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# FIELD INVESTIGATIONS IN KOLAR SUBBASIN OF RIVER NARMADA

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## 1.0 INTRODUCTION

Under the present project, six sub-basins of river Narmada were chosen for simulation of hydrologic response using the SHE model. The Kolar river basin upto Satrana gauge-discharge site is one of these six sub-basins. During the simulation of these basins, it was realized that the quantum of information on soil properties available was extremely inadequate particularly for a model like SHE. It is well known that correct and detailed information about soil properties is very crucial input for a physically based distributed rainfall-runoff model.

At the third meeting of the Project Steering Committee held on June 9, 1989 at National Institute of Hydrology, Roorkee, it was recommended that a programme of simple field measurement be carried out in Kolar Basin with the aim of reducing uncertainty in the soil parameter values for the SHE simulations, and providing experience to NIH Staff in making field measurement for SHE applications. Detailed specifications for this purpose were drawn up [1]. Originally it was planned to carry out the investigation during November 1989. During last week of November 1989, a visit was made to Bhopal and Kolar basin to have first hand idea about the time requirement for field investigations. Some preliminary field tests were conducted during this visit with the participation of engineers of M. P. Irrigation Department (MPID), Kolar Project Circle. However,

in view of Lok Sabha Elections, and non-availability of logistic support, to the extent needed from MPID during that period, the programme was postponed. At the time of fourth meeting of Steering Committee held at Bhopal on 13th December 1989, detailed discussions were held by Dr S M Seth, Project Coordinator and Dr. J C Bathurst, Consultant with Superintending Engineer, Kolar Project Circle, MPID. The programme of field investigation to be carried out during the two week period in January 1990 was finalised and arrangements were made for carrying out some field and laboratory tests by Quality Control Division of the Kolar Project Circle of MPID.

The field investigation was carried out during January 10-25, 1990 by NIH Scientists and Scientific Staff with active participation of Consultant Staff and Staff of MPID. A total of 12 sites distributed in the Kolar basin upto Satrana gauging site (area 828 sq.km.) were investigated, soil cores and disturbed samples were taken and infiltration tests were carried out. Besides soil sampling activity, information was also obtained regarding typical topographical features, forest types, soil depths, overland and channel flow roughness and river channel characteristics. Slides and photographs, depicting various characteristic features of the basin were also taken.

This report prepared by Mr. S K Jain, Scientist 'C',

and Mr. M Erlich, Consultant in interaction with Dr S M Seth, Project Coordinator describes the information collected and results of tests carried out in the basin. Mr. T Vijay, Research Asstt. has assisted in the preparation of this report.

The timetable of field investigation and the staff participation in this campaign is given in Appendix A.

## 2.0 OBJECTIVES

There were two main objectives of field investigation activity as formulated in the Project document [1]. The improvement of the knowledge about soil parameter values based on measurement campaign carried at different locations in the catchment, which in turn would reduce the uncertainty (in deterministic meaning of the word) about input parameters and consequently about the results of simulations of the SHE, was considered as the main goal. Also, the field investigation was expected to provide a sufficient experience to the NIH staff in planning, organizing and carrying out a field programme in order to collect the data required by SHE. Although the programme was focused on the assessment of spatial distribution on soils and their physical properties, other parameters like vegetation cover, leaf area index, ground water levels survey, geometry of the river channels and topography of the catchment were also investigated. Ultimately all this information will be used for Kolar basin SHE model updating.

## 3.0 PRELIMINARY INVESTIGATION

A preliminary visit of Bhopal was made by three NIH staff members associated with this project ( Dr. S M Seth, Mr. S K Jain and Mr. A K Singh) during the period Nov., 29 to Dec., 02, 1989. During this visit, detailed planning of the forthcoming field campaign was carried out. A two-day mini field campaign was also carried out in which several sites of the catchment were visited. Each of the tests which were planned to be carried out during the field campaign was also performed. Samples of soil were taken for later analysis. Slide pictures depicting various characteristic features of the basin were taken.

The catchment area of Kolar river upto Satrana gauge-discharge site being simulated under the present project covers an area of about 828 Sq. Km. This area has wide variations in topography, soil, and land use. In order to obtain information about all typical features of the basin, it was decided to conduct in situ tests and collect samples along three traverses covering lower, middle, and upper part of the basin. Three testing sites were chosen along each traverse [1]. Later on, during the course of the field investigation, one more traverse was added to this list. The location of these traverses and the testing sites is shown in Fig. 3.1.

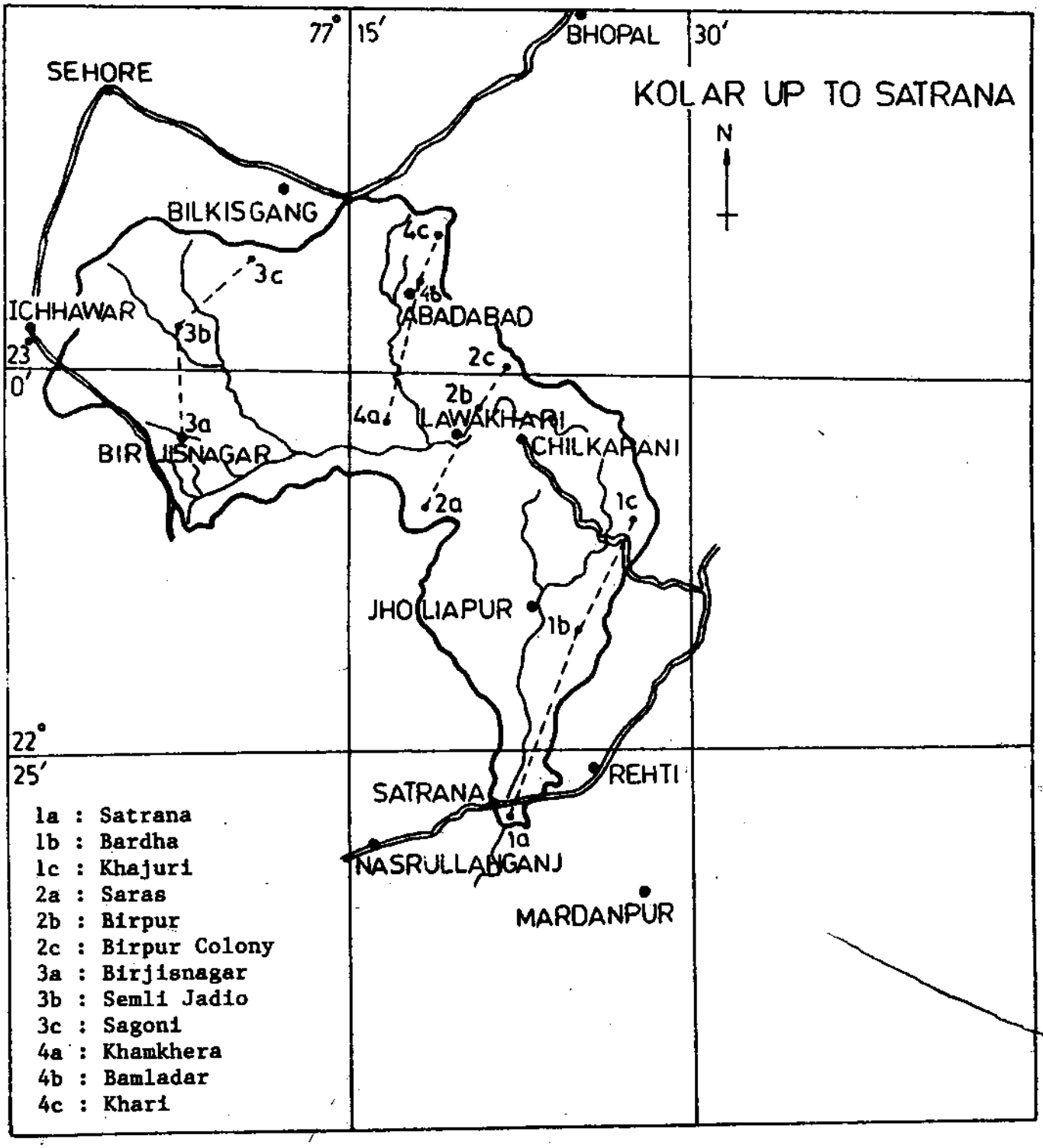



Fig. 3.1 : LOCATION OF SAMPLING TRAVERSES

## 3.1 TESTS CARRIED OUT BY M P IRRIGATION DEPARTMENT

During the above visit to Bhopal, the M P Irrigation Department Officers were requested to dig pits of plan size 1.0 m * 1.5 m at 20 locations in the basin. The soil depth was measured, samples were taken for laboratory analysis and other information collected at these 20 sites. The results of this investigation are given in Appendix B.

## 4.0 DESCRIPTION OF MEASUREMENT TECHNIQUES AND SAMPLING

### 4.1 Measurement Techniques

A number of approaches are available for determination of soil properties and various functional relationships. These include field investigation and laboratory testing. In the present case, a combination of these two was used - measurement were carried out in the field and soil samples were taken to laboratory for further analysis. A detailed description of the equipment used and procedure adopted follows.

#### 4.1.1 Infiltrometer test

The ~~in~~ situ infiltrometer test was conducted at various sites using double ring cylindrical infiltrometer ( inner cylinder internal diameter approx 22.5 cm and outer cylinder internal diameter 35.5 cm). After clearing the ground surface of debris, grass, etc., the infiltrometer was driven in the ground to a depth of approximate 15 cm. Next, water was filled in the outer ring to a height of about 15 cm. Now a needle was hung in the inside ring such that its point is at a height of approx. 15 cm above the ground level. Water was then rapidly filled in the inner ring. The stop watch was started when the water level touched the point of the needle. For providing additional water supply, a graduated drum with an outlet tube at the bottom was installed. The initial water level in the drum was noted down. After one minute, there was a drop in the water level

in the inner ring due to infiltration. Extra water from the graduated drum was filled in the inner ring till the water level again touched the needle point. The new water level in the graduated drum was noted down. The volume of water filled in the inner ring was calculated using the diameter of the drum. This process was repeated and observations taken at different times, viz. 1, 3, 5, 8, 11 , 15, 20, 30, 45, 60, 75, 90, 105 min... till the infiltration rate become nearly constant. The water level in the outer ring was kept at same level throughout by periodically adding water as needed.

The results of this test carried out at different sites are given in Section 6.

4.1.2 Soil sampling

To determine properties of undisturbed soil samples, 15 soil cores were taken at the sampling sites, as detailed in Appendix C. The inner diameter of the core pipes was 3.8 cm and length 23.5 cm. These cores will be subsequently analysed in laboratory. However, it was observed that while driving the core pipe in ground, some compaction of soil was taking place thereby affecting the soil structure.

At each site, about 3.0 kg disturbed soil sample was taken. These samples will be used for laboratory analysis for grain size distribution and for determination of soil

moisture versus tension relationship. This relationship will be obtained with the help of pressure plate apparatus.

## 4.2 Other Investigations of the Catchment

The information about the soil profile and soil depth at the sampling sites was obtained by digging pits of plan dimension 1.0m*1.5m and through the profile in the dug wells. Other information gathered includes the vegetation type and density, the cropping pattern (if the site is near an agricultural area), the water level in wells, the ground surface roughness and dimension of river channel, if any, near the sampling site. Some investigations on these lines were also carried out by the officers of MPID as reported in Section 3.1.

## 5.0 DESCRIPTION OF SAMPLING SITES

The strategy for sampling programme in Kolar basin was designed in September 1989 [1]. On the basis of three traverses, in the upper, middle and lower zones of the catchment, nine potential sites (3 sites per traverse) were identified. The choice of sites, within the technical constraints of accessibility by road, took into account the topographical variation for each traverse as seen from the 1:250,000 map 55 E/F of the basin. According to the plans, during the preliminary period of field investigations, the Quality Control Directorate of Kolar Project (MPID) had prepared 40 pits dug in 20 different locations within the catchment (Appendix B) and had carried out the permeability tests. Some of these pits were used for the detailed investigation during January 10 - 25, 1990. The original traverse design assumed that the network of sites will cover the major soil and topographical divisions of the basin, while during the course of field investigation, the necessity of introduction of one additional traverse was felt. The main reason for that, as explained in Soil Expert Draft Report (Appendix E), was the unusual variation in soil depth observed at the sites of traverse 2. As suggested, the visits were made to three new sites also in order to check the hypothesis about soil distribution in the zone 6 and its western border.

The detailed description of the sampling sites is given

in Appendix D. Where these coincide with the MPID pit sites, the pit number from Appendix B is reproduced in Roman numbers after the site name.

# 6.0 RESULTS AND CONCLUSIONS

## 6.1 Infiltration Results

The results of infiltrometer test carried out at various sites using the double ring infiltrometer are given in Appendix E. The final infiltration rate at each site to be taken as representative value is an asymptotic infiltration rate at 24 hrs after the test started. This is obtained by extrapolating the actual time vs. infiltration curve. This best linear fit curve is plotted on a double log scale. The final infiltration rate thus calculated corresponds to the value obtained from linearized equation at time 24 hrs. The summary of the analysis of infiltration tests are given in Table 6.1. For example, the results obtained in this way give the infiltration rate for black cotton soil at Sagoni (Site 3C) at 24 hrs equal to 1.649 cm/hr, while the last observed infiltration rate at 3 hrs was 3.61 cm/hr. The only available source [2] reports the value of infiltration rate of black cotton soil at Jabalpur as varying in the range 0.2 - 0.4 cm/hr.

## 6.2 Land Use and Soil Maps

As a result of this survey, the new soil map and land use map have been prepared. As compared with the old soil map, the soil depths have been changed at various locations in the basin. Initially the information about the distribution of soil depth and landuse pattern was based on a map obtained from NVDA. Moreover, the soil depth was

Table 6.1

Summary Results of Infiltrometer Test

| Site Name | Surface Soil Type | Best Fit Equation On Log-Log Scale | Last Observation | | Extrapolated Rate at 24 hr (Cm/hr) |
|---|---|---|---|---|---|
| | | | Time(min) | Rate(Cm/hr) | |
| Khajuri (1C) | Black | i= -0.415t +1.808 | 165 | 9.40 | 3.14 |
| Bardha (1B) | Black | i= -0.567t +2.504 | 165 | 20.26 | 5.15 |
| Saras (2A) | Black | i= -0.395t +1.323 | 180 | 3.61 | 1.188 |
| Birjisnagar (3A) | Black | i= -0.593t +1.568 | 165 | 2.17 | 0.497 |
| Semli Jadid (3B) | Black | i= -0.510t +1.722 | 180 | 5.06 | 1.294 |
| Sagoni (3C) | Black | i= -0.354t +1.335 | 180 | 3.61 | 1.649 |
| Khari (4C) | Black | i= -0.401t +1.787 | 135 | 8.68 | 3.31 |
| Satrana (1A) | Yellow | i= -1.049t +1.933 | 180 | 0.38 | 0.04 |
| Birpur (2B) | Yellow | i= -0.457t +1.526 | 285 | 3.26 | 1.21 |
| Birpur Colony(2C) | Yellow | i= -0.364t +1.606 | 180 | 6.51 | 2.862 |
| Bamladar (4B) | Red | i= -0.475t +2.902 | 195 | 79.62 | 25.137 |
| Khamkhera (4A) | Red | i= -0.525t +1.489 | 120 | 3.62 | 0.678 |

assumed to be dependent on land use and ground slopes. After the field investigation, it was concluded that the old map was not precise and comparison of old and new soil and landuse map shows that there are significant changes in the new map. The old soil and landuse setup is given in Table 6.2. Initial estimates of soil depth and distribution in the new setup are given in Table 6.3. The values were subsequently allowed to vary over a restricted range during the calibration. The revised details of landuse are given in Table 6.4.

The new maps were used in updating SHE calibration for the Kolar basin.

## 6.3 River Cross Sections

In the old Kolar setup, the information of the river cross section at only one location ( Satrana gauge discharge site) was available and used. The recent survey provided for four more locations where information about the Kolar river and its tributaries were collected. The old width of the river at Satrana which was used to generate the whole river network in the catchment will be supplemented with the information at these four locations. As an example, at the Jholiapur site, the old width was 50.0 m while the new measured width is 60.0 m. This will change the depth of flow in the river system.

Table 6.2

The soil depth distributions used in old setup

| Land use class | Percent of basin covered | Soil Depth (m) |
|---|---|---|
| Agriculture - low land | 13 | 15.0 |
| Agriculture - upland | 14 | 3.0 |
| Dense Forest - upland | 34 | 4.0 |
| Dense Forest - slopes | 24 | 6.0 |
| Open Forest | 13 | 2.0 |
| Wasteland | 2 | 2.0 |

Table 6.3

Initial estimates of soil depth distributions for use in new setup based on field investigation

| Land use class | Percent of basin covered | Soil Depth (m) |
|---|---|---|
| Agriculture on deep soil | 2.9 | 8.0 |
| Agriculture on moderate deep soil | 11.9 | 1.7 |
| Agriculture on medium deep soil | 8.2 | 1.0 |
| Agriculture on shallow soil | 19.1 | 0.5 |
| Forest upland | 3.9 | 0.5 |
| Forest lowland | 46.9 | 0.3 |
| Wasteland | 8.1 | 0.3 |

Table 6.4

The landuse distribution used in new setup

| Land use class | Percent of basin covered |
|---|---|
| Agriculture | 42.1 |
| Forest - upland - open | 1.0 |
| Forest - upland - medium | 2.6 |
| Forest - upland - dense | 0.3 |
| Forest - lowland - open | 10.3 |
| Forest - lowland - medium | 27.3 |
| Forest - lowland - dense | 9.3 |
| Waste land | 8.1 |

## 6.4 Other General Information

Other information collected during this field investiation, like, the leaf-area-index, the root zone depth and its variation with time and the Strickler roughness coefficient will be used in the updated setup of Kolar catchment.

## 7.0 ACKNOWLEDGMENT

The field investigation was carried out with the active cooperation of M P Irrigation Department, Bhopal. The help, both in terms of manpower and logistics, without which this work would not have been possible, is gratefully acknowledged.

## 8.0 References

[1] - "Specification for field investigation in the Kolar basin", Project ALA 86/19, Hydrological computerized modelling system (SHE), Sept.1989.

[2] Dakshinamurti, C. et al., Water Resources of India and Their Utilization in Agriculture, Water Technology Center, Delhi, 1973. page 145.

Fig. 1 : AN OVERVIEW OF VEGETATION IN THE KOLAR CATCHMENT

Fig. 2 : A VIEW OF BIRPUR FROM THE KOLAR DAM

Fig. 3 : VEGETATION AND GROUND COVER IN WATERSHED AREA

Fig. 4 : VEGETATION AND GROUND-COVER IN THE EDGE OF DENSE FOREST AREA

Fig. 5 : LEAF SIZE OF THE VEGETATION FOUND IN KOLAR

Fig. 6 : ROOT ZONE IN AREA OF DEEP SOILS

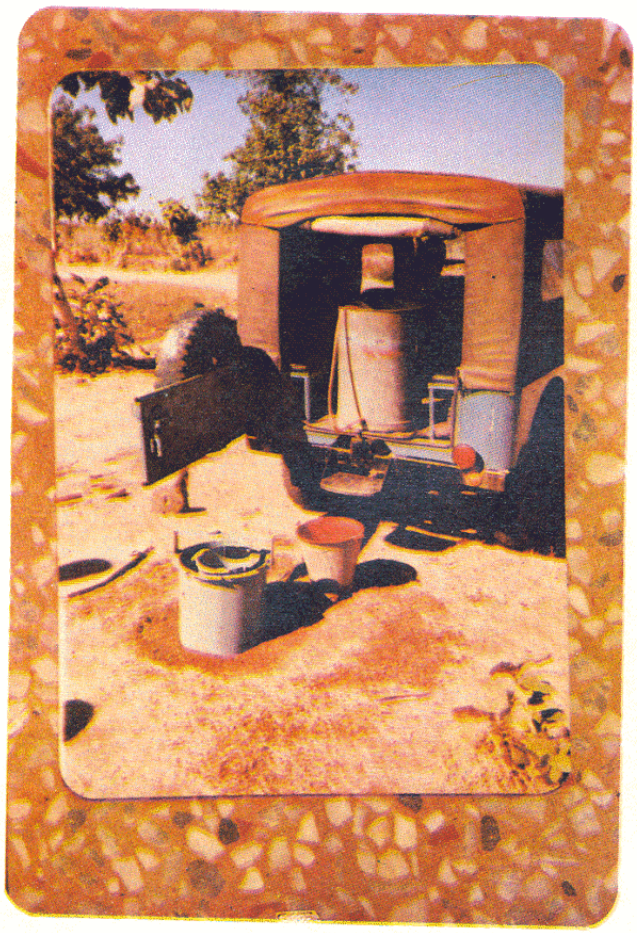


Fig. 7 : SET UP FOR DOUBLE RING INFILTROMETER TEST

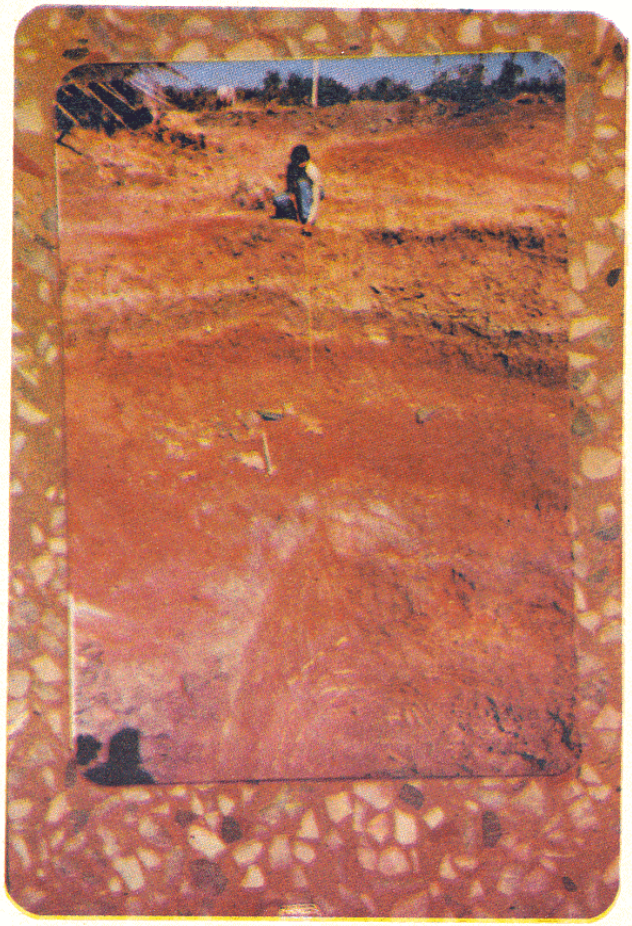


Fig. 8 : SUBSURFACE CONDITIONS IN WELL UNDER CONSTRUCTION

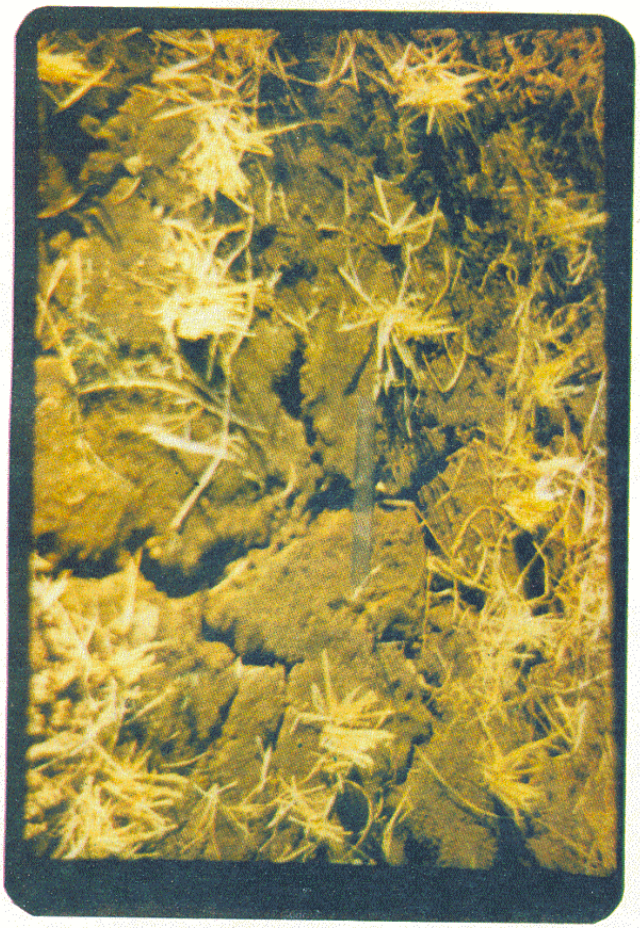


Fig. 9 : SOIL CRACKS IN AGRICULTURAL AREA

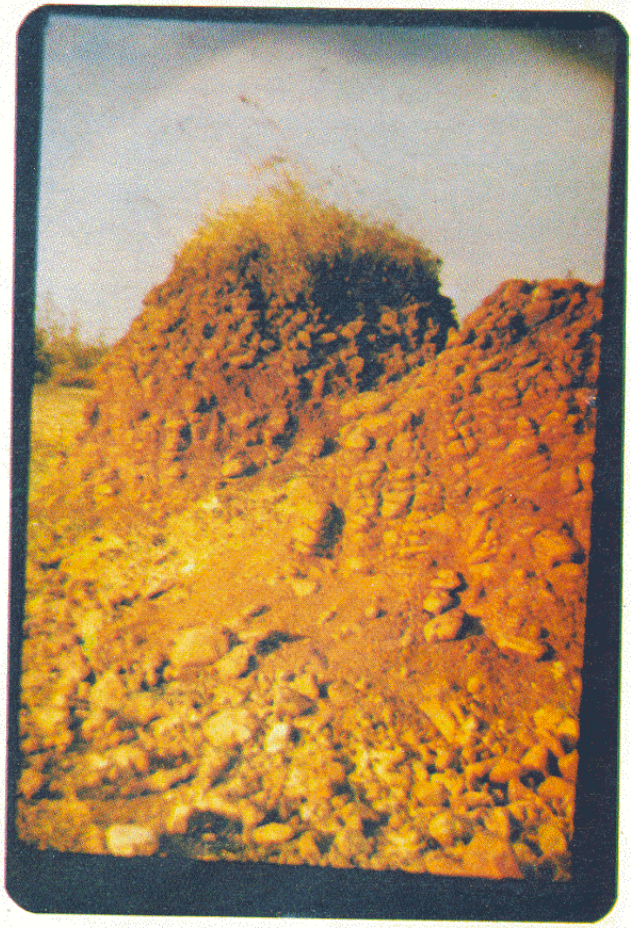


Fig. 10 : SOIL PROFILE IN DAM BORROW AREA

Fig. 11 : RIVER CHANNEL BETWEEN KOLAR DAM AND JHOLIAPUR

Fig. 12 : A VIEW OF THE WASTE LAND AREA

APPENDIX A

# FIELD INVESTIGATION IN THE KOLAR BASIN
## TIMETABLE AND PARTICIPANTS

| DATE | STAFF | | ACTIVITY CODE | SITE(S) VISITED |
|---|---|---|---|---|
| | NIH | CONSULTANT | | |
| 10-1-90 | RK/AKS/PKG/DS | GHJ | 1 | 2c |
| 11-1-90 | RK/AKS/PKG/DS | GHJ | 1 | 1a |
| 12-1-90 | RK/AKS/PKG/DS | GHJ | 1 | 1b |
| 13-1-90 | RK/AKS/PKG/DS | GHJ | 1 | 3c |
| 14-1-90 | RK/AKS/PKG/DS | GHJ | 2 | |
| 15-1-90 | RK/AKS/PKG/DS | MS/GHJ | 2 | 2b |
| 16-1-90 | RK/AKS/PKG/DS | MS/GHJ | 1 - 2 | 2a-2b-2c |
| 17-1-90 | RK/AKS/PKG/DS | MS/GHJ | 1 - 2 | 1a-1b-1c-3b |
| 18-1-90 | SKJ/AKS/PKG/DS | MS/GHJ | 1 - 2 | 2a |
| 19-1-90 | SKJ/PKG/DS | | 1 | 3a |
| 20-1-90 | SKJ/AKS/PKG/DS | ME/MS/GHJ | 1 - 2 | 1c |
| 21-1-90 | AKS | ME/GHJ | 2 | |
| 22-1-90 | SKJ/AKS/DS | ME | 1 | 4a |
| 23-1-90 | SKJ/AKS/DS | ME | 1 | 4c |
| 24-1-90 | SKJ/AKS/DS | ME | 1 | 4b |
| 25-1-90 | AKS | ME | 2 | |

Staff : NIH
- SKJ - S K Jain
- RK - R Kumar
- AKS - A K Singh
- PKG - P K Garg
- DS - D Singh

Consultant
- MS - M Styczen
- GHJ - G H Jorgensen
- ME - M Erlich

Activities :
1 - Sampling, infiltrometry test site survey,
2 - Review of collected samples and site locations.

## DETAILS OF SOIL SAMPLES

| S N | Date | Code | Name of Station | Depth | Remarks |
|---|---|---|---|---|---|
| 1. | 10.1.90 | 2C | Birpur Colony (2 km) | | PIT(M) |
| 2. | 10.1.90 | 2C | -do- | | PIT(A) |
| 3. | 11.1.90 | 1A | Satrana | | |
| 4. | 11.1.90 | 1A | -do- | | |
| 5. | 11.1.90 | MISC | Itawa in Narmada Basin | 7m | |
| 6. | 11.1.90 | 1B | Bardha | | |
| 7. | 12.1.90 | 1B | -do- | | |
| 8. | 12.1.90 | 3C | Sagoni | | BC soil |
| 9. | 13.1.90 | 3C | -do- | | Yellow soil |
| 10. | 13.1.90 | 3C | -do- | | BC soil |
| 11. | 13.1.90 | 3C | -do- | | Red soil |
| 12. | 15.1.90 | 2B | Left Rostrum of Dam | .25 m | |
| 13. | 15.1.90 | 2B | -do- | .20 m | |
| 14. | 15.1.90 | 2B | -do- | .25 m | |
| 15. | 15.1.90 | 2B | -do- | .60 m | |
| 16. | 16.1.90 | 1C | Khajuri | | |
| 17. | 16.1.90 | 1C | -do- | | |
| 18. | 17.1.90 | 3B | Semli Jadid | | |
| 19. | 18.1.90 | 2A | Saras | | |
| 20. | 18.1.90 | 2A | -do- | | |
| 21. | 18.1.90 | - | Supplied by Q.C. Unit | | |
| 22. | 19.1.90 | 3A | Birjish Nagar | | |
| 23. | 19.1.90 | 3A | -do- | | |
| 24. | 19.1.90 | 3A | -do- | | |
| 25. | 20.1.90 | 1C | Khajuri | | |
| 26. | 22.1.90 | 4A | Kham Khera | | |
| 27. | 23.1.90 | 4C | Khari | | |
| 28. | 24.1.90 | 4B | Bamladar | | |

Appendix II

RESULTS OF INVESTIGATIONS OF KOLAR CATCHMENT AREA FOR SHE MODEL STUDY
BY
QUALITY CONTROL DIVISION, KOLAR PROJECT, M.P. IRRIGATION DEPARTMENT

| Sl No | Location | Soil Colour | Soil Depth Pit-1 cms | Soil Depth Pit-2 cms | Average soil depth cms | Soil Depth by well observation mts. | Depth of Water level in well mts. | Moisture content at time of sampling | Permeability in ft./year ++ | % of soil passing 75 micron sieve |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Birpur $ | Black | 100 | 100 | 100 | - | - | 5.26% | 393.03 | 4.80% |
| 2 | Lamakhedi | Black | 125 | 70 | 97.5 | - | - | 29.03% | 112.29 | 0.94% |
| 3 | Salikheda | Red | 75 | 45 | 60 | 2 | 2.7 | 11.73% | 725.92 | 0.84% |
| 4 | Khamkheda $ | Red | 75 | 65 | 70 | - | - | 4.70% | 364.96 | 0.60% |
| 5 | Abidabad | Red | 70 | 100 | 85 | 1.9 | 2.6 | 10.49% | 252.66 | 0.70% |
| 6 | Jhalpipli | Red | 50 | 110 | 80 | - | - | 6.95% | 898.36 | 0.50% |
| 7 | Lohapathar | Yellow | 115 | 125 | 120 | 2.1 | 2.5 | 8.16% | 280.74 | 1.30% |
| 8 | Saras $ | Red | 45 | 75 | 60 | 1.3 | 2.4 | 11.11% | 926.44 | 1.28% |
| 9 | Chikal Pani | Yellow | 30 | 25 | 27.5 | 0.75 | 1.75 | 10.49% | 954.51 | 1.14% |
| 10 | Khajuri $ | Red/Black | 25 | 25 | 25 | 1.7 | 2.4 | 9.04% | 1403.70 | 2.80% |
| 11 | Amdoh | Red | 70 | 20 | 45 | - | - | 14.28% | 364.95 | 2.70% |
| 12 | Dabri | Yellow | 115 | 70 | 92.5 | 1.0 | 1.5 | 9.28% | 505.33 | 1.30% |
| 13 | Brijesh Nagar | Black | 120 | 20 | 70 | 1.4 | 2.0 | 13.00% | 196.51 | 1.90% |
| 14 | Bordikala | Red | 70 | 110 | 90 | - | - | 6.38% | 1094.88 | 2.00% |
| 15 | Gular Chhapri | Red | 40 | 90 | 65 | 2.0 | 2.5 | 10.49% | 898.36 | 0.06% |
| 16 | Balandia | Black | 110 | 100 | 105 | 1.2 | 3.0 | 7.52% | 356.49 | 2.10% |
| 17 | Lotia | Red | 90 | 80 | 85 | 1.8 | 2.9 | 5.26% | 842.22 | 1.80% |
| 18 | Baala Dar $ | Black | 150 | 110 | 80 | 2.7 | 4.0 | 12.35% | 196.51 | 2.10% |
| 19 | Nagarpat | Red | 90 | 100 | 95 | 1.0 | 1.8 | 6.38% | 1403.70 | 1.40% |
| 20 | Bet Lotia & Brijesh Nagar | Black | 105 | 95 | 100 | - | - | 13.63% | 168.44 | 2.50% |

$ Coincide with sites used by NIH/ Consultant in field study
++ 100 ft/year = 0.083 m/day = 3.5 mm/hr

# DETAILS OF CORE SAMPLES COLLECTED

| Sl. No. | Site Code | Date | Location |
|---|---|---|---|
| 1. | 2C | 10.1.90 | Birpur Colony |
| 2. | 1A | 11.1.90 | Satrana |
| 3. | 1B | 12.1.90 | Bardha |
| 4. | 3C | 13.1.90 | Sagoni |
| 5. | 3C | 13.1.90 | Sagoni |
| 6. | 2B | 15.1.90 | Birpur |
| 7. | 2B | 15.1.90 | -do- |
| 8. | 2B | 15.1.90 | -do- |
| 9. | 3B | 17.1.90 | Semli Jadid |
| 10. | 2A | 18.1.90 | Saras |
| 11. | 3A | 19.1.90 | Brijesh Nagar |
| 12. | 1C | 20.1.90 | Khajuri |
| 13. | 4A | 22.1.90 | Khamkhera |
| 14. | 4C | 23.1.90 | Khari |
| 15. | 4B | 24.1.90 | Bamladar |

# DESCRIPTION OF SITES

## Site 1a, Satrana ( Fig. D.1)

Location : 80 km from Bhopal, near village Satrana, 1km from Rehti and approximately 500 m upstream of road bridge on Kolar.

Pits : only one pit could be dug up to 2.22 m, but the rock bottom has not been reached. Observations made at a number of surrounding wells allow to estimate that black cotton layer is extended up to 8 - 9 m. It was directly underlained by the black impervious basalt. One layer (up to 0.22 m) of sandy clay/clay loam (black cotton ) and one layer of gray soil (2.0 m bellow) was found. Soil at the top contained some coarse material and some amount of lime was found.
Root zone depth ~1.2 m.

Soil sample : taken from the mid depth of dug soil, core from the depth 0.15 m.

Core numbers: 3, 4

Vegetation : The village had an exceptionally good agricultural area (almost 100% cropped), irrigated by pumping the water directly from a medium size tributary of Kolar river. Main crops standing were wheat, gram and cotton. Soyabean is grown during monsoon period.

Overland roughness: Strickler K between 1 - 3.

Ground surface slope : relatively flat area

Channel : the channel bed was made up of a irregular, rough sheet of very hard rock bed boulders.

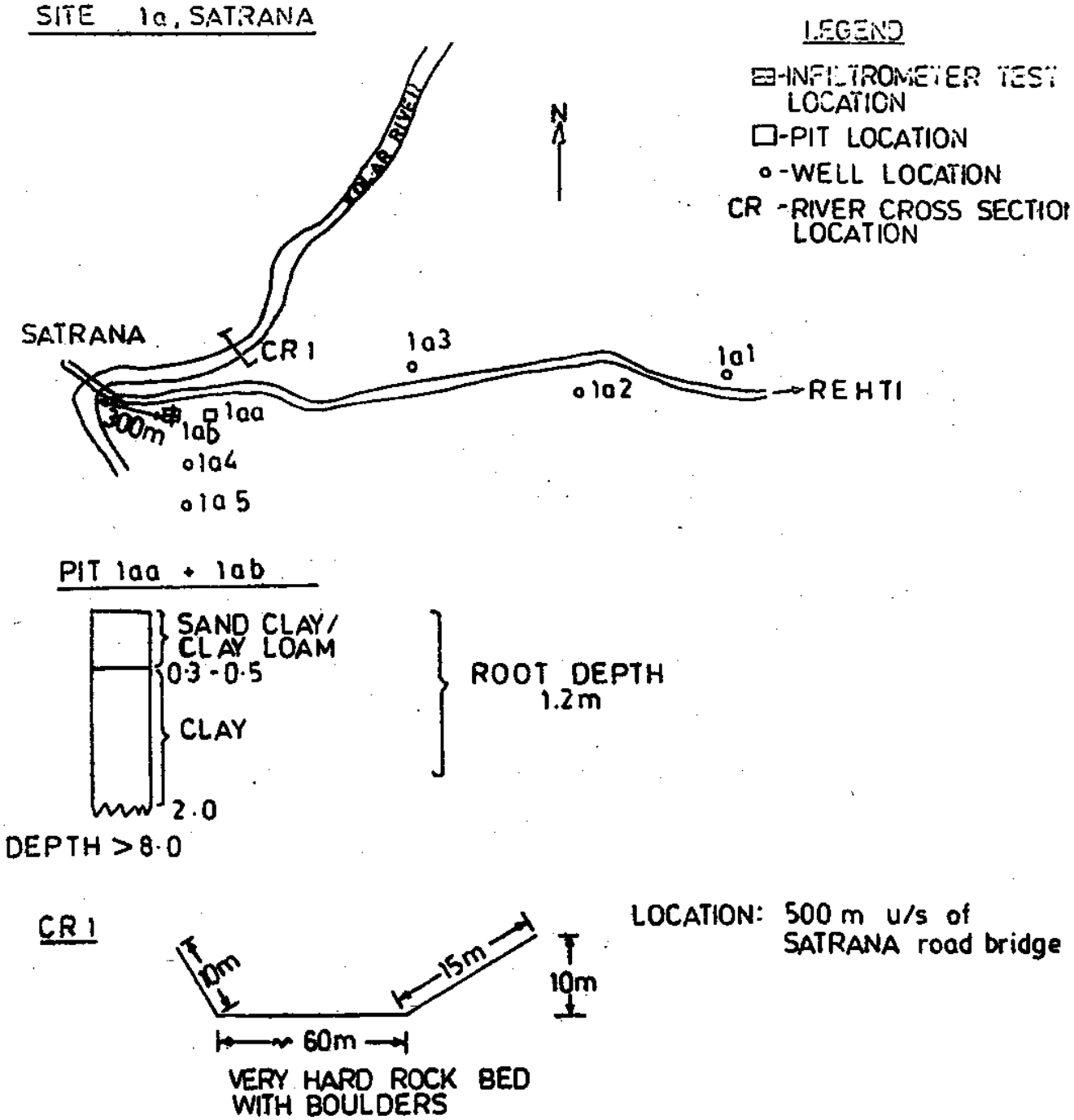



**Fig D.1 : SKETCH OF SITE SATRANA**

Site 1b, Bardha ( Fig. D.2)

Location : near Bardha village, between Rehti and Jholiapur.

Pits : Only one pit could be dug in an agricultural land (harvested 3 months back) up to 1.65 m, depth the soft rock had been reached. One layer of black cotton clay (1.4 m) and one layer of yellow soil (0.25 m below) was found. Auger drill: 1.65 m deep hole was bored. The two open wells available (one on each side of the trial pit) showed the impervious bed at about 2.1 and 1.8 m below ground level respectively. It allows to assume the soil depth to be almost the same in the near by area.

Soil sample : taken from the depth 0.5 and 1.5 m one core from 1.0 m depth.

Core numbers: 6, 7

Vegetation : According to inhabitants more than 80% of land is under the crop during good rainy seasons, this ratio falls to 60% in the dry season because of lack of water supply.
(i) near Bardha agricultural area (~65%), typical crops: gram, wheat, linseed, and soyabean, around 25% of leaves on big trees had fallen down.
(ii) tall thiele trees in the forest area.

Overland roughness : 1 - 3.

Topography : (i) from Rehti to Bardha relatively flat,

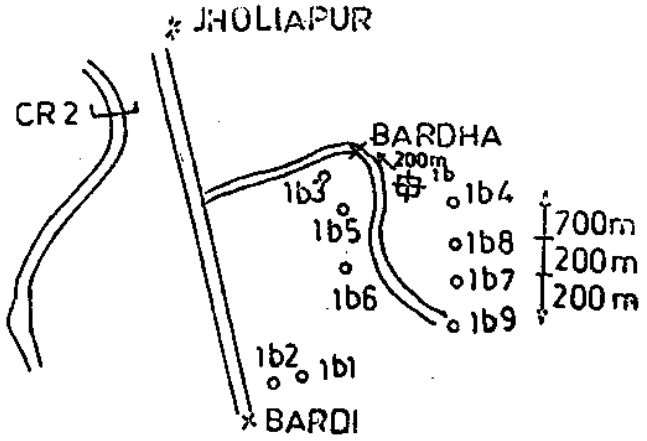
(ii) from Bardha to Birpur (18km) steep hilly area covered by dense forest.

Channel : rough, rocky bed covered with boulders.

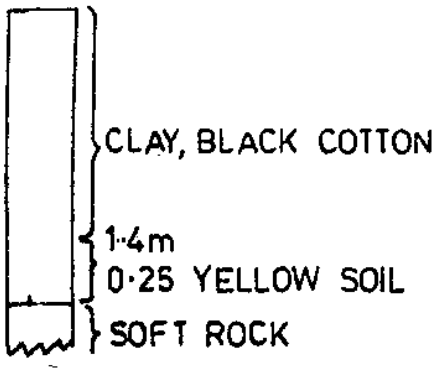
Wells :

| well code | depth to water level (m) | depth to impermeable bed (m) | remarks |
|---|---|---|---|
| 1b1 | 2.9 | 2.0 | not pumped for 3 days |
| 1b2 | - | 1.98 | pumped |
| 1b3 | - | 1.65 | pumped |
| 1b4 | 6.5 | 1.0 | pumped |
| 1b5 | < 7.8 | 2.1 | pumped |
| 1b6 | < 2.1 | 1.25 | pumped |
| 1b7 | < 5.9 | 1.9 | pumped |
| 1b8 | - | 1.62 | under const. |
| 1b9 | < 4.0 | 1.4 | pumped |

SITE 1b, BARDHA




PIT 1b




CR 2

LOCATION:- 500m d/s of barrage at JHOLIAPUR

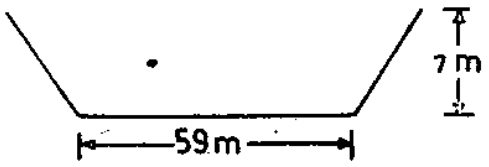



Fig D.2:- SKETCH SITE OF BARDHA

Site 1c, Khajuri (X) ( Fig. D.3)

Location : near Khajuri village,

Pits : 3 pits in wasteland/forest, agricultured and forested areas were dug (1ca, 1cb and 1cc respectively); infiltrometer test was carried on near the pit 1ca on a thin layer of brown/red soil (0.15m) and fractured basalt layer below. In the field big cracks in soil varying in depth 0.1-0.4 m were observed. Roots were going up to the rock, major ones penetraining through the cracks, which is one of the causes of rock weathering. In the forest some of the roots traveled parallel to the rock surface and some of them were seen coming back to the surface.

Soil sample : taken from the depth 0.5 m
3 cores from 0.1 m depth.

Core numbers: 16, 17 and 25.

Vegetation : the road from Birpur to Khajuri passes through dense and medium forest (teak, riple trees). An open forest ~100m from infiltrometer test location covered with embedded boulders; huge litters on ground, leaf area index 50%. There is dense/medium forest towards north and agriculture area in south of this site.

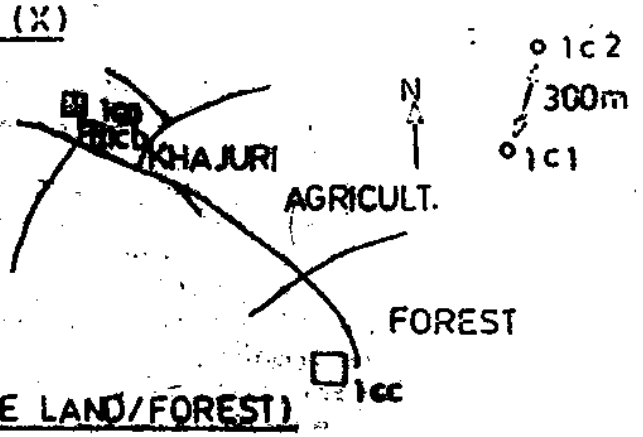
Overland roughness: traces of intensive erosion process on the surface due to overland flow (Strickler K between 5 and 10 )

Topography : the forested area nearby has mild slopes and the agriculture area has gentle slopes.

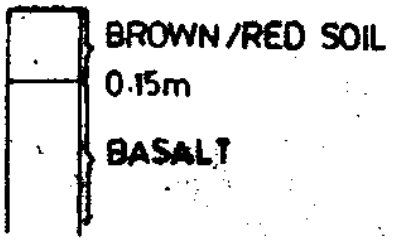
Wells :

| well code | depth to water level (m) | depth to impermeable bed (m) | remarks |
|---|---|---|---|
| 1c1 | 7.62 | 6.0 | pumped |
| 1c2 | 7.0 | 5.5 | pumped |

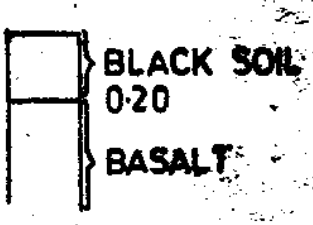
SITE 1c, KHAJURI (X)




PITS: 1Ca (WASTE LAND/FOREST)




PIT. 1Cb (AGRICULTURE)




PIT 1Cc (FOREST)

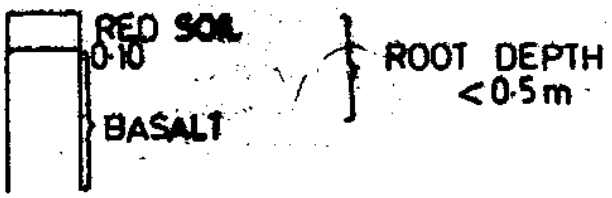



Fig D.3 : SKETCH SITE OF KHAJURI

Site 2a, Saras (VIII) ( Fig. D.4)

Location : About 6.5 km SW from Lawakhari (~47 km from Bhopal) in the village Saras.

Pits : Two pits were dug (up to 1.0 m deep), both in very good agricultural fields reaching impermeable rock. In the pit 2aa red colour soil with ~50% of boulders dominated the first layer (up to 0.5 m), below soft morrum was found, in the pit 2ab a 1.0 m layer of black cotton and a layer of morrum were noticed. In the dry, barrow fields, very deep (up to 0.35 m) and continuous cracks, 0.05 - 0.07 m wide on the surface, were found. Auger drill: gravel at depth of 0.7 m

Soil sample : taken from the depth 0.1 (black cotton) and 0.2 m (murram); two cores from 0.2 m depth.

Core numbers: 19, 20

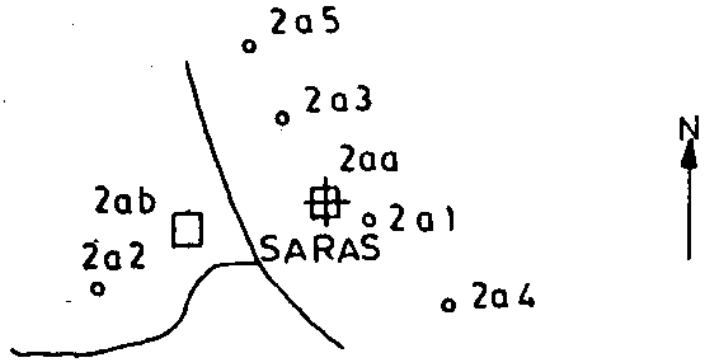
Vegetation : typical agricultural land, crops: wheat, gram, brinjals and pulses; maize and joar during another season; about 75% of the land is barren in dry season, a part of it is used only during heavy rains.

Topography : The village Saras is surrounded by sagar forests, in the depression areas soil depth is greater than usually observed shallow layers on the soft rock.

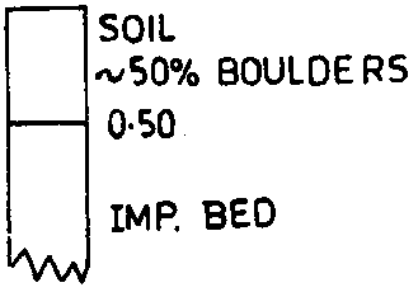
Wells :

| well code | depth to water level (m) | depth to impermeable bed (m) | remarks |
|---|---|---|---|
| 2a1 | 0.0 - 4.0 | 6.0 | water at 1.2 in mid Janua |
| 2a2 | 0.0 - 4.0 | 10.0 | water at 1.4 in mid Janua |
| 2a3 | 2.5 | - | pumped |
| 2a4 | 4.7 | 1.0 | under constr water starts creeping |
| 2a5 | < 2.1 | 1.25 | pumped |

SITE 2a SARAS (VIII)




PIT 2aa




PIT 2ab

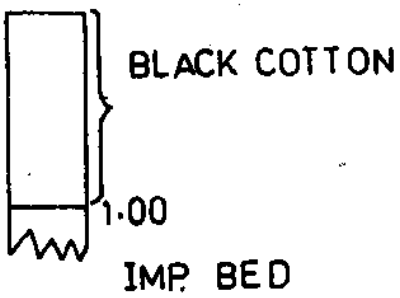



Fig. D.4 : Sketch of Site Saras

Site 2b, Birpur (I) ( Fig. D.5)

Location : Just downstream of left Rostrum of the Dam (~34 km South from Bhopal).

Pits : Four pits were dug up to 1.2, 1.0, 0.9 and 0.9 m respectively all reaching deep impervious rock. Pit 2ba was located in area clear of forest (slopy land), pits 2bb and 2bc in flat,waste land area, almost without vegetation, 2bd was situated in a forested area among standing trees. In the pit 2ba top layer (0.45 m) of loam and gravel mixed clay followed by a layer of black clay (up to 0.8 m) and then a layer (up to 1.2m) of soft weathering rock (red colour) were found. The infiltration test was carried out very close to this pit. In the pit 2bb 0.50m layer of yellow clay and gravel is followed by the soft rock up to 1.3 m. Pit 2bc had red clay layer on top (0.3 - 0.4 m) and weathering rock below (up to 1.0 m). In this pit soil containing some coarser material with red clay was found. Presence of holes and/or tubes inside the soil mass can be explained by animal activity and decayed roots. Traces of lime and mangnese were noticed. Pit 2bd had similar two layers as pit 2ba, but black cotton layer (gravely at the top) was deeper here. Root zone depth varies from 0.45 to 0.8 m .

Soil sample : taken from the depth 0.1 (black cotton),0.5m below (pit 2ba), from pits 2bb (red soil) and 2bc (yellow soil).4 cores have been collected (ground level, 0.25m from pit 2ba) 0.25 m (from pit 2bb) and 0.6m from pit 2bd.

Core numbers: 12, 13, 14, 15

Vegetation : deep forest (teak, chola, tendu trees). Leaf area index : 30% of leaves had fallen down.

Topography : graduated to average ground surface slope, boulders and gravel.

Overland roughness : Strickler K in the range 3 - 5.

Wells : no groundwater wells near by

Other remarks : A big barrow area used for dam construction was visited.
At few places soil columns were left standing, so the entire soil profile upto the original ground level could be observed. Both red and black type of clay were found in borrow area.

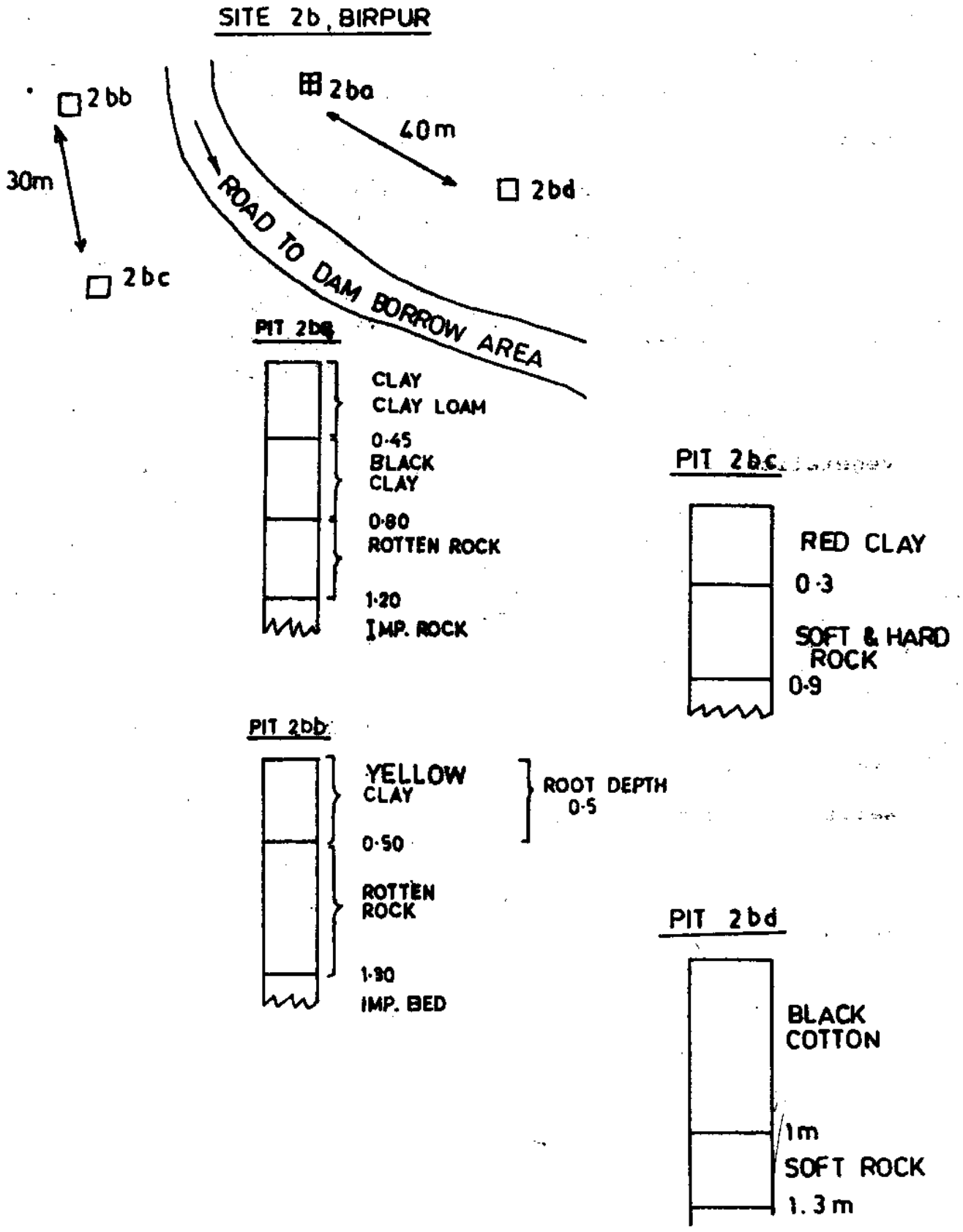



Fig. D.5 : Sketch of Site Birpur

Site 2c, Birpur Colony ( Fig. D.6)

Location : About 2km North from Birpur Dam Colony and ~30km SW from Bhopal, near the road.

Pits : Five shallow pits were dug up to 0.5, 0.83, 0.25, 0.25 and 0.3m respectively reaching impermeable rock. In all the pits a mixture of yellow/brown soil and boulders was found. Auger drilling was tried at 5 locations, but due to boulders it could not be completed. Root zone depth varying from 0.2 to 0.45 m.

Soil sample : taken from the middle depth 0.25 m. Two cores from 0.2 m (pits 2ca and 2cb).

Core numbers: 1, 2.

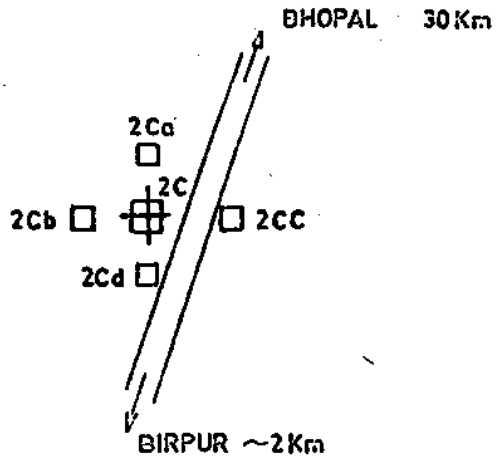
Vegetation : The site was surrounded by dense and mixed forest area (teak, kher, tendu trees, usual height 8-10 m) at about 0.5 km from site. Bushes and some wasteland with vegetation of mixed type was seen.Small grass (1-3cm) of brown colour covers wasteland. Leaf area index: 30% .

Topography : hilly area, undulated ground surface covered with boulders (0.1 X 0.25m), very rough.

Overland roughness : 5 - 8.

Wells : no groundwater wells near by

SITE 2C, BIRPUR COLONY




PIT 2CC

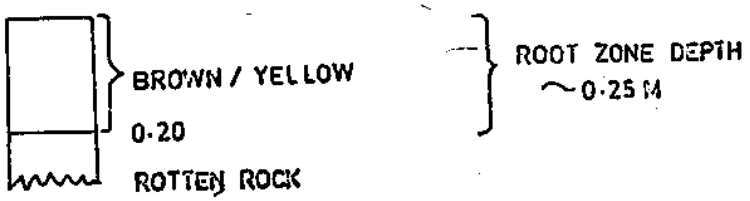



Fig. D.6 : Sketch of Site Birpur Colony

Site 3a, Birjisnagar (XIII) ( Fig. D.7)

Location : About 14 km SE from Ichhawar, 150 m from self-recording rain gauge in Birjisnagar.

Pits : Two pits were dug up to 0.7 and 0.4 m respe ctively. Gray to red colour soil layer of 0.4 and 0.25m covers soft disintegrated rock. Root zone ~0.25 m.

Soil sample : taken from the depth 0.5 (pit 3aa) and 0.12m (pit 3ab)
3 cores have been collected (0.1 m depth).

Core numbers: 22, 23, 24, 25

Vegetation : Mainly agricultural area, ~20% wasteland.

Overland roughness : 1 - 3.

Topography : The area surrounding the site is quite flat. The road from Ichhawar to Birjisnagar passes through relatively flat sloped area which is predominantly cultivated.

Wells :

| well code | depth to water level (m) | depth to impermeable bed (m) | remarks |
|---|---|---|---|
| 3a1 | | 1.9 | pumped |
| 3a2 | | 2.0 | pumped |

SITE 3a, BIRJISNAGAR (XIII)

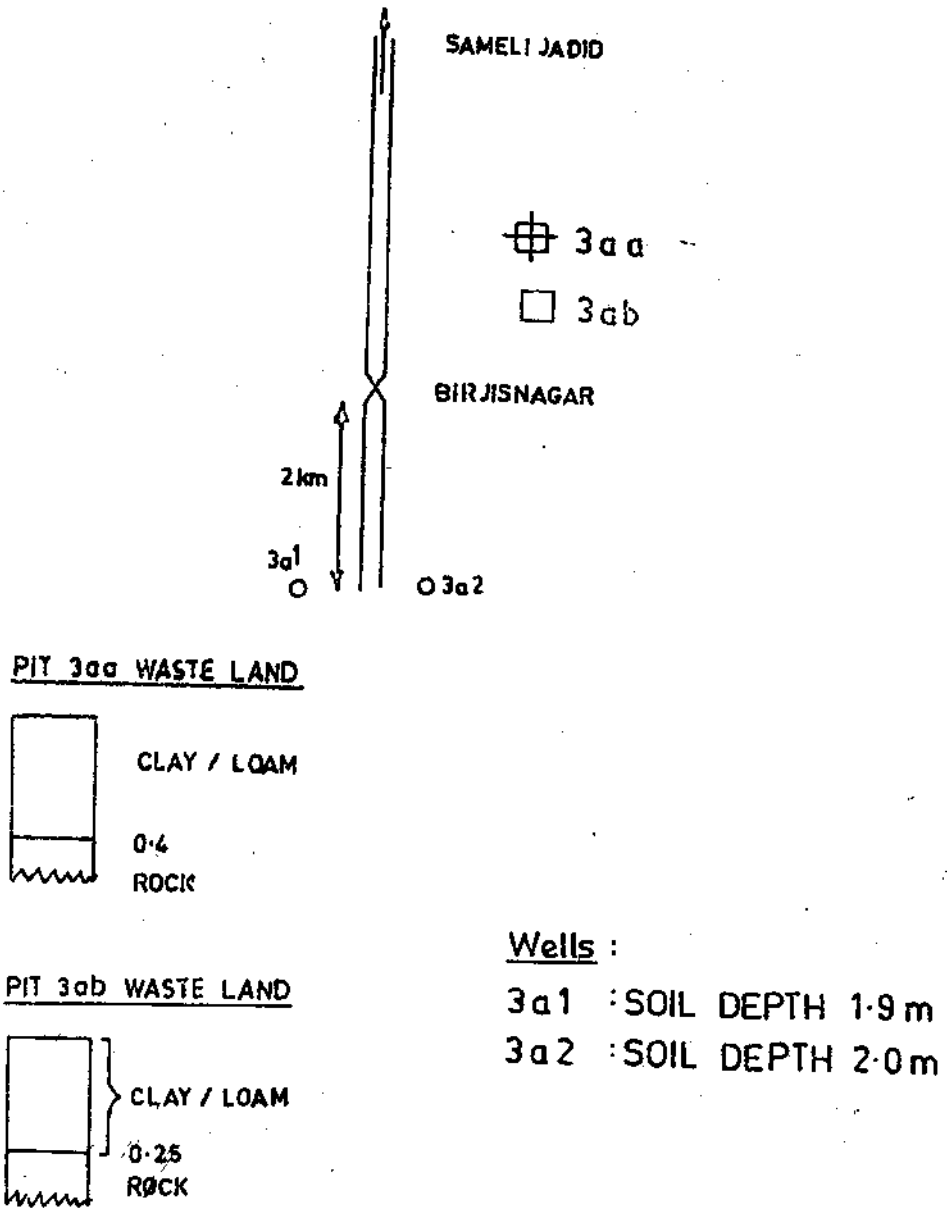



Fig. D.7 : Sketch of Site Birjisnagar

Site 3b, Semli Jadid ( Fig. D.8)

Location : about 10 km from Sagoni (via Bilkisganj)

Pits : two pits could be dug one in agricultural area (up to 0.8 by digging and 0.4 m by auguring), second in the wasteland (up to 0.3 m depth). In the field, black cotton soil (with presence of mangnese due to whe thering effect) dominated in the profile. In the second pit the soil was mixed with rotten rock and pebbles. Root zone at 0.3 and 0.18 m respectively in two pits.

Soil sample : taken from the mid soil depth (0.5 m); one core at 0.2 m was taken in some distance from the pit 3ba, as in the immediate proximity the core could not be filled due to cohesive nature of soil.

Core numbers: 18

Vegetation : mainly agricultural area with some portion of wasteland; crop: wheat, gram, pea and pulse; around 25% of leaves on big trees had fallen down;

Overland roughness: 1 - 3.

Topography : generally flat land was visible. On the way from Semli Jadid to Birjisnagar open forest and wasteland areas were seen.

Wells :

| well code | depth to water level (m) | depth to impermeable bed (m) | remarks |
|---|---|---|---|
| 3b1 | 5.6 | 1.0 | not pumped |
| 3b2 | 4.4 | 2.15 | not pumped |
| 3b3 | 5.5 | 2.1 | not pumped |

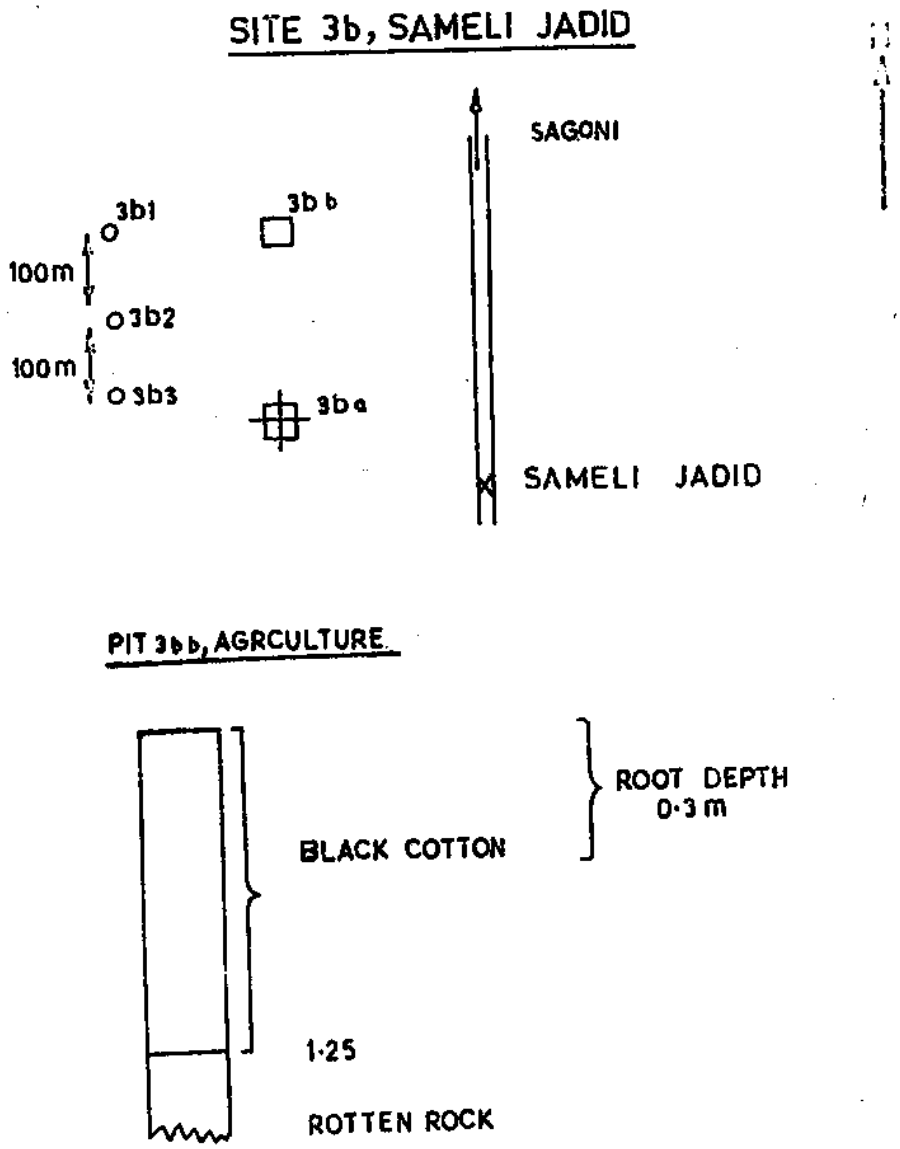



**Fig D.8 : Sketch of Site Sameli Jadid**

Site 3c, Sagoni ( Fig. D.9)

Location : near Sagoni village, ~5km from Uljhawan (~50 km SW from Bhopal).

Pits : only two full depth pits could be dug; pit 3ca in agricultural area (up to 2.3 m) pit 3cb in the wasteland (up to 1.2m depth). In the field, 0.9 m of black cotton soil overlaid red moram (yellow clay) soil. In the second pit the shallow layer (0.2 m) of black cotton soil was followed by yellow soil. Two other pits (0.5 and 0.75 m depth respectively) on very shallow (0.2m) layers of black cotton soil were also digged, but without reaching the stratum. Root zone is varying between 0.4 - 1.25 m .

Soil sample : 4 samples of were taken : 2 of black cotton 1 of yellow and 1 of red soil.

Core numbers: 8, 9, 10, 11

Vegetation : mainly agricultural area with large portion of wasteland (~30%);no source of surface irrigation were seen; crop: wheat, gram, pea and masoor; around 25% of leaves on big trees had fallen down, no traces of big litter.

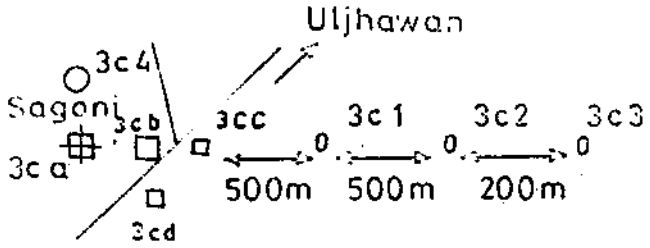
Overland roughness : 1 - 3.

Topography : upstream part of the basin, but relatively flat; mild slope of the ground surface was noticed.

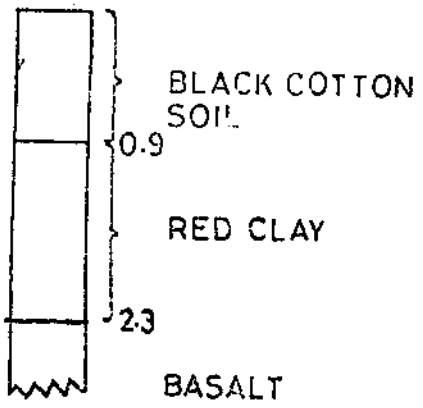
Wells :

| well code | depth to water level (m) | depth to impermeable bed (m) | remarks |
|---|---|---|---|
| 3c1 | - | 1.2 | under constr |
| 3c2 | - | 0.2 | under constr |
| 3c3 | 5.0 | 0.8 | pumped |
| 3c4 | 6.0 | - | not pumped for 15 days |

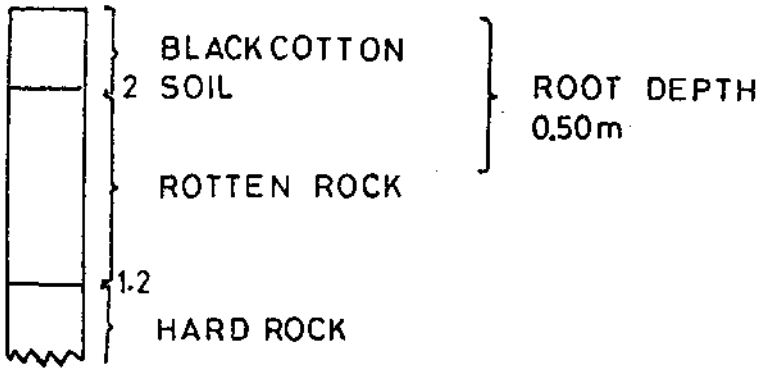
## SITE 3c, SAGONI




### PIT 3ca, Agriculture




### PIT 3cb WASTE LAND




PIT 3cd – WASTE LAND, SOIL DEPTH 0·2 m

**Fig. D.9 : Sketch of Site Sagoni**

Site 4a, Khamkhera (IV) ( Fig. p.10)

Location : In the village Khamkhera, ~16 km from Abadabad.

Pits : Three partial depth pits were dug: 4aa in the wasteland (up to 0.8 m), 4ab and 4bc in agricultural area (up to 1.2 and 1.8 m respectively). Pit 4aa had a shallow layer of red soil mixture with soft rock and the infiltrometer test was carried there. In the 4ab 1.2 m of black cotton soil and in the 4ac 1.8 m of red soil were found. soil. Two other pits (0.5 and 0.75 m depth were dug.

Soil sample : One from the agriculture area and one from the wasteland taken at 0.50 m.

Core numbers: 26

Vegetation : mainly agricultural area. Crop: wheat, gram, pea and masoor;

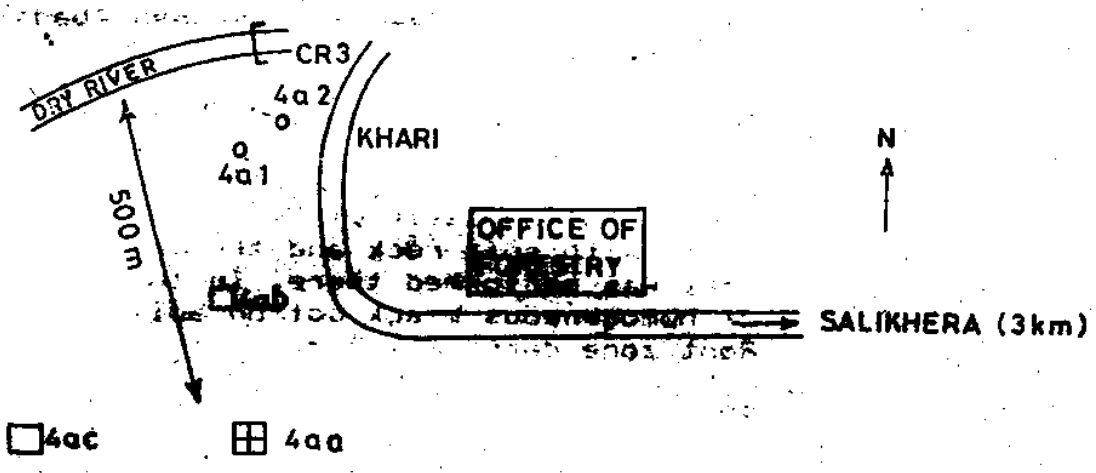
Overland roughness: Strickler K between 2 and 5

Topography : relatively flat area.

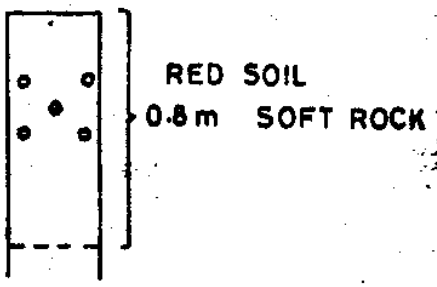
Wells :

| well code | depth to water level (m) | depth to impermeable bed (m) | remarks |
|---|---|---|---|
| 4a1 | 1.4 | - | |
| 4b2 | 4.4 | - | pumped |

SITE 4a, KHAMKHERA (IV)

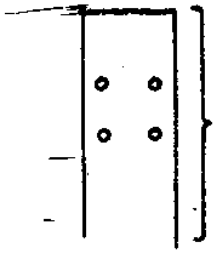



PIT 4aa, WASTELAND

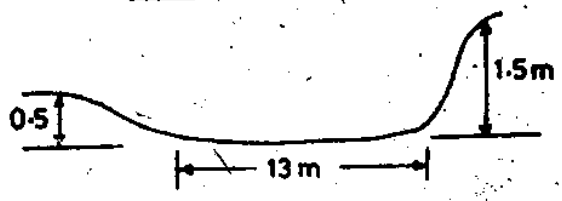



PIT 4ab, AGRICULTURE LAND


PIT 4ac, AGRICULTURE LAND




CR3




SILTED BED

Fig. D.10 : Sketch of Site Khamkhera

Site 4b, Bamladar (XVIII) ( Fig. D.11)

Location : In the village Bamladar, between Abadabad and Bilkhera.

Pits : Two partial depth pits were dug: 4ba in wasteland and 4bb in the agricultural area (up to 1.8 and 1.5 m respectively). Pit 4bb had a shallow layer of red soil (0.3 m) mixed with soft rock and the infiltrometer test was performed there. In the 4ba 1.5 m of homogeneous black cotton soil was found. Root zone depth : 1.5 m.

Core numbers: 28

Vegetation : mainly agricultural area. Crop: wheat, gram, pea and masoor;.

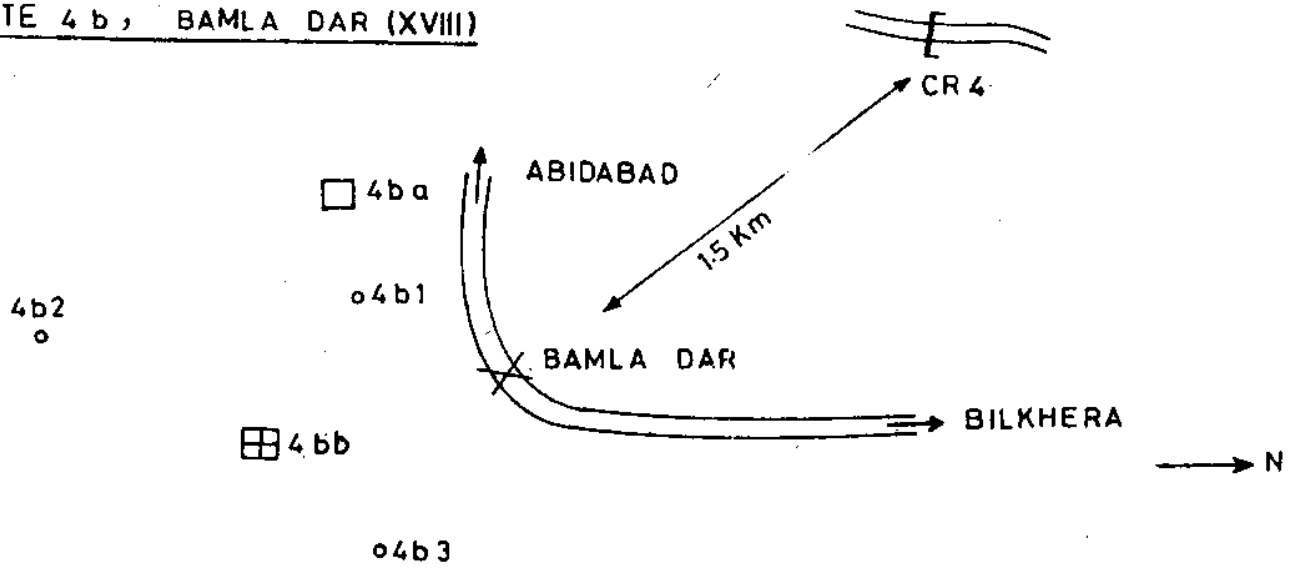
Overland roughness: Strickler K between 2 and 5

Topography : flat area.

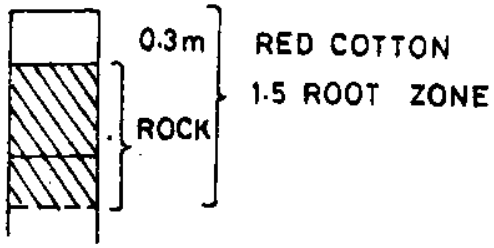
Wells :

| well code | depth to water level (m) | depth to impermeable bed (m) | remarks |
|---|---|---|---|
| 4b1 | 6.6 | 0.25 | pumped |
| 4b2 | 2.65 | 1.2 | not pumped |
| 4b3 | 2.6 | 1.0 | not pumped |

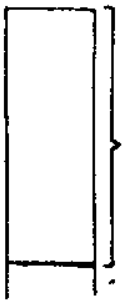
SITE 4 b, BAMLA DAR (XVIII)




PIT 4ba WASTE LAND




PIT 4bb AGRICULTURE AREA



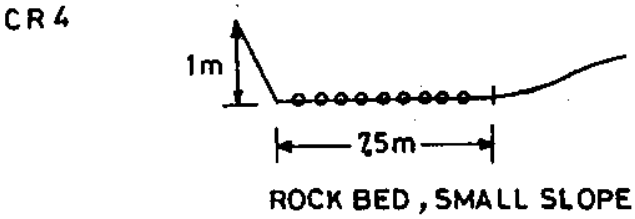




**Fig. D.11 : Sketch of Site Bamla Dar**

Site 4c, Khari ( Fig. D.12)

Location : In the village Khari, on the way from Bhopal and Bilkhera.

Pits : No pits were dug.Infiltrometer test carried out in agriculture area having black cotton soil.

Core numbers: 28

Vegetation : mainly agricultural area. Crop: wheat, gram, pea and masoor;

Overland roughness: Strickler K between 2 and 5

Topography : flat area, but in the distance of 2 km from the site in the direction to Abadabad a single rocky hill (~670 m) dominates the area.

Wells :

| well code | depth to water level (m) | depth to impermeable bed (m) | remarks |
|---|---|---|---|
| 4c1 | | | dry |
| 4c2 | | | dry |
| 4c3 | 0.5 | 4.1 | not pumped |
| 4c4 | 0.5 | 6.2 | not pumped |

SITE 4c , KHARI

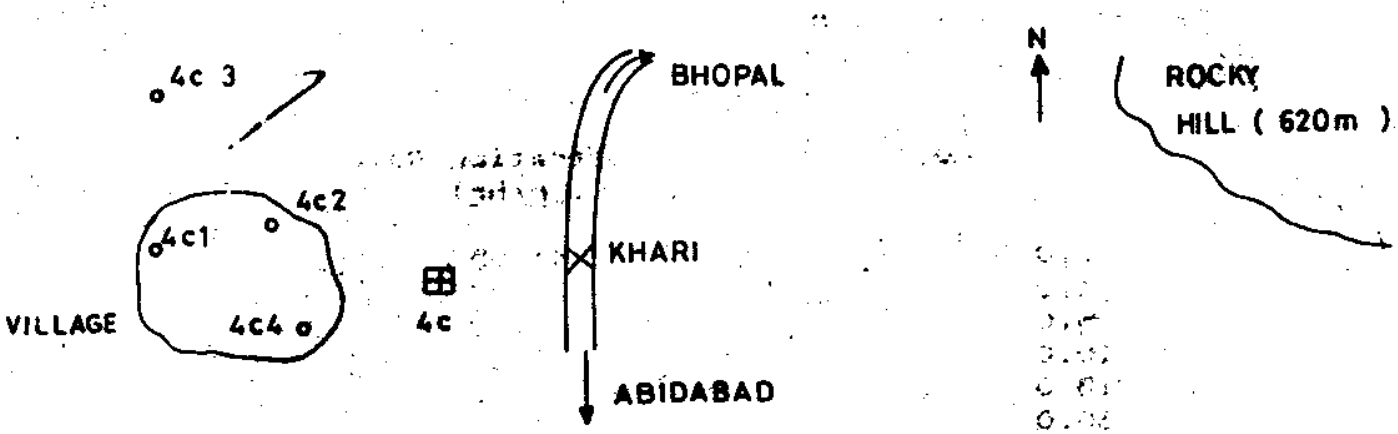



Fig. D.12 : Sketch of Site 4c1

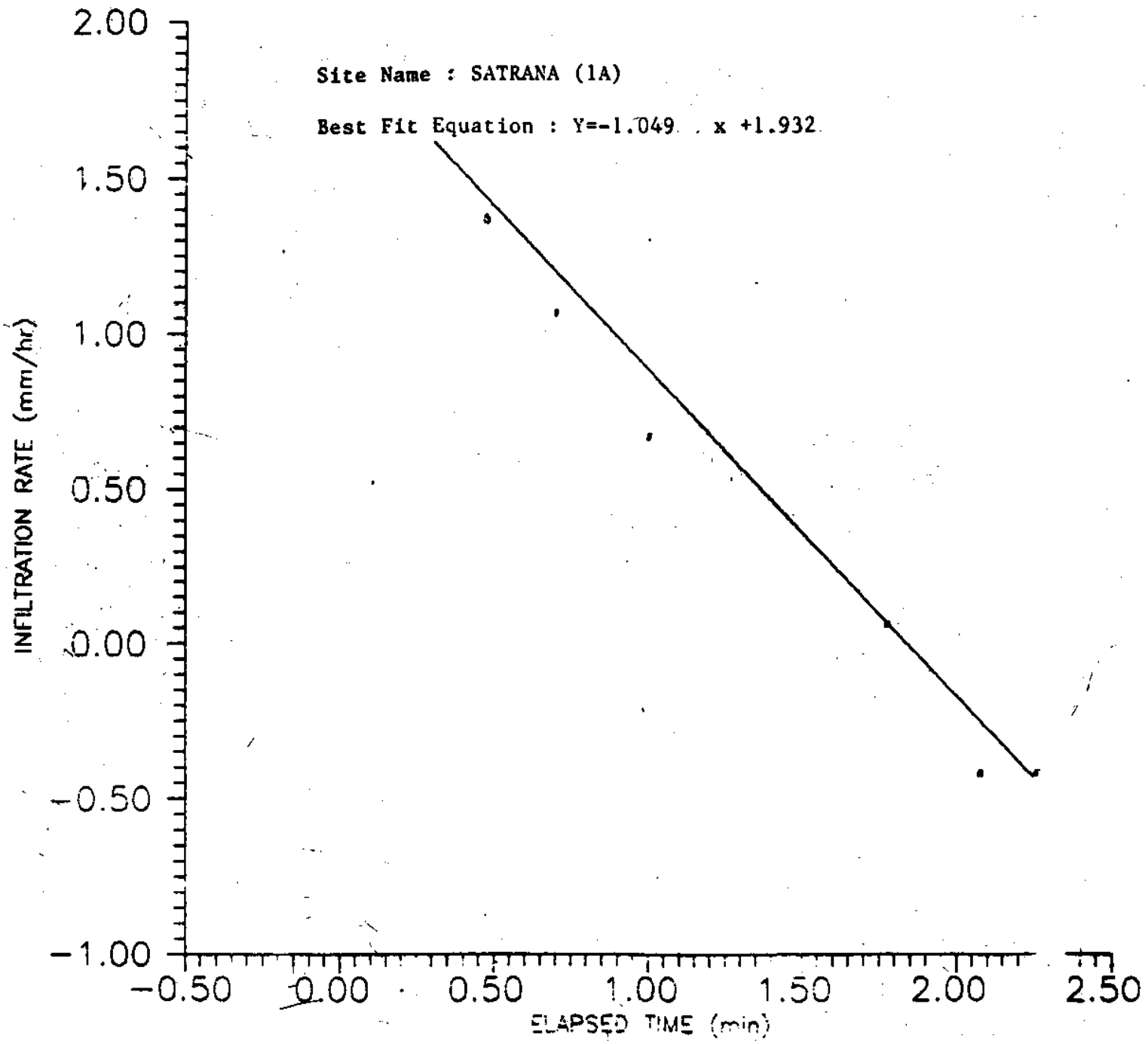
## RESULTS OF INFILTROMETER TEST CARRIED OUT USING DOUBLE RING INFILTROMETER

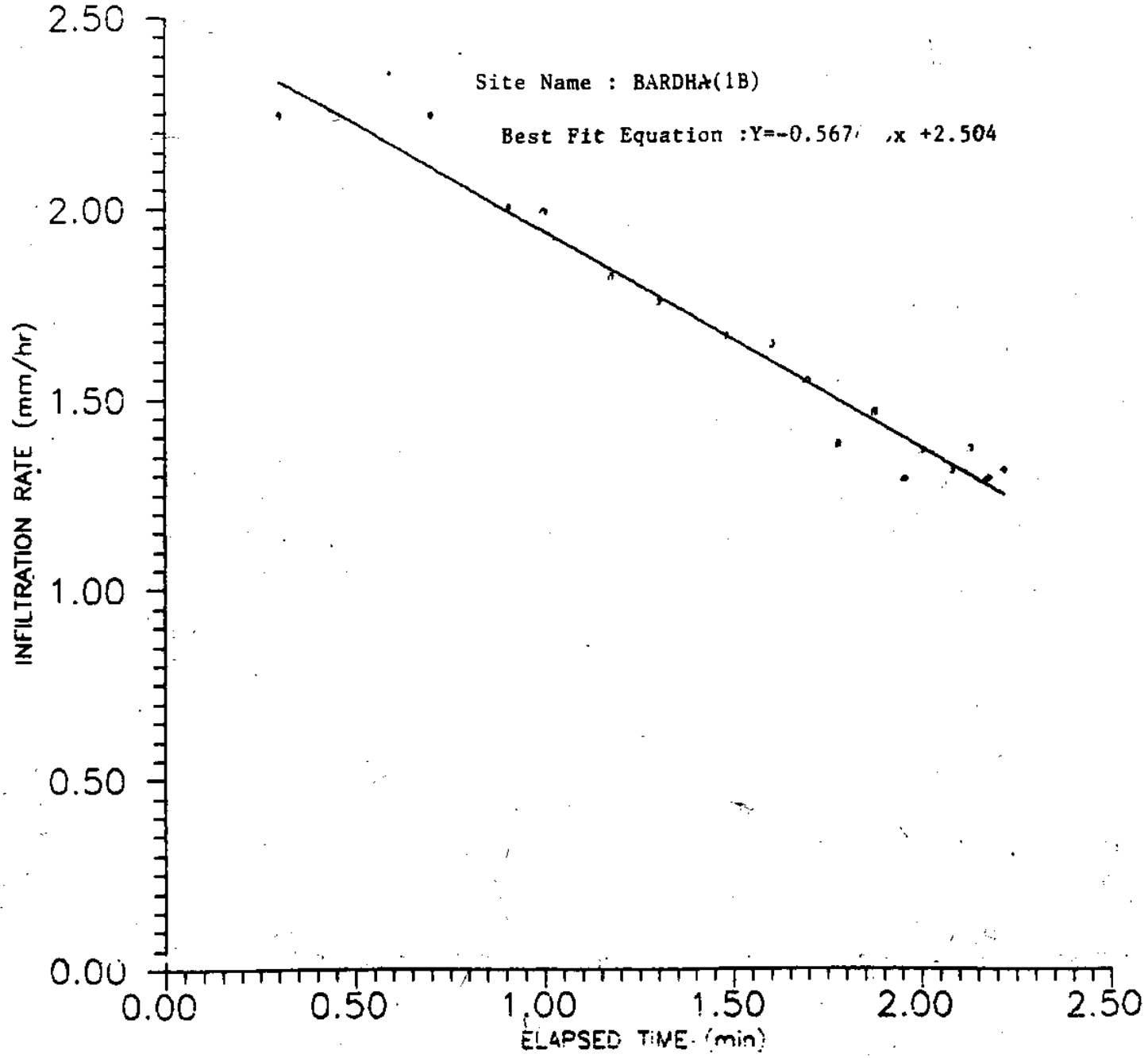
Site - SATRANA (1 A)
Date - 11-01-90

| Elapsed Time (min.) | Infiltration Rate (Cm/hr) |
|---|---|
| 2.0 | 46.05 |
| 3.0 | 23.02 |
| 5.0 | 11.52 |
| 10.0 | 4.61 |
| 15.0 | 13.82 |
| 30.0 | 3.07 |
| 60.0 | 1.15 |
| 120.0 | 0.38 |
| 180.0 | 0.38 |

Site - BARDHA (1 B)
Date - 12-01-90

| Elapsed Time (min.) | Infiltration Rate (Cm/hr) |
|---|---|
| 2.0 | 173.42 |
| 5.0 | 173.42 |
| 8.0 | 101.33 |
| 10.0 | 97.21 |
| 15.0 | 65.14 |
| 20.0 | 56.45 |
| 30.0 | 45.60 |
| 40.0 | 43.43 |
| 50.0 | 34.74 |
| 60.0 | 23.89 |
| 75.0 | 28.95 |
| 90.0 | 19.27 |
| 105.0 | 23.16 |
| 120.0 | 20.26 |
| 135.0 | 23.16 |
| 150.0 | 19.27 |
| 165.0 | 20.26 |


Site Name : SATRANA (1A)
Best Fit Equation : Y=-1.049 . x +1.932
INFILTRATION RATE (mm/hr)
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-0.50
0.00
0.50
1.00
1.50
2.00
2.50
ELAPSED TIME (min)

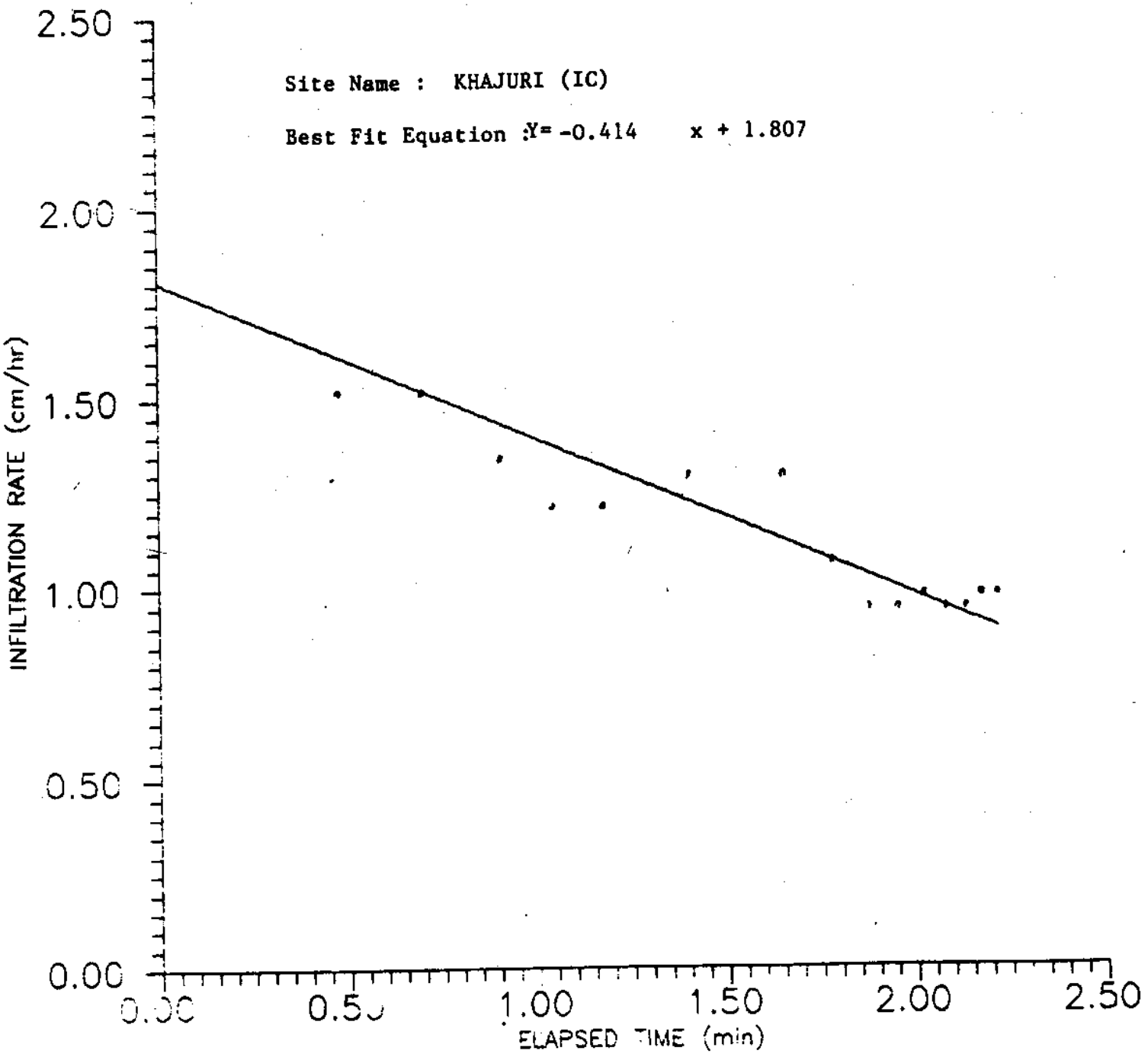

Site Name : BARDHA(1B)
Best Fit Equation :Y=-0.567 x +2.504
INFILTRATION RATE (mm/hr)
2.50
2.00
1.50
1.00
0.50
0.00
0.00
0.50
1.00
1.50
2.00
2.50
ELAPSED TIME (min)

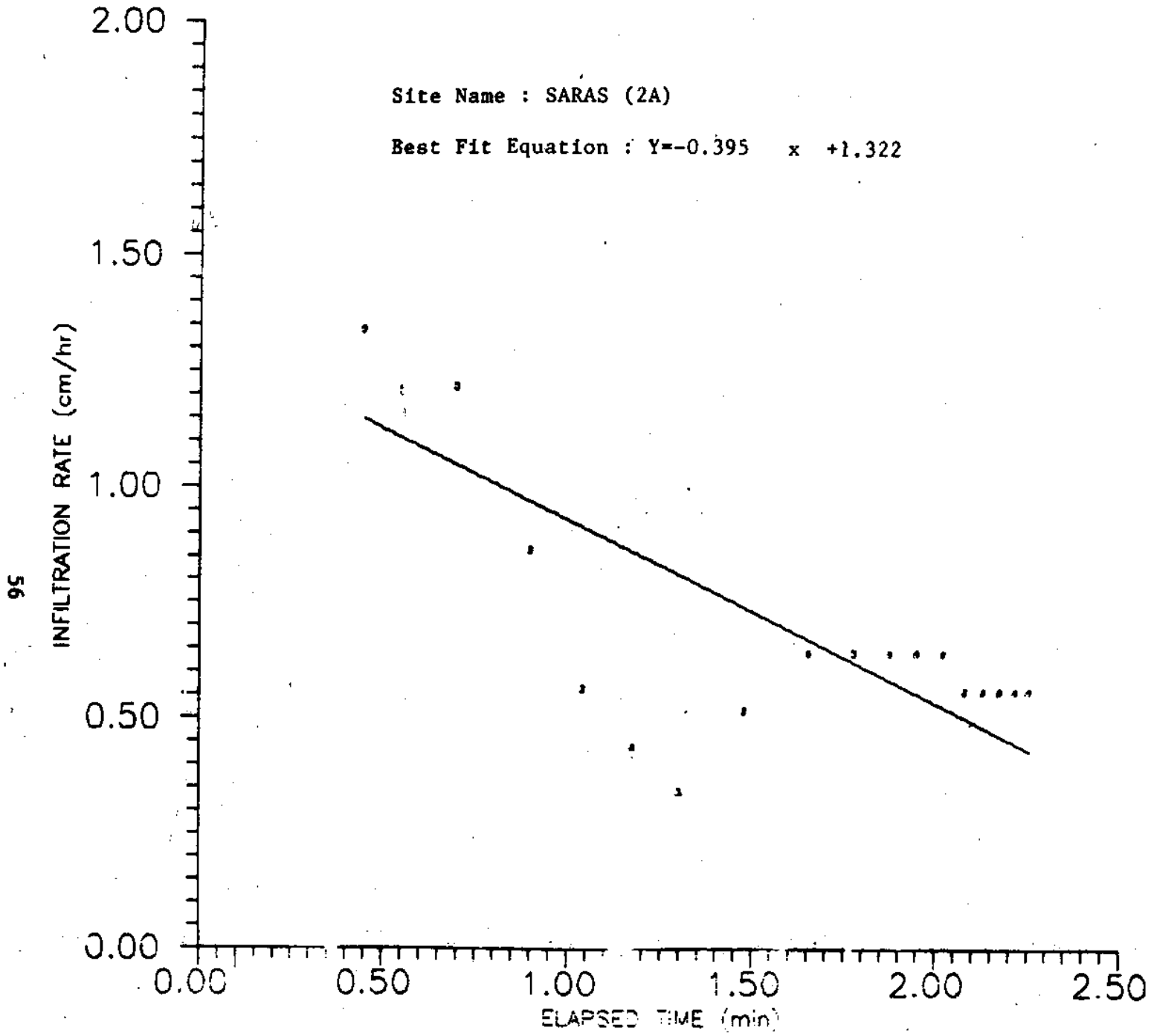
Site - KHAJURI (1 C)
Date - 20-01-90

| Elapsed Time (min.) | Infiltration Rate (Cm/hr) |
|---|---|
| 1.0 | 108.57 |
| 3.0 | 32.57 |
| 5.0 | 32.57 |
| 8.0 | 21.71 |
| 11.0 | 16.28 |
| 15.0 | 16.28 |
| 25.0 | 19.54 |
| 45.0 | 19.54 |
| 60.0 | 11.58 |
| 75.0 | 8.68 |
| 90.0 | 8.68 |
| 105.0 | 9.40 |
| 120.0 | 8.68 |
| 135.0 | 8.68 |
| 150.0 | 9.40 |
| 165.0 | 9.40 |

Site - SARAS (2 A)
Date - 18-01-90

| Elapsed Time (min.) | Infiltration Rate (Cm/hr) |
|---|---|
| 1.0 | 48.43 |
| 3.0 | 21.71 |
| 5.0 | 16.28 |
| 8.0 | 7.23 |
| 11.0 | 3.62 |
| 15.0 | 2.71 |
| 20.0 | 2.17 |
| 30.0 | 3.26 |
| 45.0 | 4.34 |
| 60.0 | 4.34 |
| 75.0 | 4.34 |
| 90.0 | 4.34 |
| 105.0 | 4.34 |
| 120.0 | 3.61 |
| 135.0 | 3.61 |
| 150.0 | 3.61 |
| 165.0 | 3.61 |
| 180.0 | 3.61 |


Site Name : KHAJURI (IC)
Best Fit Equation :Y= -0.414 x + 1.807
INFILTRATION RATE (cm/hr)
2.50
2.00
1.50
1.00
0.50
0.00
0.00
0.50
1.00
1.50
2.00
2.50
ELAPSED TIME (min)

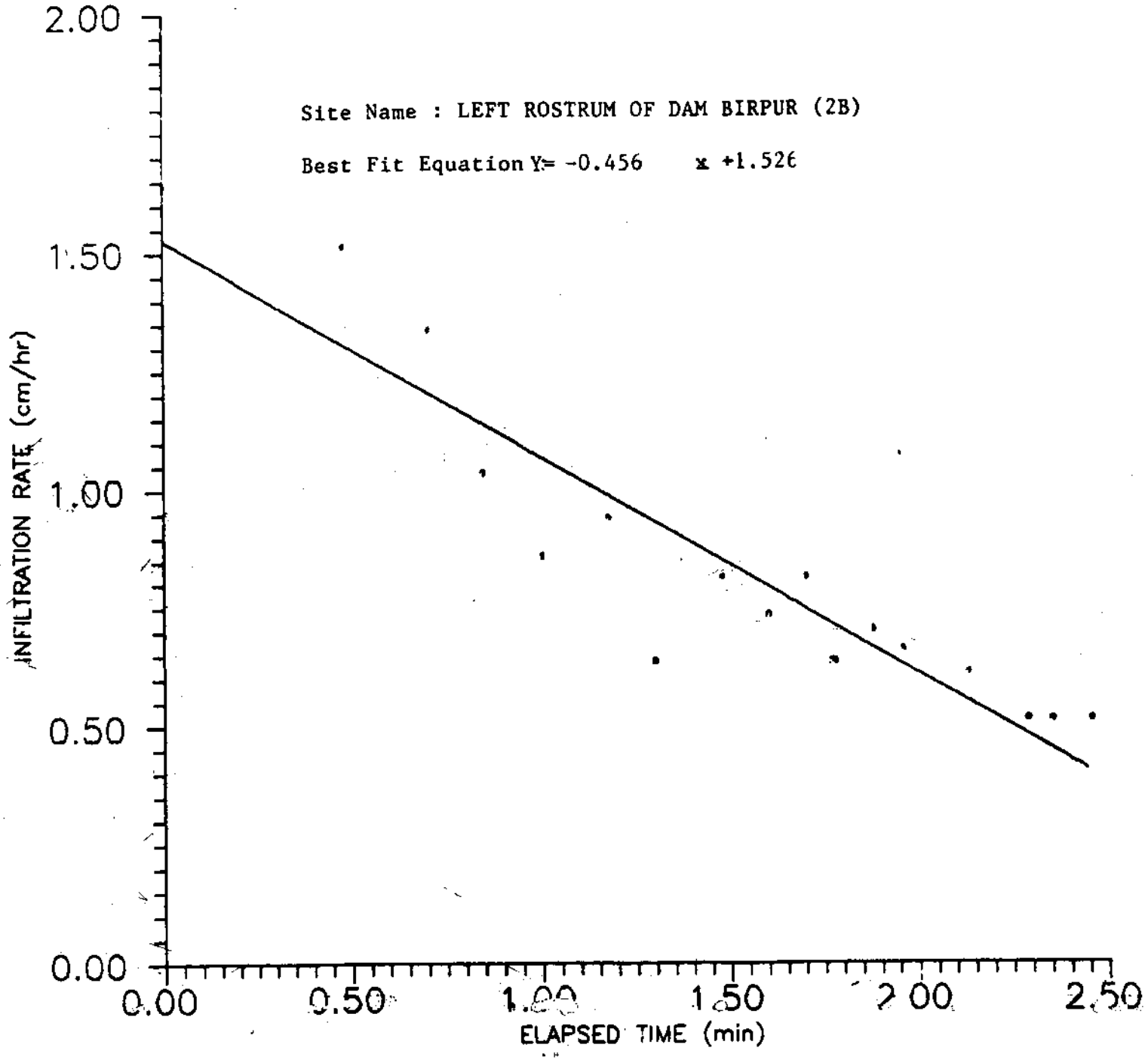

Site Name : SARAS (2A)
Best Fit Equation : Y=-0.395 x +1.322
INFILTRATION RATE (cm/hr)
ELAPSED TIME (min)
2.00
1.50
1.00
0.50
0.00
0.00
0.50
1.00
1.50
2.00
2.50

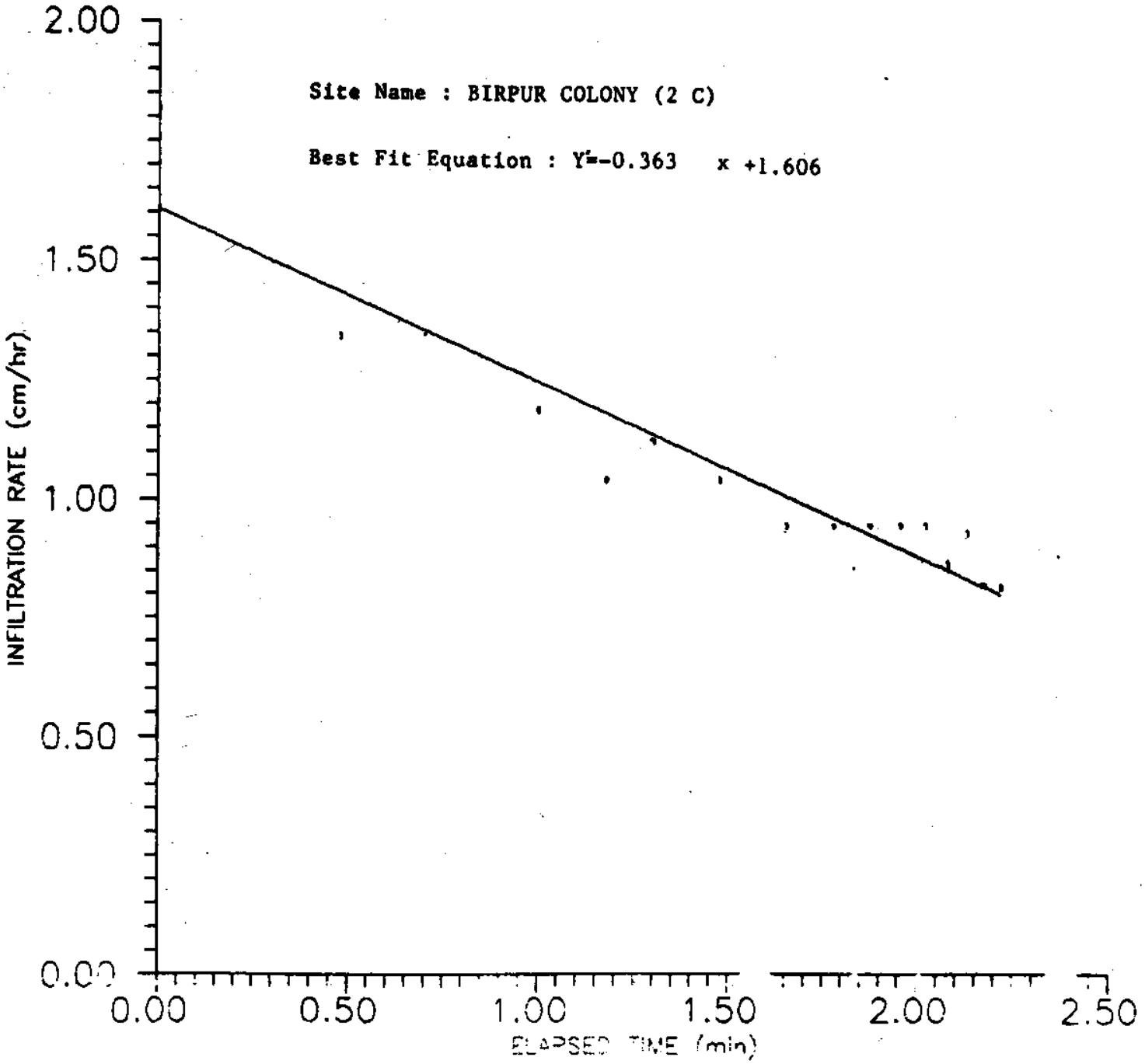
Site - BIRPUR (2 B)
Date - 15-01-90

| Elapsed Time. (min.) | Infiltration Rate (Cm/hr) |
|---|---|
| 1.0 | 43.43 |
| 3.0 | 32.57 |
| 5.0 | 21.72 |
| 7.0 | 10.85 |
| 10.0 | 7.24 |
| 15.0 | 8.69 |
| 20.0 | 4.34 |
| 30.0 | 6.51 |
| 40.0 | 5.42 |
| 50.0 | 6.51 |
| 60.0 | 4.34 |
| 75.0 | 5.06 |
| 90.0 | 4.61 |
| 135.0 | 4.10 |
| 195.0 | 3.26 |
| 225.0 | 3.26 |
| 285.0 | 3.26 |

Site - BIRPUR COLONY (2C)
Date - 18-01-90

| Elapsed Time (min.) | Infiltration Rate (Cm/hr) |
|---|---|
| 1.0 | 65.14 |
| 3.0 | 21.71 |
| 5.0 | 21.71 |
| 10.0 | 15.20 |
| 15.0 | 10.85 |
| 20.0 | 13.03 |
| 30.0 | 10.85 |
| 45.0 | 8.69 |
| 60.0 | 8.69 |
| 75.0 | 8.69 |
| 90.0 | 8.69 |
| 105.0 | 8.69 |
| 120.0 | 7.23 |
| 135.0 | 8.40 |
| 150.0 | 6.51 |
| 165.0 | 6.51 |
| 180.0 | 6.51 |


Site Name : LEFT ROSTRUM OF DAM BIRPUR (2B)
Best Fit Equation Y= -0.456 x +1.526
INFILTRATION RATE (cm/hr)
2.00
1.50
1.00
0.50
0.00
0.00
0.50
1.00
1.50
2.00
2.50
ELAPSED TIME (min)

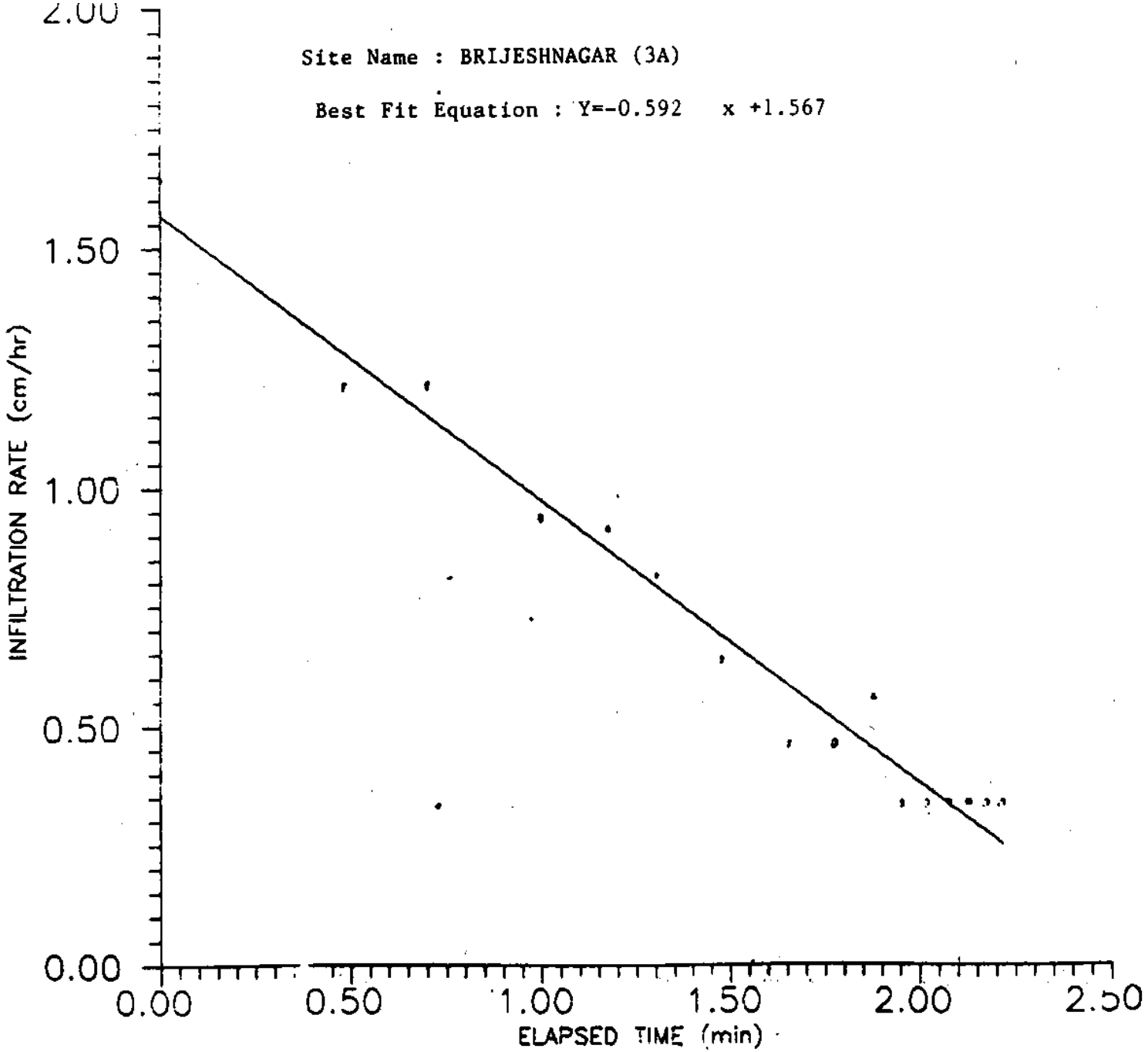

Site Name : BIRPUR COLONY (2 C)
Best Fit Equation : Y=-0.363 x +1.606
INFILTRATION RATE (cm/hr)
2.00
1.50
1.00
0.50
0.00
0.00
0.50
1.00
1.50
2.00
2.50
ELAPSED TIME (min)

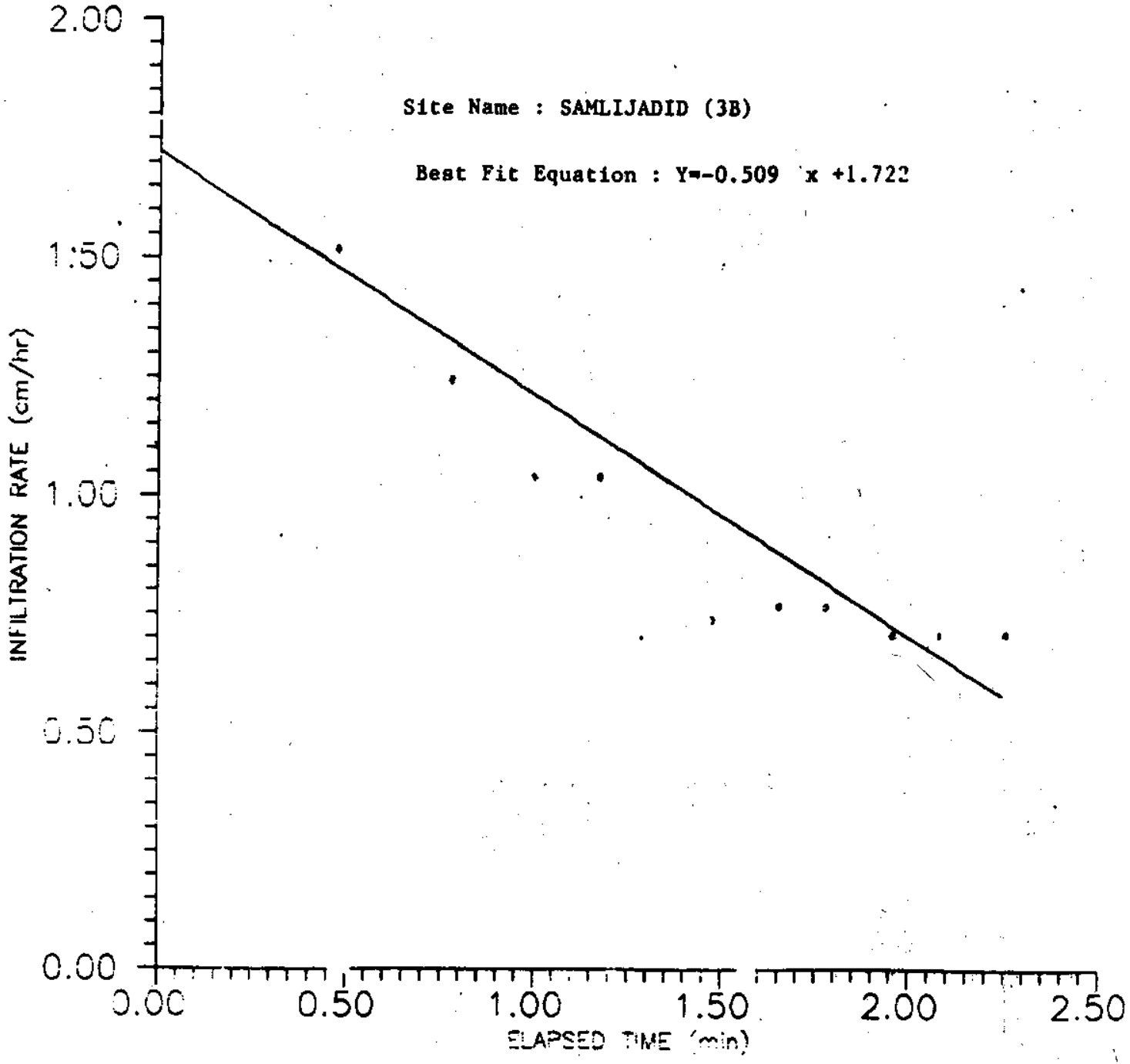
Site - BIRJISNAGAR (3A)
Date - 19-01-90

| Elapsed Time (min.) | Infiltration Rate (Cm/hr) |
|---|---|
| 1.0 | 43.43 |
| 3.0 | 16.28 |
| 5.0 | 16.28 |
| 10.0 | 8.62 |
| 15.0 | 8.14 |
| 20.0 | 6.51 |
| 30.0 | 4.34 |
| 45.0 | 2.89 |
| 60.0 | 2.89 |
| 75.0 | 3.61 |
| 90.0 | 2.17 |
| 105.0 | 2.17 |
| 120.0 | 2.17 |
| 135.0 | 2.17 |
| 150.0 | 2.17 |
| 165.0 | 2.17 |

Site - SEMLI JADID (3B)
Date - 17-01-90

| Elapsed Time (min.) | Infiltration Rate (Cm/hr) |
|---|---|
| 1.0 | 65.14 |
| 3.0 | 32.57 |
| 6.0 | 17.23 |
| 10.0 | 10.85 |
| 15.0 | 10.85 |
| 20.0 | 34.74 |
| 30.0 | 5.42 |
| 45.0 | 5.79 |
| 60.0 | 5.79 |
| 90.0 | 5.06 |
| 120.0 | 5.06 |
| 180.0 | 5.06 |


Site Name : BRIJESHNAGAR (3A)
Best Fit Equation : Y=-0.592 x +1.567
INFILTRATION RATE (cm/hr)
ELAPSED TIME (min)
2.00
1.50
1.00
0.50
0.00
0.00
0.50
1.00
1.50
2.00
2.50

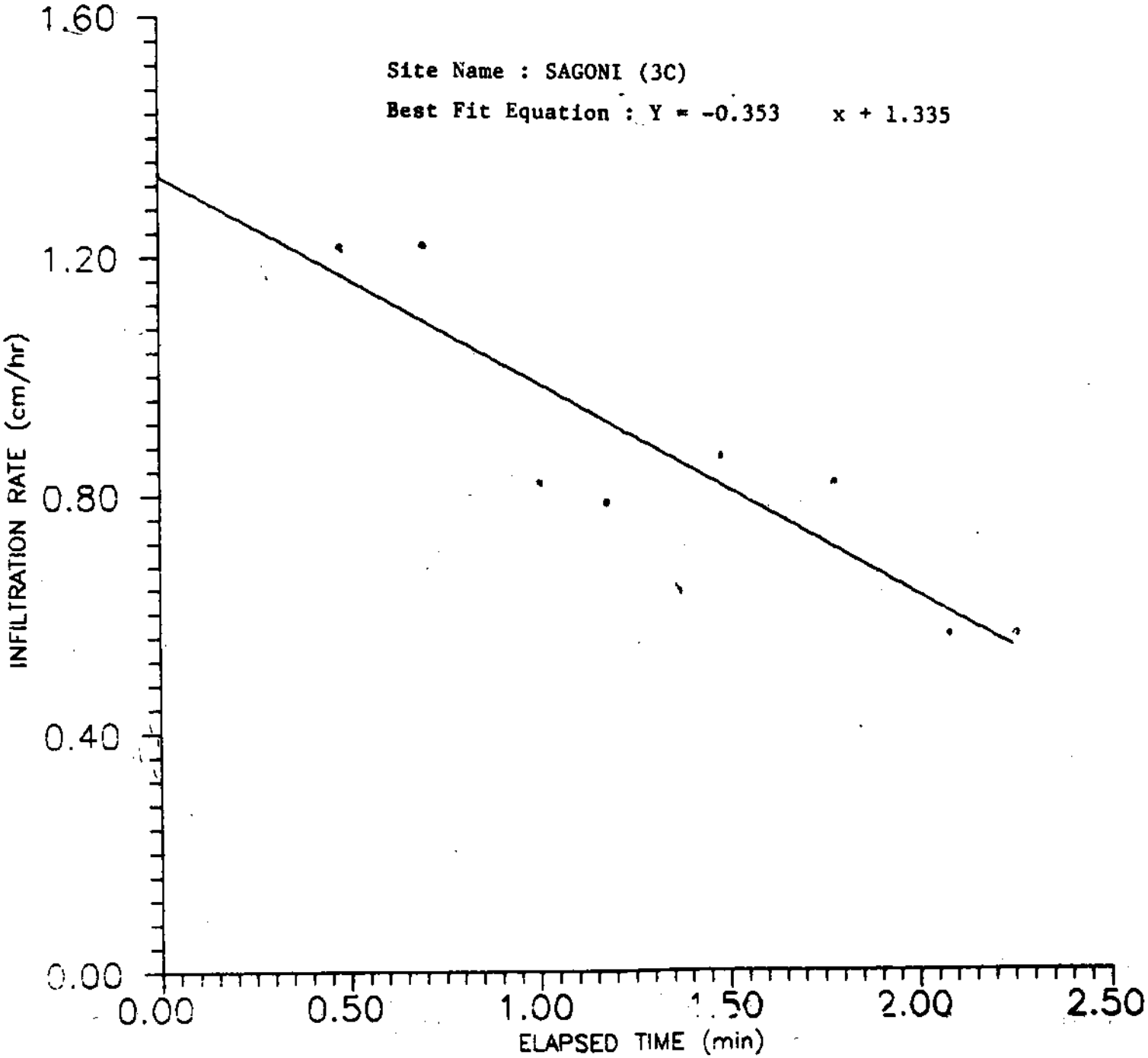

Site Name : SAMLIJADID (3B)
Best Fit Equation : Y=-0.509 x +1.722
INFILTRATION RATE (cm/hr)
2.00
1.50
1.00
0.50
0.00
0.00
0.50
1.00
1.50
2.00
2.50
ELAPSED TIME (min)

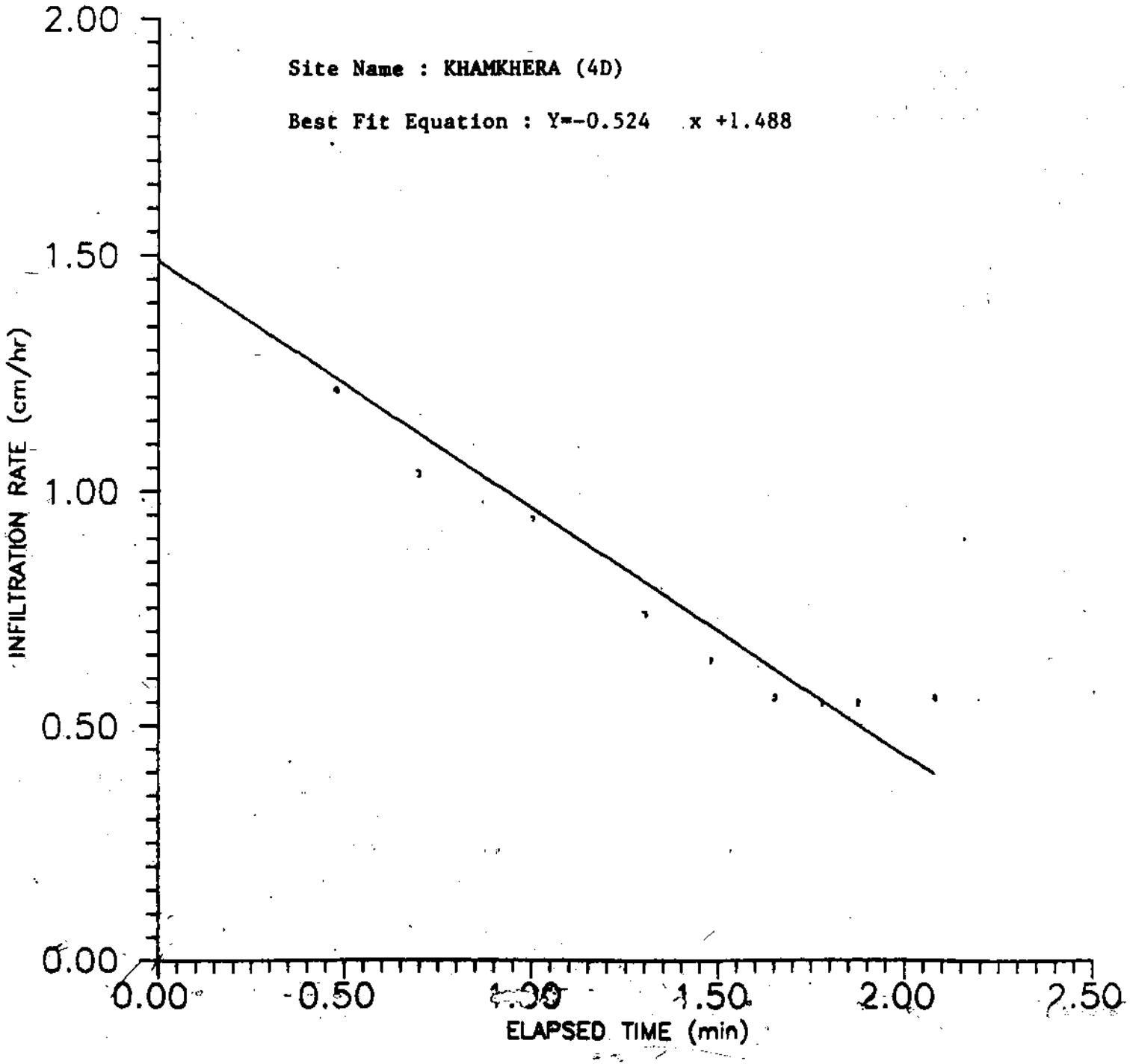
Site - SAGONI (3C)
Date - 13-01-90

| Elapsed Time (min.) | Infiltration Rate (Cm/hr) |
|---|---|
| 1.0 | 21.71 |
| 3.0 | 16.29 |
| 5.0 | 16.29 |
| 10.0 | 6.51 |
| 15.0 | 6.05 |
| 30.0 | 7.23 |
| 60.0 | 6.51 |
| 120.0 | 3.61 |
| 180.0 | 3.61 |

Site - KHAMKHERA (4A)
Date - 22-01-90

| Elapsed Time (min.) | Infiltration Rate (Cm/hr) |
|---|---|
| 1.0 | 43.43 |
| 3.0 | 16.28 |
| 5.0 | 10.85 |
| 10.0 | 8.68 |
| 20.0 | 5.42 |
| 30.0 | 4.34 |
| 45.0 | 3.62 |
| 60.0 | 3.54 |
| 75.0 | 3.54 |
| 120.0 | 3.62 |


Site Name : SAGONI (3C)
Best Fit Equation : Y = -0.353 x + 1.335
INFILTRATION RATE (cm/hr)
1.60
1.20
0.80
0.40
0.00
0.00
0.50
1.00
1.50
2.00
2.50
ELAPSED TIME (min)

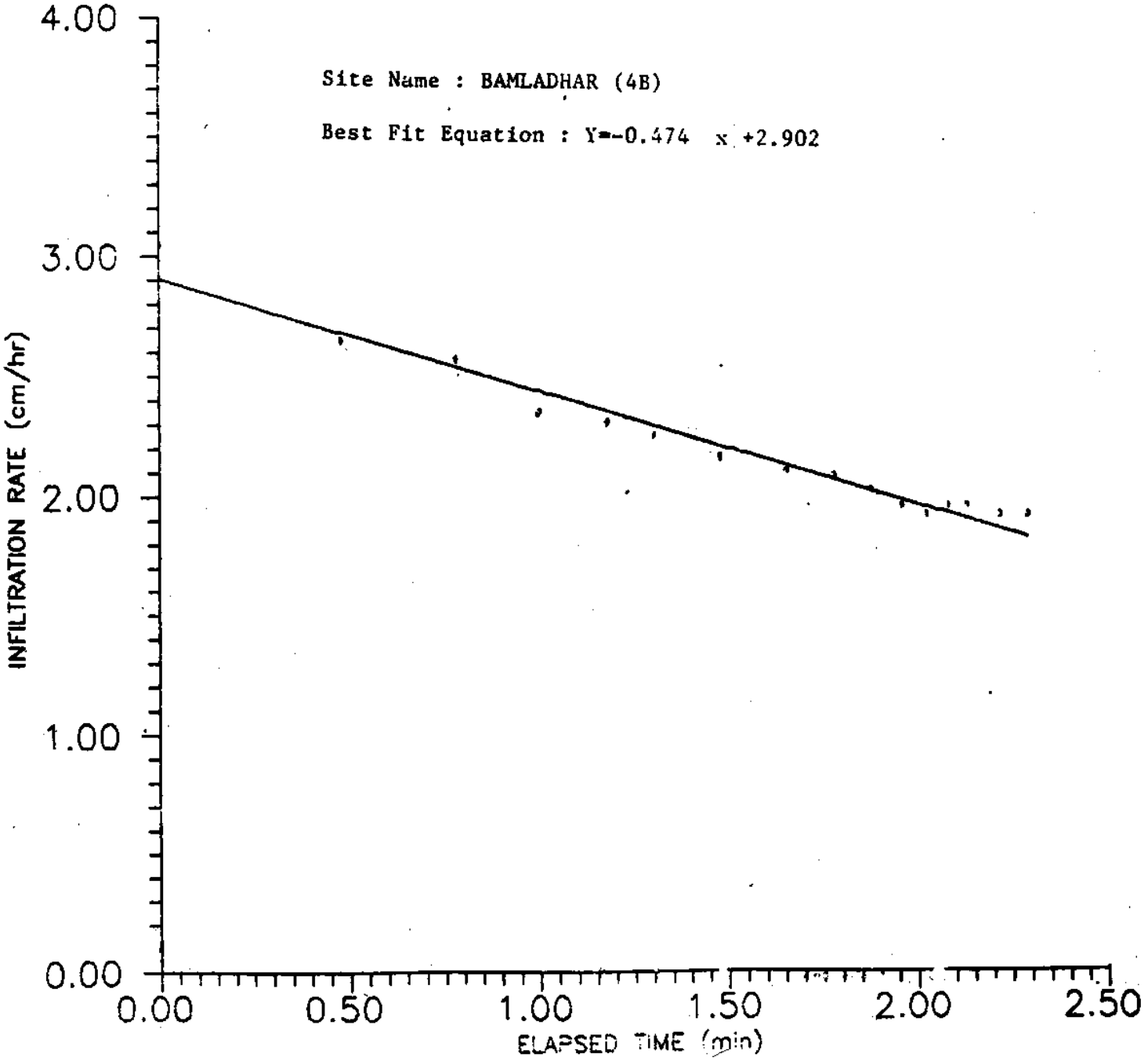

Site Name : KHAMKHERA (4D)
Best Fit Equation : Y=-0.524 x +1.488
INFILTRATION RATE (cm/hr)
2.00
1.50
1.00
0.50
0.00
0.00
0.50
1.00
1.50
2.00
2.50
ELAPSED TIME (min)

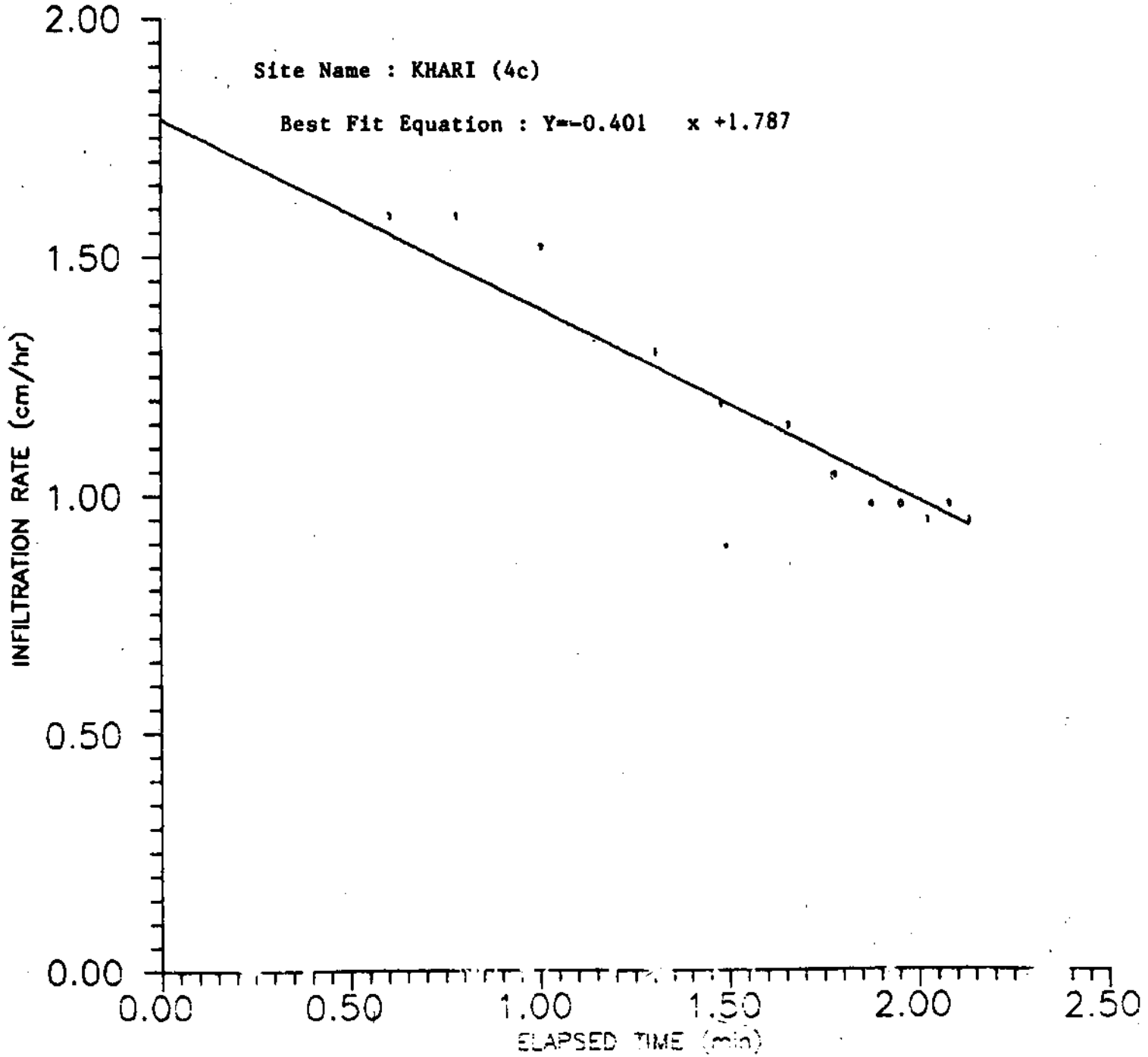
Site - BAMLADAR (4B)
Date - 24-01-90

| Elapsed Time (min.) | Infiltration Rate (Cm/hr) |
|---|---|
| 1.0 | 1085.73 |
| 3.0 | 434.29 |
| 6.0 | 361.91 |
| 10.0 | 217.14 |
| 15.0 | 195.43 |
| 20.0 | 173.72 |
| 30.0 | 141.14 |
| 45.0 | 123.04 |
| 60.0 | 115.81 |
| 75.0 | 101.33 |
| 90.0 | 86.85 |
| 105.0 | 79.62 |
| 120.0 | 86.85 |
| 135.0 | 86.85 |
| 165.0 | 79.62 |
| 195.0 | 79.62 |

Site - KHARI (4C)
Date - 23-01-90

| Elapsed Time (min.) | Infiltration Rate (Cm/hr) |
|---|---|
| 1.0 | 43.42 |
| 4.0 | 38.00 |
| 6.0 | 38.00 |
| 10.0 | 32.57 |
| 20.0 | 19.54 |
| 30.0 | 15.20 |
| 45.0 | 13.75 |
| 60.0 | 10.85 |
| 75.0 | 9.40 |
| 90.0 | 9.40 |
| 105.0 | 8.68 |
| 120.0 | 9.40 |
| 135.0 | 8.68 |


Site Name : BAMLADHAR (4B)
Best Fit Equation : Y=-0.474 x +2.902
INFILTRATION RATE (cm/hr)
4.00
3.00
2.00
1.00
0.00
0.00
0.50
1.00
1.50
2.00
2.50
ELAPSED TIME (min)


Site Name : KHARI (4c)
Best Fit Equation : Y=-0.401 x +1.787
INFILTRATION RATE (cm/hr)
2.00
1.50
1.00
0.50
0.00
0.00
0.50
1.00
1.50
2.00
2.50
ELAPSED TIME (min)

# REPORT ON ADVISORY VISITS TO THE KOLAR CATCHMENT FROM 15/1 TO 20/1, 1990 WITH EMPHASIS ON SOILS AND SOIL PROPERTIES.

BY MERETE STYCZEN

## 1. INTRODUCTION

In connection with the hydrological simulations for the Kolar Catchment, a field programme is being carried out (10-26/1). To support this study and to help summing up the results, an advisory visit was carried out.

Nine sites were visited where soil pits had been prepared and parts of the catchment were driven through by car. 1:50000 maps were made available by the NIH-staff, as well as some generalized soil maps and vegetation maps based on satelite photos (1986). The methods of soil sampling and measurements of hydraulic properties of the soils were discussed.

## 2. RESULTS

### 2.1 General observations

The catchment is generally formed from basaltic rocks. Due to local differences in parent material, topography and drainage conditions this has given rise to red loamy or clayey soils, or heavy black clay soils. Soils are generally shallow to medium deep, the deepest soils are usually used for agriculture. In the southern part of the catchment the soils are influenced by alluvial deposits, giving rise to deeper soils, probably with a loamier texture on top and rising clay content with depth, intermixed with black clay soils in the depressions and redder clay soils in higher spots of the topography.

According to a 1:250000 soil map of the area, three groups of soils are found in the area: (S1) Vertic ustifluvents, vertic ustorthents, vertic ustochrepts, (S3) vertic ustochrepts, vertic ustorthents, typic chromusterts, and (S5) lithic/paralitic ustorthents and parralitic vertic ustochrepts. The soils and land use have been traced in 1:250000 scale (Annex 1c and 1d). Land use have been transferred to the scale of 1:50000 on the preliminary soils and land use map (annex 1a).

### 2.2 Zonation

The preliminary soils and land use map of the Kolar catchment was traced from the 1:50000 topographic maps, and the land use recorded (data from 1967-1971) was marked on

the map, together with the sites visited. According to the observtions made in the field, the catchment was divided into six zones, which are descrisbed separately. Two of these zones need further investigations, and it would be an advantage if ground checks on the soils information could be carried out by members of the staff when visiting the catchment, as the exact location of the zone borders are dubious.

2.2.1 Zone 1:
The soils in this area (the very southern part of the catchment) fall under the group S1 mentioned above. The soils are partly alluvial and show some vertic properties, but they are not quite as developed with respect to cracking and not quite as heavily textured as vertisols. The texture is sandy clay to clay loam in the upper 30 to 50 cm, but the clay content increases with depth to light or heavier clay. The colour is dark brown. The profile studied (site no. 1a) was situated close to some eucalyptus trees, and showed roots to at least 1.2 m. According to observations from wells in the area the soils may be more than 8 m deep. In depressions soils with more vertic properties were found and higher in the topography and soils show redder hues. Most of this area is used for agriculture, and farmers harvest two to three crops depending on their access to water. Near the river a whole series of pumps had been installed. According to the 1967-1971-maps some riverine forest should still be available. Soil samples have been taken, but the guess is that the available water (pF 2 - 4.2) and the conductivity will be higher than for the black cotton soils.

2.2.2 Zone 2:
In zone 2 the soils are still predominantly agricultural with 1.7-1.8 m soil (site no. 1b) above soft basaltic rock (at least 1 m). The agricultural soils are a mixture of vertisols and vertic inceptisols, which are not quite as heavy. Retention and conductivity properties are expected to cover the range between zone 1 and black cotton soils. Soils not used for agriculture will be vertic entisols, meaning something like maximum half meter of black clay on top of soft rock. At the northern end of this zone, the soils grade towards the forest area in zone 3. One agriculturally used site (site no. 1c) was visited in this intermediate area, showing 20 cm of black clay on top of 60 cm soft basalt. The soils are expected to go from Inceptisols to Entisols to Lithosols.

2.2.3 Zone 3:
Most of zone 3 is forest, and characterized by 0 to 30 cm reddish loam or clay on top of 1 m rotting rock over hard rock. Most of the tree roots are found in the upper 50 cm. These soils are the paralitic/litic ustorthents of group S5.

The agricultural areas in zone 3 (i.e. site no. 2a) probably show Vertisols of approx. 50 cm over rotting basalt down to 2 m over hard rock. The profile investigated showed only 20 cm of black clay, with obvious cracks. The agricultural soils will cover the paralithic vertic ustochrepts mentioned in group S5. This zone contains only minor amounts of wasteland, but in case of deforestation, the land will no doubt turn into barren rock or wasteland.

2.2.4 Zone 4:
Zone 4 is a bit strange as the agricultural soil seems to be slightly different from other sites. The soils are rather deep (1.9 m were recorded), but with a stone content of more than 50% (weathering rocks). The texture of the soil seems to be loamy, but is different to assess in the field due to the weathering material. The wasteland in this area had 10-40 cm of soil (clay loam, i.e. site 3a) over weathering rock. According to the soil-map, the agricultural soils in this area should show vetic properties, but this does not match our field observations.

2.2.5 Zone 5:
Zone 5 is characterized by a mixture of cropland, wasteland and forest land. The typical case seems to be that the agricultural areas show a depth of 0.5 to 2m, with probably an average of 1m. In Sagoni (site no. 3c) alluvial deposits were clearly seen, so the texture is expected to vary from heavy clays in vertisols to clay loam in vertic inceptisols. The tendency seems to be that old agricultural areas, marked on the 1967-1971 map, are deeper, while land taken in later is less deep and poorer quality. Wasteland, which is found extensively in this area, usually contains 20 cm of black clays or loamier red soil on top of 1m rotten rock or directly on the rock. Forests in this area tend to be open and degraded, overgrazed and show signs of runoff. The depth is max 30 cm, the texture is loamy (brown/red) and is underlain by hard basalt.

2.2.6 Zone 6:
Zone 6 has not been visited properly. It is expected that we have touched the edge of the zone near Birpur, where there were some indications of thicker red clay loams or clays, which may be up to three meters deep on the higher plateaus. Near Birpur (site 2b), the profiles showed slightly thicker soils in the forest than usual, at least on the foot slopes (50-80 cm of clay, 40-80 cm of soft rock on top of bedrock) and in depressions (0.5 - 2.5 m black clay on top of hard basalt (Vertisols)). This is the only part of the forest where such characteristics have been acknowledged, and it fits with the 1:250000 soil map provided. It is suggested that visits to the area Khari, Lilakhari, Adabadad, Amamay and maybe Jiwantal/Kalamkhera

should be conducted in order to get a better descrisption of this part of the catchment (zone 6 and its western border).

2.2.7 Review of formerly used soil parameters:
The soil parameters used for the Kolar catchment simulations have been reported in the workshop notes as well as in the Interim report of Dec. 1988. It is clear that the soil depth is grossly over-estimated, as the estimates given for agricultural land, dense forest, open forest and weasteland are 12, 8, 3 and 1.5m respectively. The correct depths are more likely to be in the order of 0.5-2m for most of the agricutural land, and 30-50 cm for the three last classes. Only in zone 1, agricultural areas with a depth of more than 8 m are found (alluvial soils). The root zones must be adjusted according to the soil depths, and will thus be much shallower than the depths formally used in the simulations, particularly in the forest. The hydraulic conductivity in the unsaturated zone is probably in the right order of magnitude, but should of course be to much according to the measurements carried out. The conductivity in the saturated zone (8m/day) is expected to be much too high. Measurements indicate a saturated conductivity of .25 m/day or so. The formerly used parameters are added as Annex. 3.

2.3 Observations regarding the vegetation:
2.3.1 Forest :
Concerning forest, the general observation is that zone 3 forest is dense to medium dense, while most other forest is open to severely degraded. A more precise grouping will be made from the 1:250000 vegetation maps from 1986 in conjunction with the 1:50000 basemaps. The LAI values used in the former simulations (annex 3) are expected to be too high, particularly for open and degraded forest. Some suggestions for LAI-values are given in Annex 2. The degraded forest is slowly developing into wasteland in the more populated areas. Verly little if any grass was observed in the forest, particularly in the degraded forest.

2.3.2 Cropland:
The cropping pattern is one to three crops according to water availability. Three crops per year can be grown only in the very southern end of the catchment. For the other areas a rough estimate would be that the total agricultural area is cropped during the rainy season, while 75% is irrigated for a second crop. The first crop consists of soyabean, maize, sorghum, and pigeon peas while the dominating second crops are wheat, chickpea (gram), and some linseed. The water requirement for wheat would be at least 50 cm of water, while for chickpea, 15 to 20 cm would suffice. A rough estimate of ground water extraction for irrigation during the months November to March would be the following:

According to the previous simultions 27% of the catchment is covered by agricultural land. Approximately 15% will be in the southern part of the catchment where the sources of irrigation are more reliable, and some pumping takes place.

The rest, 12%, can be irrigated from wells only. In the southern part of the area, 2 or 3 crops are grown, and it is estimated that 50cm of water (requirement for a wheat crop) is applied in almost all of the area. For the rest of the area, it is estimated that 3/4 of the agricultural land is irrigated. 1/4 of the irrigated land is cropped with relatively poor wheat (water requirement = 40 cm) and the rest with chichpea and pigeon pea (grams) (water requirement =15 cm);

For the southern area:
15% * 100 * 50 cm = 75 mm based on the area of the whole catchment, or 500 mm based on the area of the southern agricultural area.

For the northern area:
12% * 75% * (25% * 40 cm + 75% * 15 cm) = 19 mm on the basis of the whole catchment, or 22mm on the basis of the rest of the total catchment (total area- southern agricultural area).

Yield levels vary considerably - from 2 qt/acre of maize to 5 qt/acre of soyabean were reported by the farmers. Taking into account the yield potential for the crops, this shows a large difference between deeper and shallower soils.

LAI values used in the former simulations should be checked against the measured values from the Barna irrigation scheme. While the data from soyabean during the rainy season probably can be used directly, the information on wheat and chickpea (gram) probably needs some correction, as the watersupply from the wells is less abundant than what is found in the Barna area.

2.3.3 Wasteland
The wasteland often shows little grass cover, and the LAI values used (1) may have to be changed somewhat over the year. A suggestion is given in Annex 2.

2.3.4 Land use changes:
For information on land use the maps of 1967-1971 were compared with the satellite based maps with information from 1986. This should give some indication of changes in agricultural areas and forest cover over the 15 years in question. Generally large areas of the forest have been degraded. The agricultural areas in the southern part of

the catchment have incresed in size. This also seems to have happened around Birjisnagar. Around other villages some land have been taken in, but particularly the wasteland areas seem to have increased due to forest encroachment. The possible future developments are, that more forest land will degrade to wasteland, while it is not likely that more land can be taken in for productive agriculture. Recent agricultural development is taking place on shallow soils.

It is proposed that a new vegetation/soil depth map should be prepared on the basis of the preliminary soil/vegetation map, on 500m grid scale.

## 3. COMMENTS CONCERNING MEASUREMENTS CARRIED OUT IN THE CATCHMENT

The measurements carried out in the field are infiltrometer tests and permeability tests. Furthermore, cores are taken for estimation of hydraulic conductivity and soil samples for texture and soil retention curves.

### 3.1 Infiltrometer tests

The tests were carried out satisfactorily in the field, and particularly for the black clays it is thought that the estimates of saturated hydraulic conductivity from these tests are much more reliable than from the cores. The tests do not give any information on surface infiltration, as the infiltrometer was placed at 10-20 cm depths. For the vertisols or soils with vertic properties this means that the cracks should not affect the measruements. The only worries for these measurements are whether the outer protection zone is wide enough and whether a less impermeable layer is encountered at depth. In a number of cases (on the shallow soils) this will be the case.

In order to collect information on the permeability of the soft rock, it was recommended that infiltration tests were carried out in a few places directly on the soft rock.

### 3.2 Permeability tests

Permeability tests are carried out at certain sites, but were not studied. The reliability of the results will rely somewhat on the outcome of the studies of the soft rock. If it turns out that the permeability of the rock may be of the same order of magnitude or more than the soil above the rock, the measurements will not be totally reliable.

### 3.3 Cores for estimation of hydraulic conductivity

The cores perform unsatisfactorily in the black clay soils. The soil becoames compressed when the core is hammered down, and the soil in the core ends up having a much higher density than the natural soil. Consequently, the conductivity to be measured in the laboratory will be too

small. For other soil types, the core methods should perform better.

### 3.4 Texture

The analyses carried out so far in order to provide data on texture have been sieving. This analysis may be of use for construction purposes, but it does not provide data on soil texture of interest for the present study. As an example it may be noted, that vertisols must contain at least 30% clay while the results of the sieving analyses show less than 2% of soil in the fraction "smaller than 70 microns". The determination of texture must be done with some kind of sedimentation analyses after dispersion of the soil in sodium pyrophosphate. In case these analyses cannot be carried out locally or in Roorkee, some of the samples should be taken to Denmark for analyses.

### 3.5 Soil retention curves

Disturbed samples will be collected for determinatison of the soil retention curves. These samples will provide reliable data at higher suctions than field capacity. Particularly for the red loamy or clayey soils, the content in the range between saturation and field capacity may be underestimated.

**ACKNOWLEDGEMENT**

This report was prepared after consultations with the NIH staff working in Kolar catchment, and is based on information from profiles already prepared or prepared during my visit. The compilation of results was greatly eased by the help and assistance of the seconded staff.

20/1-1990, 5803/MES

## RESULTS OF PRELIMINARY FIELD VISIT TO KOLAR BASIN BY DR S M SETH, MR. S K JAIN, AND MR. A K SINGH

On November 30, 1989, a visit was made to a site near Bilkisganj near village Gerukhan towards road to Imlikhera, accompanied by Shri B P Asita, Executive Engineer, Quality Control Division, Kolar Project, and his staff. The main activities include:

1. Taking slide photographs providing general view of the watershed, leaf size of a teak tree, view of river channel contributing to Patara tributory of Kolar river, root zone depth of a teak tree, and pit bored for soil sample.

2. A 1.5 inch core was taken from the site after taking a 15 cm deep hole.

3. a. Soil sample was collected of the red gritty soil for particle analysis and moisture content determination in the quality control lab at Kolar Dam site.

The moisture content of the sample was obtained as 8.10% of the particle size distribution of a five kg. sample was as follows:

Particle Size Distribution

| | Weight (kg) | % |
|---|---|---|
| + 4.75 mm | 0.000 | 0.0 |
| + 2.36 mm | 0.025 | 0.5 |
| + 1.18 mm | 0.640 | 12.8 |
| + 0.60 mm | 0.835 | 16.7 |
| + 0.30 mm | 1.150 | 23.0 |
| + 0.15 mm | 0.810 | 16.2 |
| + 75 micron | 0.700 | 14.0 |
| - 75 micron | 0.840 | 16.8 |

b. On the way to Kolar Dam site near village Nimbukhera and also at half km. from dam site, slide photographs were taken to indicate the tree leves covering the forest ground and soil profile in the borrow area of the dam.

c. Near Kolar Dam site, slide photographs were taken providing view of the dam, vegetation of whole site of the dam, main body of the dam, river flow direction, index map of the Kolar Dam, typical cross-section of the Kolar earth dam, and root zone of the vegetation near dam site.

4. A soil sample was taken of the black cotton soil for moisture content determination and particle size analysis. The moisture content was 28.20% while the particle size distribution of 5 kg. sample was as follows:

Particle Size Distribution

| | Weight (kg) | % |
|---|---|---|
| + 4.75 mm | 0.090 | 1.80 |
| + 2.36 mm | 0.152 | 3.04 |
| + 1.18 mm | 0.884 | 17.68 |
| + 0.60 mm | 0.893 | 17.86 |
| + 0.30 mm | 1.325 | 26.50 |
| + 0.15 mm | 0.712 | 14.24 |
| + 75 micron | 0.419 | 8.38 |
| - 75 micron | 0.525 | 10.50 |

A field permeability test of soil near Kolar Dam site was also done by Shri O P Dubey of Quality Control Division by digging 6 inch diameter and 30 inch deep hole in the black cotton soil (near RD 90 m and 80 m downstream of the dam). The pit was filled with loose gravel and permeability test was carried out till a constant rate was reached. The values of permeability was obtained as 336.88 ft. per year by this test.

On 1st December 1989, visit was made by Shri S K Jain, and Shri A K Singh accompanied by Assistant Engineer, Quality Control Division to the north-eastern part of the basin near Mathar-Rehti area. During this visit, slide photographs were taken for vegetation, topography, soil cracks, tree leaves, and river channel between Lawakhari and Jholiapur.

In an agricultural field near village Mathar, double ring infiltrometer test was conducted. The paddy crop had been harvested about a month back and the soil ( black cotton clay) was completely dry having cracks ranging from few mm to five cm in width and more than 15 cm deep. The infiltration test was carried out after removing 25 cm top soil cover. Both the cylinders were driven to further 15 cm and water level was kept constant in the outer ring at 25 cm. depth. The results of infiltration tests using this apparatus is as follows:

| Sl. No. | Time Elapsed (min.) | Infiltration Rate (mm/hr.) |
|---|---|---|
| 1. | 1.0 | 204.66 |
| 2. | 2.0 | 146.18 |
| 3. | 5.0 | 124.26 |
| 4. | 10.0 | 61.39 |
| 5. | 15.0 | 35.08 |
| 6. | 20.0 | 26.31 |
| 7. | 25.0 | 20.46 |
| 8. | 30.0 | 17.54 |
| 9. | 35.0 | 14.62 |
| 10. | 45.0 | 13.56 |
| 11. | 60.0 | 9.75 |
| 12. | 75.0 | 8.77 |
| 13. | 90.0 | 7.80 |
| 14. | 105.0 | 8.77 |
| 15. | 120.0 | 7.80 |
| 16. | 135.0 | 7.80 |
| 17. | 150.0 | 7.80 |
| 18. | 165.0 | 6.82 |
| 19. | 180.0 | 6.82 |
| 20. | 195.0 | 5.85 |
| 21. | 210.0 | 7.80 |
| 22. | 225.0 | 6.82 |
| 23. | 240.0 | 5.85 |

It is seen that after 4 hours, the infiltration rate was around 5.8 mm per hour.

The pressure plate apparatus is available in WRDTC, University of Roorkee with facilities for carrying out tests for determination of soil moisture tension versus moisture content relationships for 1 bar, 3 bar, and 15 bar pressures. The slide photograph of the apparatus has also been taken. It was indicated by Dr. Tripathi, Reader in WRDTC that for one soil sample, the test period may range from 2 to 3 weeks. It was also informed by him that due to small size of sample, it would be necessary to carry out tests with 2 or 3 samples at a time from the same site. In case the tests are to be carried out in WRDTC, it may involve some payment to laboratory staff.

A slide photograph has also been taken of VAX Station 3200.

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**ARRANGEMENTS FOR JANUARY 1990 FIELD INVESTIGATION IN KOLAR BASIN FINALIZED BY DR S M SETH, NIH, DR J C BATHURST, CONSULTANT AND MPID IN DECEMBER 1989**

SAMPLING SITES

Nine sites in three traverses have been identified for sampling the soil properties, covering the upstream and downstream end and centre of the basin. Their approximate locations are given in Fig. 3.1. Each site is to be visited and sampled on one day (a total of 9 days). In addition, more detailed investigation is to be carried out at one site, probably site 2b, near the Kolar Dam.

STAFF

The work is to be carried out by Mr. M Erlich (for the Consultant) and one NIH Scientist (preferably Mr. S K Jain) with one or two assistants from NIH. An advisory visit in support of the work will be carried out by Dr. M Styczen during 15-19 January 1990.

ACTIVITIES

A tentative schedule of activities is shown in the table. The activties are defined as follows:

ACTIVITY -1 (10-14 January 1990) : Mr. Erlich and Mr. Jain getting familiarized with the area and establishing work procedures. Sampling to be carried out at four sites, representing the three traverses in the basin. This will lay the basis for Dr. Styczen's advisory visit. Work to be done at each site:

- 1 soil pit to give profile, depth to bedrock and root depth;
- augering to give depth to bedrock;
- collect a soil sample for particle size analysis;
- 1 double ring infiltrometry measurement;
- 1 soil core from the middle elevation of the soil pit to give the retention curve.

Additional work in the site area: This may be done by Mr. Erlich and NIH Scientist while their assistant/s is/are doing the infiltrometry measurement and the soil pit is being dug:

- approximate surveys of channel dimension at road

crossings;
- density of tree cover and leaf area index;
- observations of ground surface roughness and slope;
- Channel bed roughness;
- Photographs of soil sampling procedure and the general area

ACTIVITY - 2 (15-19 January 1990 : Complete review of the nine sampling sites by Dr. Styczen with Mr. Erlich and Mr Jain. No extensive sampling or digging work will be done during this period. The review will cover site location and sampling procedure. Sites 1a, 1b, and 1c should be visited on one day and sites 2a, 2b, and 2c should be visited on one day. Sites 3a, 3b, and 3c may require two days because of difficulty in access.

ACTIVITY - 3 (18 January & 20-24 January, 1990) : Mr. Erlich and Mr. Jain carrying out sampling at two neighbouring locations at each site. These will indicate differences between e.g. forest and agricultural cover on hilltop and hillslope. For the principal site (with the dominant cover or geomorphology) the activities are as for Activity-1, including the double ring infiltrometry measurement). For the second site, the soil sampling should be more approximate:

- 1 soil pit
- augering
- infiltration measurement by hole-in-the-ground method

The full range of additional work should also be carried out

ACTIVITY 4 : A detailed study at one site (probably site 2b). This will be carried out as Activity 3, but additional soil cores will be taken around the principal sampling site. Instead of taking just one core, cores should be taken at three elevations in the soil pit. In addition, four cores from the soil surface should be taken at points 100 m north, south, east and west of the pit. These will provide information in the spatial variability of the soil properties.

In total, fifteen soil cores are to be returned to Roorkee for analysis - seven from the detailed study site and one each from the remaining eight sites.

EQUIPMENT AND FACILITIES

a) two jeeps for the two field teams;
b) drivers and four diggers;
c) large volume water containers for the infiltration measurements;
d) 4 spades, 3 augers, 3 tape measures, 3 surveying

staff, 1 metre rulers, 1 hammer for knocking cores into the soil, 30 plastic bags for soil samples;

e) NIH will provide a double ring infiltrometer and around 25 core tubes;

f) Accommodation will be provided at the Rehti and Birpur guest house for two or three nights to save the travel back to Bhopal when working on traverses 1 and 2.

g) The Kolar project circle office will be making assessment of soil depth throughout the basin from existing wells. If the information cannot be obtained for the deeper soils of the agricultural area between Jholiapur and Satrana, a drilling rig may be used to drill 1-5 holes at sites next to the access roads.

ADDITIONAL SURVEY

In the period upto 10 January, the Kolar office is to carry out soil studies at about twenty sites distributed through the basin to give:

- Soil depth from pits, auger holes and wells;
- Soil samples to be analysed for size distribution;
- Saturated infiltration rate from the hole-in-the-ground method;
- permeability from three undisturbed samples, from the middle elevation of the soil column;
- location of sample sites on a tooographic map.

Schedule of Activities

| Date | | Staff | Activity | Site | Accommodation |
|---|---|---|---|---|---|
| January, 1990 | | | | | |
| W | 10 | ME/SKJ | 1 | 2c | Bhopal |
| T | 11 | " | 1 | 1a | Rehti |
| F | 12 | " | 1 | 1b | Bhopal |
| S | 13 | " | 1 | 3c | " |
| S | 14 | " | * | * | " |
| M | 15 | MS/ME/SKJ | 2 | 2a-2c | " |
| T | 16 | " | 2 | 1a-1c | " |
| W | 17 | " | 2 | 3c, 3b | " |
| T | 18 | ME/SKJ | 3 | 1c | " |
| F | 19 | MS/ME/SKJ | 2 | 3a, 3b | " |
| S | 20 | ME/SKJ | 3 | 3a | " |
| S | 21 | " | * | * | " |
| M | 22 | " | 3 | 3b | " |
| T | 23 | " | 4 | 2b | Birpur |
| W | 24 | " | 3 | 2a | Bhopal |
| T | 25 | " | * | * | " |
| F | 26 | Republic Day (Holiday) | | | |

Staff: ME - M. Erlich, SKJ - S K Jain, MS - M. Styczen

* Open days to allow flexibility in the programme. Possible additional activities include investigation of potential evaporation studies for different land uses carried out at neighbouring agricultural research stations.

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## PROJECT COORDINATOR

S M Seth

## STUDY GROUP

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