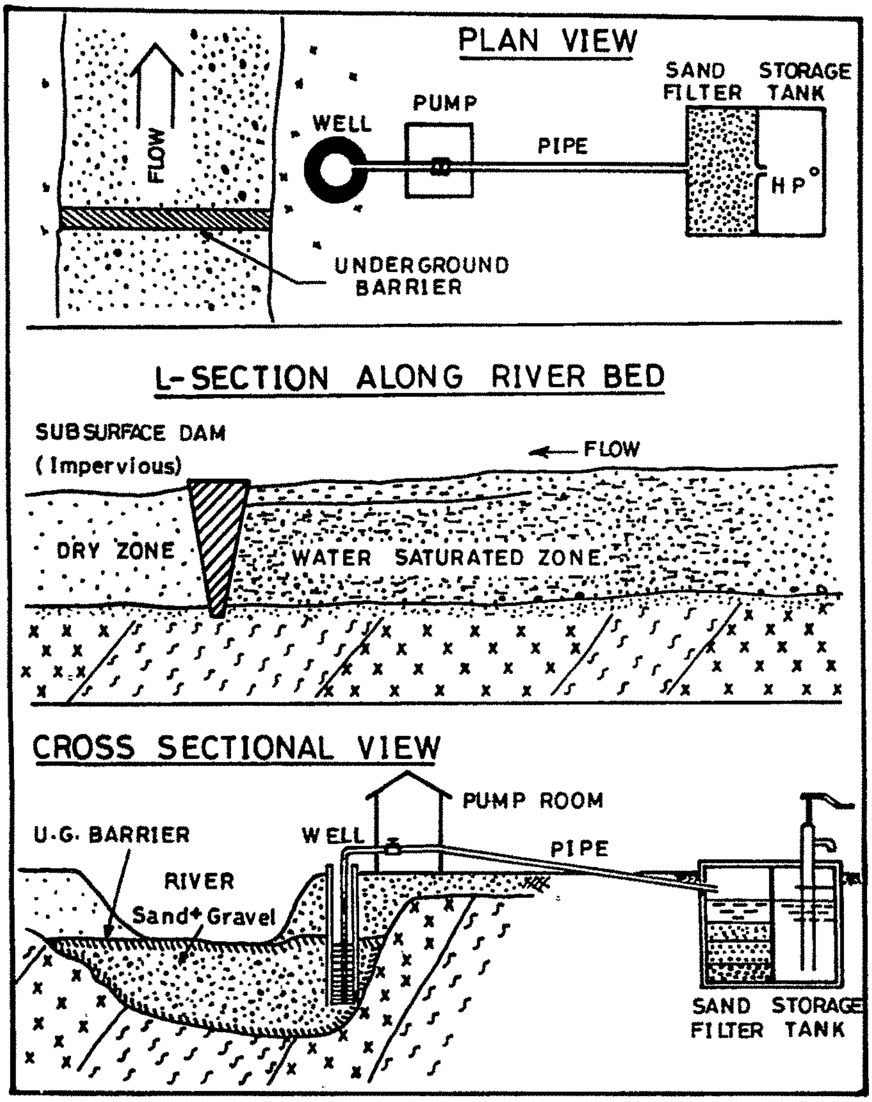

Fig. 12.12. SCHEMATIC DIAGRAM OF SUBSURFACE DAM

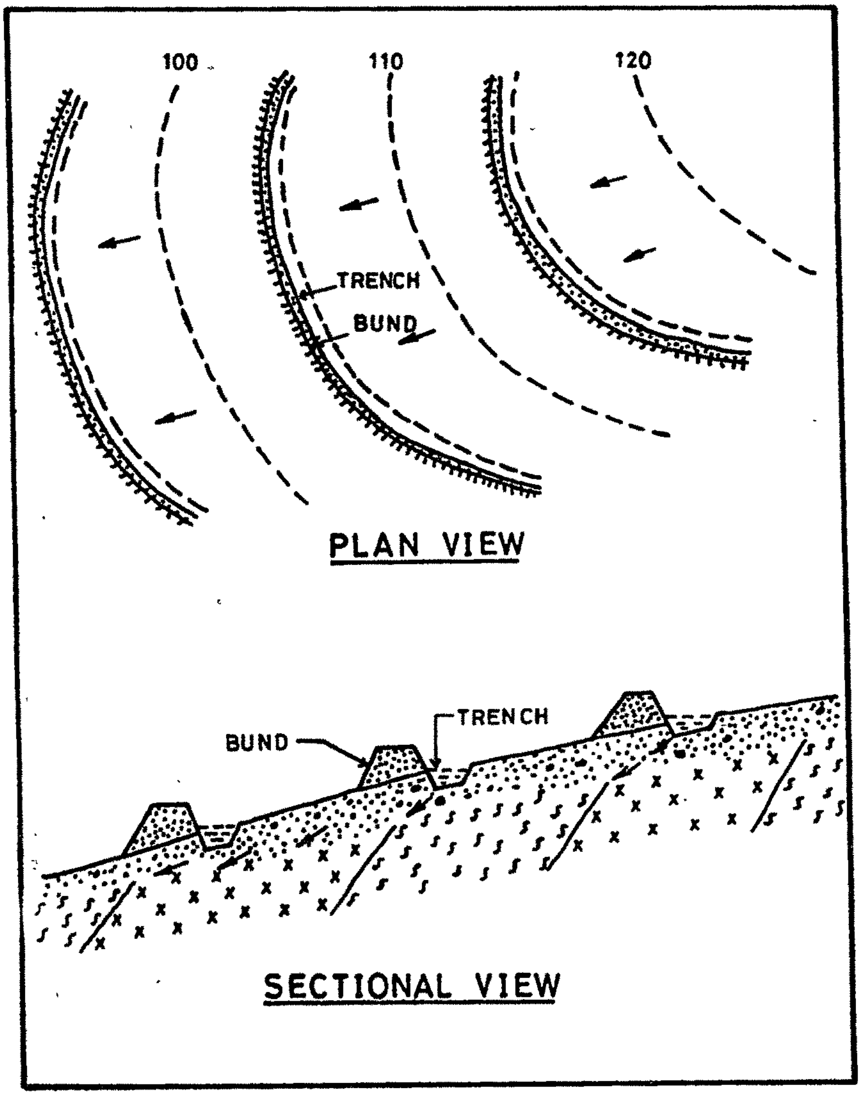

Fig. 12·13· SCHEMATIC DIAGRAM OF CONTOUR TRENCHING AND BUNDING flows as well as for collecting water for drinking water supplies to major cities. The Foy Sagar and Ana Sagar reservoirs are important reservoirs near Ajmer city in the Upper Luni block. In the Kantli basin, large dimension reservoirs and dams do not exist, but minor irrigation structures do occur in large numbers (Plate XII.7).

The presence of most of the above mentioned water resource harvesting structures in large numbers in the study area has had its merits as well as demerits. The large scale unplanned development and exploitation of water resources in the region has produced numerous ill effects. It is generally viewed that the high salinity conditions in the agricultural lands adjoining the Luni river are created mainly due to the construction of large number of irrigation structures and reservoirs along the Luni channel, especially in the upstream areas.

SUGGESTED MANAGEMENT STRATEGIES

In order to meet the total annual water requirement for human and livestock population, the following planning strategies for the development and management of total water resources are suggested. The precarious condition of water resources in the region could be improved through a planned exploitation of groundwater resources available and also by adopting conjunctive use, i.e., by resorting to water harvesting, storing, recycling of precipitation, etc.

To increase the surface storage and recharge to aquifers, the following management and development strategies are suggested.

(a) Construction of more number of nadis, anicuts, tanks and check dams at favourable sites. The geological and geotechnical aspects for the site selection of various suggested schemes are given in Table 12.1.
(b) Artificial catchments may be prepared by using concrete, asphalt and plastic sheets to increase runoff (Hollick, 1982; Singh, 1992b).
(c) Evaporation losses from the nadis and tanks can be minimised by covering them with roofs and suspended sheets, floating polystyrene covers, wax blocks, white-butyl, foamed rubber sheets, etc. Granular materials and small floats like polystyrene beads, usage of

Plate XII.7 A view of water reservoir amidst ravine land of Kantli watershed.
Location: Nim Ka Thana

Table 12.1 Geotechnical features of rainwater harvesting structures

Structure	Purpose	Site Conditions	Engineering Features
Village Pond	Surface storage and recharge to vicinity wells. Mainly for domestic use.	Close to village, undefined catchment, land with depressions, 3 to 5 m overburden.	Generally circular, diameter about 40 to 60 m, depth 3 to 5 m and overflow arrangement.
Storage Tank	Open storage for cattle needs and limited irrigation.	Rocky impervious bed, well defined stream channel and catchment.	Oval or rectangular shape, approximately 5000 to 10,000 m^2 area and about 5 to 8 m depth.
Percolation Tank	Recharge to aquifer and surface storage. Agriculture and domestic demand.	Porous and permeable bed, well defined broad stream channel and/or large ground depression, away from habitation.	3 to 5 m depth, 5000 to 10,000 m^2 area, shallow cut-off, earthen bunding, silt trap barrier in catchment, spilling arrangement.
Check Dam	Recharge to aquifer, irrigation and domestic needs.	Well defined stream channel and banks, sizeable catchment, river bed essentially rocky.	2 to 4 m bank height, masonry structure, provision for monsoonal discharge, partial treatment to foundation.
Gully Plug	Recharge to aquifers, irrigation needs, protection against soil-erosion.	Narrow stream channel, substantial thickness of alluvium, well defined banks.	5 to 8 m height, masonry structure with central spilling arrangement, guiding and training of walls.
Subsurface Dam	River base flow, conservation and recharge to aquifers, domestic and irrigation needs, protection against evaporative losses.	Broad flat sandy, gravelly stream bed, well defined channel and underflow.	Providing an impervious barrier across the sandy gravelly bed.

monomolecular films especially that of a combination of polystyrene beads and cetyl alcohol can be effective.

(d) For augmenting the recharge, trenching, pitting and flooding methods should be adopted.

(e) For seepage control, compacted clay blankets, bentonite layers, soil defloculents, chemical sealants like asphalt emulsion, petroleum emulsion and resinous polymers, sealing membranes either exposed or buried under a protective earth layer can be used.

(f) Tankas (cisterns) could be constructed in more numbers in the areas where the groundwater is saline and unfit for drinking.

(g) Silting of the proposed water storage structures should also be checked by treating the catchments with concrete, asphalt and plastic sheets or by constructing silt barriers, traps or nets, etc.

(h) Renovation, repairing, desilting and cleaning of the already existing structures should also be undertaken.

Conjunctive use of the available water resources should be an important strategy in the water resources development and management programmes of the area.

As far as the groundwater resources are concerned, the unexploited zones with poor, moderate and good potentials and the under exploited zones should be delineated. The present largely exploited groundwater zones, *viz.*, the flat and sandy undulating buried pediments, buried courses of prior stream channels and younger alluvial plains should not be considered for further exploitation to avoid over exploitation of the groundwater resources. Exploited groundwater should be rationally and judiciously utilized.

Vast groundwater resource in the study area is contaminated due to inbuilt salinity. Hence, suitable measures should be adopted to improve the quality of groundwater by way of blending with good quality water in appropriate ratios.

Methods for importing/borrowing water from the adjoining watersheds having surplus water should also be considered.

By involving improvised irrigation practices, *viz.*, drip irrigation, change in land use and crop pattern, etc., the darker side of the water resources in the region could be improved.

Soil conservation is another important aspect to be considered during resource management and development of the area. Afforestation techniques should be employed in order to minimise the effects of shifting sands. The active sand dunes could be stabilised using the phyto-reclamation techniques by fixing brushwood barriers on windward side of dunes, fencing the dunes, etc.

The above suggested strategies and envisaged management practices for improving the water resource in the study area cannot be successful unless and until the active participation of the local people is involved. A general awareness towards the conservation and judicious use of water resources of the region has to be created among the people.