A. Introduction

1. Assignment

The two-fold assignment was:

a. To make an assessment of the work on environment that had already been done at TransIndus.
b. To design and suggest further improvements.

<u>Objective of the study</u>:

To determine the current situation regarding issues of the environment, and specifically with regard to sustainable water management

2. Location

The TransIndus community is located West of Tataguni, which is South of Bangalore and approximately 25 km from the centre of town.

B. Evaluation of Indus programme of nature conservation – past and present

"Conservation of nature" refers to efforts made to control topsoil erosion by measures such as soil and moisture conservation, management of runoff waters, permanent vegetation, etc.

1. Soil and moisture conservation measures at TransIndus : recharge pits, ponds, contour trenches, permanent vegetation, topsoil

BCIL has made efforts to introduce soil and moisture conservation measures at TransIndus. These include small recharge pits along the road drains, 4 open ponds largely in the centre of the campus and at present contour trenches on the higher hill slopes.

<u>Assessment</u>: Considering the large area of the campus, the first two measures merit a careful look.

i. <u>Recharge Pits</u>: The small recharge pits are clearly incapable of helping in effective recharge. Though these could be part of a group of several measures, the low transmissitivity of water through the soil renders these ineffective as standalone measure for groundwater recharge due to the low surface area available in each unit. In reality, as soon as the pit is filled, the water just runs off the drain surface.

ii. <u>Ponds</u>: The four water ponds are located quite well. However, since these ponds fall in the residential sites, it will be advisable to remove these to alternate sites on common land. It is understood that water does not stay in the pond for more than a week to ten days. It is important to understand the purpose for which the pond is being constructed, either as a holding pond or as a percolation pond. My assessment is that these serve as percolation ponds. The four ponds are listed in order in the table given below (see map also for locations). Their surface areas and holding capacities have been worked out on the basis of my observations and discussions (with Mr Benchappa and Mr Nagaraj).

No	Location	Length & breadth (m)	Surface area (m^2)	Depth (m)	Volume standing (m^3)
1	North of swimming pool	12 x 12	144	0.75	108
2	North of main road after sharp curve	24 x 9	216	0.75	162
3	South side of side road parallel to main road	18 x 11	198	1	198
4	North side of side road, just north of pond 3	24 x 9	216	1	216
	Total				**684**

As can be seen from the table, the ponds can hold considerable quantities of water and contribute to the recharge of ground water (*Refer design part for relocation and modification of ponds)*

iii. Contour Trenches on upper hill slopes

The contour trench work, which has been started recently is too elaborate and not a cost-effective measure since the hill slope is already covered with bush vegetation and contains a lot of boulders that help in reducing runoff and arresting soil erosion. Observations indicate that runoff will be quite low and such trenching of 15ft separation with rock fill, etc, is not warranted. The projected cost of Rs 1.8 lakhs can be brought down considerably by increasing separation and changing vegetation type. (*Refer design part for modified contour trenching work)*

iv. Permanent Vegetation at TransIndus as Part of Soil and Moisture Conservation strategy

From the time BCIL stared work in 1994 at TransIndus, a very clear strategy in terms of tree planting can be seen. At this time of the year, aided by the monsoon rains, the entire campus looks very green and the trees, shrub and other vegetation looks pleasing to the eye. The trees planted over the years include the Singapore cherry, Calendra - bottle brush, and many flowering and aesthetic trees.

The cherry tree brings lot of birds and contributes to humus by way of high leaf litter. As a pioneer tree, it is very useful. (*Refer design part for further improvements)*

iv. Topsoil

There is good improvement of soils at various points and this can also be seen in the quality of plants and fruit like custard apple. The onsite nursery has a programme for the production of vermicompost (2 tanks of approx. 3 m3 each of 3 round harvest = 2.4 tons harvest estimated per year). This is used only for the nursery.

New tree planting must be accompanied by good preparation of the planting pit with compost, biofertiliser, etc, mixed with topsoil.
The use of Termex for destroying termite mounds is reported. This must be stopped immediately since termites are part of the composting cycle in semi- arid environs and Termex is a dangerous chemical. Termites eat only dead cellulose so green and living plants are not so much in danger. Of course, the dead bark is adjacent to the green bark so there are chances of drying up the green layers.

2. Freshwater

Some of the issues related to freshwater include freshwater sourcing, freshwater distribution and freshwater availability.

i. Freshwater sourcing

Since 2003, the main sources of freshwater for drinking and other household use comes from the borewell located in Mr Srinivas's farm, around half a kilometer away from the TransIndus campus. There are two borewells in the Srinivas farm, which has now been purchased.

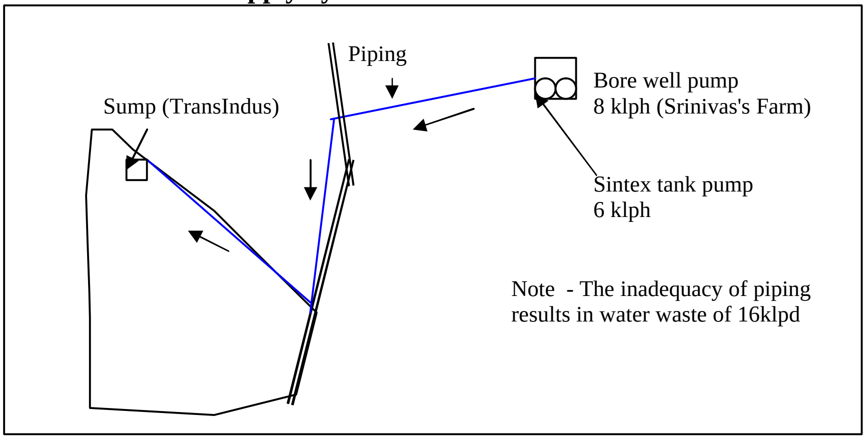
It was reported that every day, a total of 8 hours of pumping with a submersible pump of 4 HP is done. The output at this stage is 8000 lts during the months from June to February; the yield reduces to 5000 lts during the summer months of March to May.

The water fills a Sintex tank of 2000 lt capacity and from this tank, another submersible pump water to the sump on the campus. This pump though of the same 4 HP is hampered by the inappropriate piping to the campus and is able to pump only 6000 lts per hour. The excess water flows out and accumulates in a dugout water pool nearby.

Total water pumped at 8000 lts per hr (lph) by bw1	= 64,000 lpd
Sintex tank pump – 6000 litres per day (lpd)	= 48,000 lpd
Fresh water reaching TransIndus sump from Srinivas BW	= 48,000 lpd
Wasted due to pipe restriction	= 16,000 lpd
Water use according to pumping statistic (48klpd x 365)	= 17.5 mil litres
Water wasted for around 9 months in the year	= 4.3 million litre

This is a situation of poor water management and conservation of not only water but also the energy used in pumping the water. (*Refer design part for improvements)*

Current Freshwater Supply System



ii. Freshwater distribution

The freshwater is pumped through two main distribution lines - one for good quality freshwater for homes and the other for gardening water form the BWSSB backwash. Homes and other common facility areas are connected with both lines.

iii. Freshwater Availability

The freshwater from the Srinivas Farm borewell yield is reported to be fairly steady at 8000 lph during the large part of the year, except for the three summer months.

The BWSSB backwash is also affected during the lean period since other farmers also have access and use the backwash water for irrigation. The pumping from the BWSB backwash is done daily for around 5 hours using a 7.5 HP pump to an open well on the campus. This is then pumped to the gardens.

The valley south of the campus broadens out in a westerly direction and there are several coconut farms that use borewells for irrigation. This is a factor that must be contended with in the quest for water from fractured hard rock as opposed to phreatic water.

3. Grey and black water management

It would be definitely be an interesting proposition to separate the grey and black wastewater for the new houses under construction.

4. Storm and runoff water management

At present, the storm water management includes roadside shallow drains and larger concealed drains to lead the water on roads in the general direction of the lake. Efforts are now on to redirect these to ponds.

Currently runoff is still high from certain areas of TransIndus. At the moment, the main recipient of the TransIndus runoff is the lake on the southern part of the property. This 3 acre lake with an estimated average 5 m depth has a holding capacity of around 60,000 cum (6 million litres, conservative estimate). The catchment for this lake is only the TransIndus campus.

C. Situation Analysis

1. Borewells on Campus

The borewell information was quite scanty. However, form the borewells inside and outside TransIndus, certain conclusions have been made, which would help with the strategy for water management.

The 40 acres of TransIndus land has 4 borewells, while the 5-acre plot at the south West End belonging to Dr Suganathy has 7 borewells drilled.

The following table provides an overview of the borewells. (See map no. 2 for borewell locations)

No	Location	Depth (ft)	Casing (ft)	Year of Drilling	Water yield in lph	Present pumping
1	Dr Sugunathy land	700	60	2000	400	Cmp* 1hr
2	Dr Sugunathy land	500	40	2000	400	Cmp 1hr
3	Dr Sugunathy land	400	40	2003	No Yield	No Yield
4	Dr Sugunathy land	450	40	2000	200	Cmp ½ hr
5	Dr Sugunathy land	350	40	2003	600	Only during rains
6	Dr Sugunathy land	700	60	2000	200	Cmp ½ hr
7	Dr Sugunathy land	320	40	1998	600	Cmp 1 ½ "
Borewells in TransIndus land All old, no new drilling						
1	Near SB9 in front	350	40	1994	400	Cmp
2	Inside site office inside	300	40	1994		Low
3	In FB05	350	40	1990	600	Cmp**
4	In FB30	300	40	1990	No Yield	No Yield

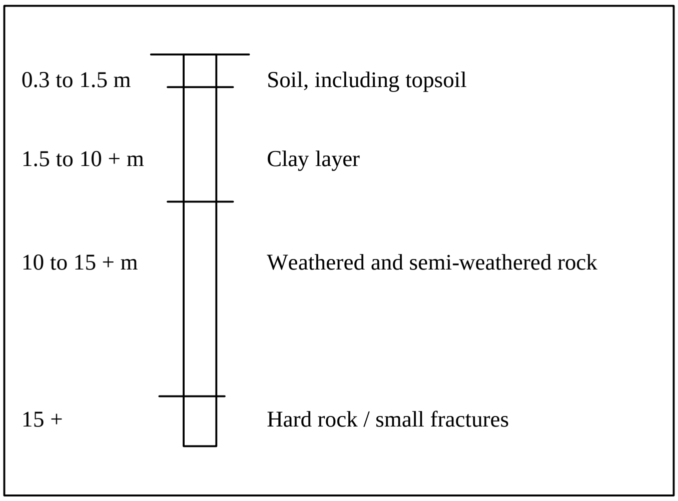
*Compressed Pump
** Not being used

A couple of points to be noted about borewells, which will help in designing recharge systems are:

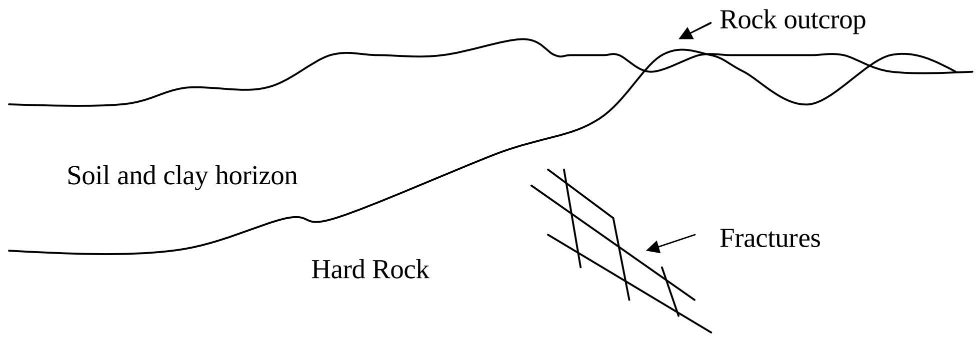
1. The borewells are all of low yield, and at least two are dry.
2. The casing length is between 40 and 60 ft.

2. <u>Soils Profiles</u>

The inference from the study of the rock outcrops and the borewell analysis leads to an understanding of the soil profile. At TransIndus, the soil profile in large measure is as given below.



The soil and rock profile



Porosity is defined as the ration of volume of voids of pores in the soil to its total volume. At TransIndus, the porosity can be taken as average of around 0.40 to account for the soil layer made up of silt and larger particles as well as clay.

TransIndus area = 45 acres = 18 ha = 180,000 m^2
Volume of soil layer considering 10 m soil depth uniform = 180,000 x 10
= 1800,000 m^3
Porosity at 0.40 = 1800,000 x 0.4 = 720,000 m^3
Moisture that can be held in the soil layer = 720 million lts.

D. Design for sustainable community management of natural resources

1. Designs for Soil and Water Conservation

Rainwater harvesting and groundwater recharge in common areas and individual plots
Holding ponds, percolation ponds and wells
Staggered Trenches on Contours

Pond Design:

Since good pond development is part of a long-term strategy for the management of water resources, I suggest that pond development be kept in common areas since dislocation also means loss of both time and money. It is possible to use runoff water to recharge groundwater and for the aesthetic development of the campus.

All the common areas are large enough to spare some space for pond development. This can be designed as combination of both holding and percolation ponds. The percolation ponds can also have at one point well rings so that surface area for recharge can be increased. The holding ponds need to be either lined with natural or artificial materials.

Holding and Percolation Ponds:
A baffle stone will break the energy of the inflow water at all entry points and prevent churning of pond water. The ponds may serve as a water body for the breeding of

mosquito larvae therefore it be necessary to introduce fish varieties like gambusia or the guppy which feed on the mosquito larvae.

The basis for the development of the multi purpose pond is the need for increasing holding capacity and recharge during the rainy season into the phreatic zone. Often, hard pans and the low permeability of the clay layer result in the phreatic zone being unsaturated even by the end of the rainy season. This focussed approach on saturating the phreatic zone with continuous rainwater made available by the ponds will help change the water table at TransIndus.

The campus is 45 acres (18 ha) with a soil clay layer of average of 10 m. Calculations of the volume of water that can be held in the phreatic zone is provided below.

One ha rainfall = 10,000 m^2 x 0.8 m = 8 million litres
Volume of rainfall on 1 acre = 3.2 million litres
Volume of rainfall on 45 acres = 45 x 3.2
= 144 million litres / year

Space required to hold 1 acre rainfall
Approximate area required to hold 3.2 million litres= 30 m x 30 m x 3.5 m
Surface area of 1 acre = 4000 m^2
Area required for holding 3.2 mil lts with 3.5 lts water depth = 900 m^2
At 0.40 porosity water holding capacity in 1 acre with 10 m soil depth
= 4000 x 10 x 0.4
= 16,000 m^3
= 16 million litres or 5 years of rainfall

In theory, the soil layer if saturated can hold five years of current rainfall water. Even if just 20% of this were recharged into the soil layer, and with improved moisture holding of soils, it should be possible to improve the water table at TransIndus. Since the soil layer has low transmissivity compared to fractured hard rock, leakage will be much lower. Besides, the fracturing at depth in the TransIndus campus is not much as indicated by the low yields of borewells.

The design of the pond is provided below and the catchment area decides the dimensions of the pond. The table given below gives the locations, catchment and pond dimensions proposed. The well will have a dimension of 1.5 dia and 10 m depth and can hold 18,000 litres of water. The development of these can be done in a phased manner over three or four years even.

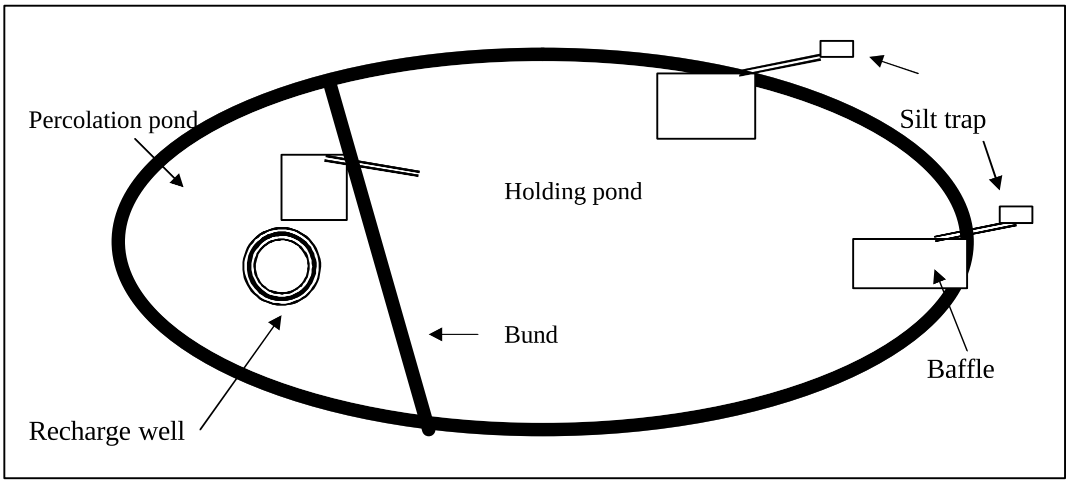


Table showing locations, catchment and pond dimensions:

No	Location	Catchment area (m^2)	Pond dimension lbh (m)	Storage volume (KL)
1	Common area south of FB03	20700	10 x 6 x 1.5	100
2	Common area east of TT04	6300	6 x 5 x 1	30
3	Common area east of FB25	9900	7 x 7 x 1	50
4	Common area west of swimming pool	10800	7 x 7 x 1	50
5	Common area west of FB 43	9000	7 x 7 x 1	50
6	Common area south of TT16	10800	7 x 7 x 1	50
7	Common area east of TT15 , nursery *	4500	5 x 1 x 1	50
	Total			**380**

Total Storage after implementing the designs:	
Existing Well	= 785 KL
Open Wells (7 X 15 KL)	= 105
Proposed Ponds	= 380 KL
Total	**= 1270 KL**

Lining of Holding Ponds:
The lining of the holding ponds can be done by introducing an impervious layer with either plastic, Fibre Reinforced Plastic or by a technique of sealing porosity using humic materials. The average cost of the plastic liners range from Rs 35 to Rs 60 per m^2.

Design of Bunds:
Presently, the trees are provided with a bund at about 1m around their trunk. I propose that the bunds be made half moon on the slopes. This will help in slowing down the velocity of the run off water and also provide adequate moisture to the roots of the trees.

Rainwater harvesting and management in individual plots

It is recommended that the individual plots at TransIndus adopt rainwater harvesting, recharge, and use and recycle strategies as well. Water harvesting at household level will help in reducing the dependence on the external source by approximately 30 %.

2. Management of freshwater supply

Freshwater Supply
The intervention in freshwater sourcing and supply is the addition of storage of 3000 lts connected to the present Sintex of 2000 lts. For every two hours of pumping of the Borewell pump, the Sintex pump must be run for 3 hours.

An auto mechanism can be introduced in the Sintex tank with a cutoff device at bottom of tank for switching off the pump (as is already present but not placed at the bottom of the tank). A separate auto switch can also be introduced for the borewell pump to cut off after 2 hours of its pumping (or when the Sintex tanks are full).

Current Fresh water use on the TransIndus Campus

No	User	No of usage days	Water Use (litres / day)	Water Use / annum (litres)
1	Present homes under use full time	11 x1000 lpd	11000	4,000,000
2	Week end users	5 x 60 days	1000	300,000
3	Restaurant	50 days	2000	100,000
4	Conference facility	50 days	2000	100,000
	Total			**4,500,000**

Future Use Projections
Total for domestic if all houses constructed (60 houses x 1000 lpd) = 60,000 lpd = 22 mil lts/yr

No	User	No of usage days	Water Use (litres / day)	Water Use / annum (litres)
1	Present homes under use full time	60 x1000 lpd	60000	22,000,000
2	Restaurant	300 days	2000	600,000
3	Conference facility	200 days	1000	200,000
4	Gardening	200 days	150000	30,000,000
	Total			**52,800,000**

Water use planning

Total Rainfall on Campus	= 144 million litres
Total Projected Use	= 52 million litres

The water use and availability suggests that there is a surplus of 92 million litres, which through the ponds and other recharge structures can be allowed to recharge the groundwater aquifers.

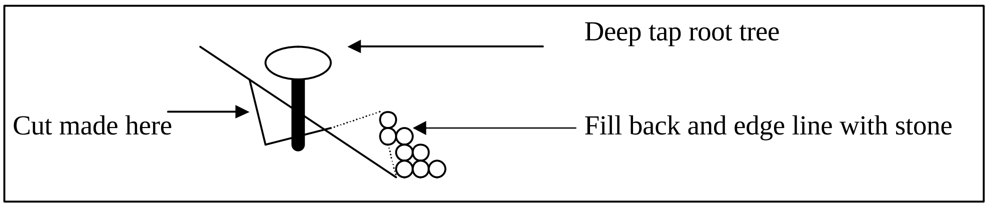
<u>Water Audits</u>
I recommend that regular water audits be done to evaluate and correct the situation. It can be done at the rate of an audit every three months to start with and then reduce to half yearly audits.

3. Management of Grey and Black water at common facilities and residences

It is recommended that the grey water must be separated from black water. Appropriate designs for grey water and black water for individual houses and common areas can be provided as well.

4. Permanent vegetation and Soil Nutrient Management

<u>Contour Trenching:</u>
Separation of 20 to 30 m, depending on the slope. The cut in the soil must be made as shown below.



Instead of contour trenching, staggered trenches on the contour will be sufficient.

<u>Soil Nutrient Management:</u>

Over the last decade, there is considerable improvement in the quality of soil as defined by texture and structure. However, from the point of moisture holding capacity of the soil, more work has to be done. This includes the addition of compost prepared from the farm yard manure purchased locally, especially for the new permanent vegetation proposed. It is recommended that rock powders (locally available) be added to improve the content of micronutrients in the soil. This can be added during the preparation of compost at the rate of 20 kgs or so for compost of around 300 kgs or at the base of larger vegetation at the rate of 200 gms or so per tree.

Approaches to Permanent Vegetation:

At present, the campus vegetation includes flowering ornamental trees like gulmohar, bauhunias, casuarina, sausage tree, eucalyptus, Acacia auriculiformis, shrubs like bottle brush, bamboos, etc. There are also some old banyan trees. The fruit trees include fair numbers of custard apple, Singapore cherry. Some of these are pioneer vegetation which help in building up soils but here the focus must be moving towards a climax vegetation like hardwood species with high litter and food for microbes. These will serve the purpose of overall soil and humus building.

There is also scope on campus for introducing on common lands, tree and plant varieties which provide for greens as part of the nutrition. These can be introduced and preserved as for wild collection and can in the future form natural herbal gardens with herbs and wild edible plants in different places.

It would be wise to now focus on trees that are far more deep rooted and are also soil builders and will help rebuild the environment. The planting suggested includes varieties like jackfruit, teak, honne, honge, wood apple, neem, champak, Melia azadirach, jamun, soapnut, polyalthias, pagoda tree, tree jasmine, etc.

Barring the freshwater water sump, the rest of the area must be covered with permanent vegetation of endogenous varieties like jackfruit, Pongamia pinnate, etc at spacing of 10m both along the row as well as the contour. In the early years, it is a good idea to plant trees like Glyricidia sepium in the gaps to reduce spacing.