INSTITUT FRANÇAIS DE RECHERCHE SCIENTIFIQUE POUR LE DÉVELOPPEMENT EN COOPÉRATION
Centre de Montpellier, 2051, Avenue du Val de Montferrand — B.P. 5045
34032 MONTPELLIER CEDEX 1 — ☎ 67.61.74.00 — Télex ORST MPL 485 507 F — Télécopie 67 54 78 00

NEW DATA COLLECTION AND TELEMETERING EQUIPMENT FOR THE YELLOW RIVER

PROJECT DOCUMENT

JUNE 1989

Pierre RIBSTEIN

DEPARTEMENT DES EAUX CONTINENTALES
MONTPELLIER (FRANCE)

CONTENTS

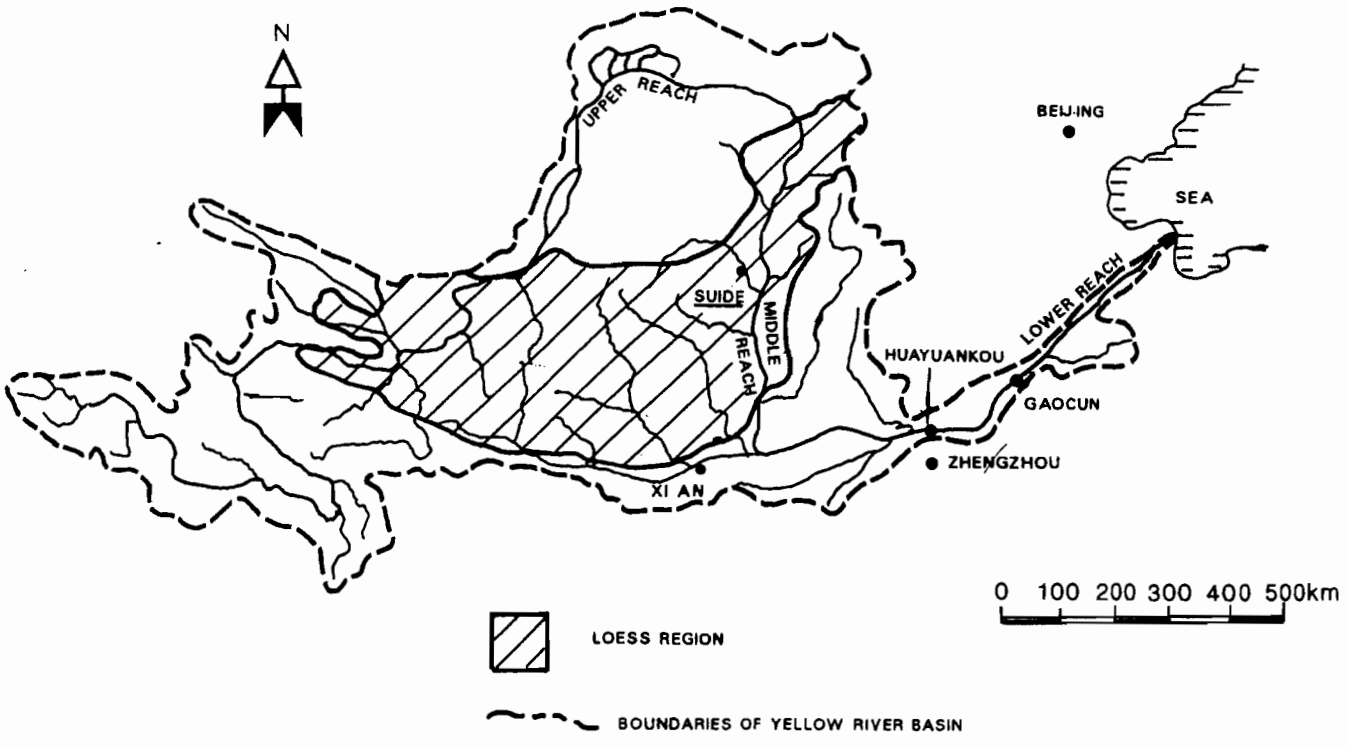


Fig. 1 : sketched map of the Yellow River valley

INTRODUCTION

This note presents the report of a mission from the 1st to 20th of May 1989 ; this mission was the first step of a French-Chinese project concerning the Yellow River and supported jointly by the Yellow River Conservancy Commission (YRCC) and the French Ministry of Foreign Affairs.

The aim is focused on the application of new technologies (satellite telemetering equipment, remote sensing data, mathematical models) in the study and the management of soil and water resources of the Yellow River. Two zones are concerned by the project : the Middle Reach with the problems of erosion in the Loess Plateau, and the Lower Reach with the problems of moving river bed and aggradation/degradation.

Three persons attended this mission: Mrs VINCHON (BRGM) for the geomorphological aspects, Mr BELLEUDY (LHF) for the modeling aspects, and Mr RIBSTEIN (ORSTOM) for proposals of new hydrological equipment.

The time table of the mission was as follows (see Fig. 1 for the locations) :

- May 5-6 : meetings at YRCC, ZHENGZHOU
- May 7-10 : trip to Middle Reach (ZHENGZHOU-XI'AN-SUIDE)
- May 11-12 : field trip in SUIDE county
- May 13-15 : return trip to ZHENGZHOU
- May 16-17 : field trip to Lower Reach (HUAYUANKOU-GAOCUN)
- May 18 : meetings at YRCC, ZHENGZHOU

An important part of our time during this mission was used to draw the guidelines relevant to the project with the engineers of the "Automatic Flood Telemetering and Forecasting and Computer Centre", of the YRCC.

We take the opportunity to thank the staff of YRCC for their welcome, especially in ZHENGZHOU, XI'AN and SUIDE.

This note is divided in 3 parts : the representative catchments visited in the Middle Reach, the problems of hydrological measurements in the Lower Reach and some proposals for setting up new equipment for the both reaches.

1. REPRESENTATIVE CATCHMENTS IN THE MIDDLE REACH

The guiding ideology of the French-Chinese cooperative project of the Loess Plateau is : "the study on the pattern of soil and water loss of the Loess Plateau, monitoring of management status and policy decision of comprehensive management are a complex system engineering, the developement of computer technology and application of remote sensing technology have provided powerful tools for a complishing system engineering".

The short-term objective of this project is to set up a practical small watershed geographical information system, and improve the soil erosion model and sand yield model for a pilot area. With the engineers of YRCC, we chose by common agreement the SUIDE county as the pilot area. Many reasons can be put forward to explain our selection :

- SUIDE county is a typical example of gullied rolling loess region which constitues the main part of Loess Plateau,

- the loss of soil is severe and the long term average of sediment delivery is the highest of the Loess Plateau,

- much work has been done in drawing up programs for remedy of soil erosion, resorting to biological and engineering control measures and conservation farming. The photos 1 and 2 show two kinds of engineering practices (terraced fields and silt-trap dams),

- many representative watersheds and experimental plots have been observed for more than 10 years during the period 1953-1970. Some of these observations continue up to the present, and others have been set up again a few years ago. Thus, long time series of hydrological data are at our disposal in this county,

- in the SUIDE experimental station, there is a staff of 180 persons. These engineers and technicians are interested in working with us, in order to improve their measurements and to advance in the knowledge of erosion and runoff processes.

But, we have also to note a disadvantage : SUIDE is far from ZHENGZHOU, 4 days by car.

Photo 1 : terraced fields in JIUYUANGOU

Photo 2 : silt-trap dam in JIUYUANGOU

In SUIDE county, we visited 5 representative catchments (see Fig. 2 for the locations) :

QIAOGOU gully (runoff plot)	:	area = 0.488 km^2
XINDIAN gully (testing plot)	:	area = 1.44 km^2
BEIJIAMAO gully	:	area = 41.2 km^2
JIUYUANGOU gully	:	area = 70.7 km^2
CHABAGOU gully	:	area = 187 km^2

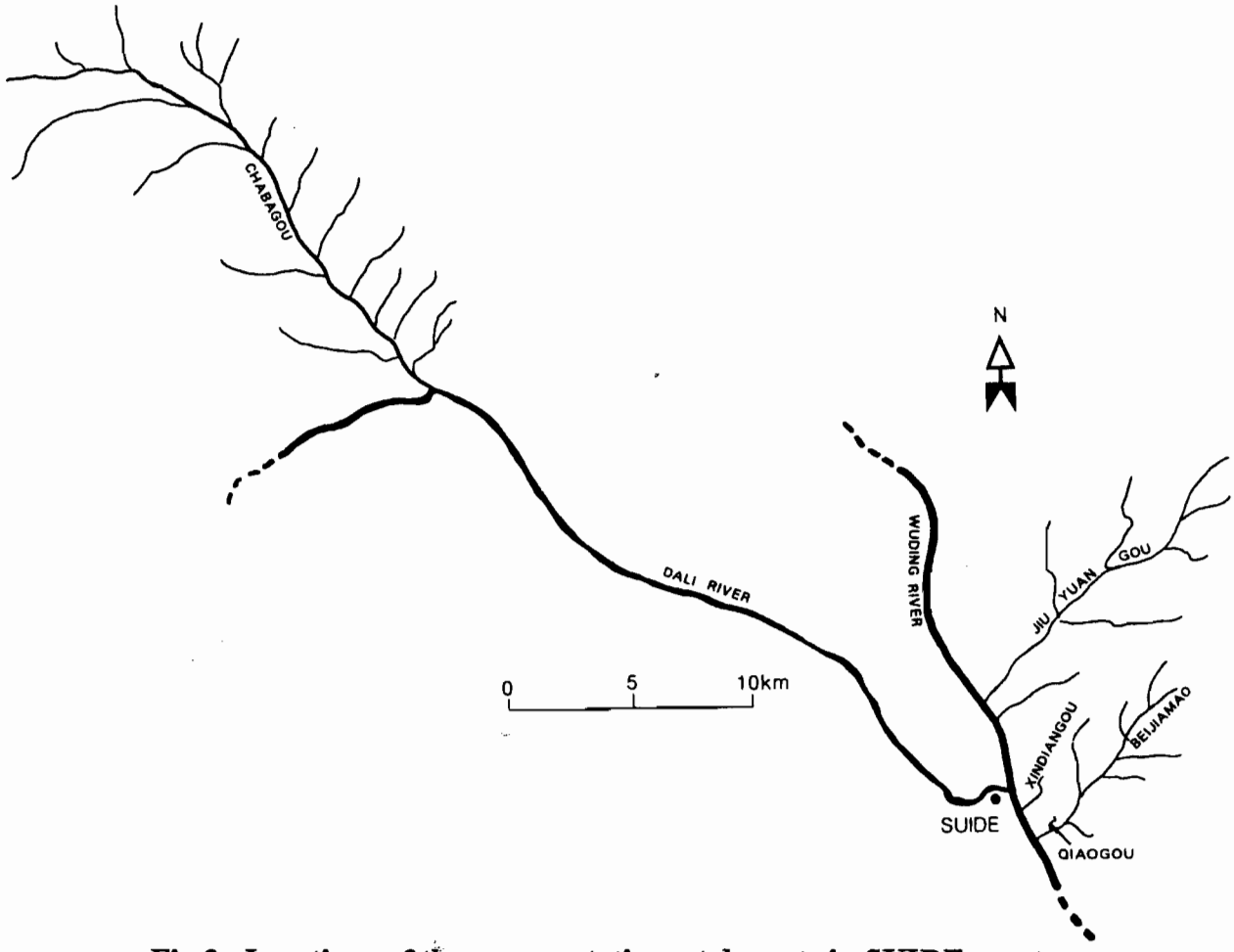


Fig 2 : Locations of the representative catchments in SUIDE county

The purpose of this chapter is to make a hydrological description of these catchments, in order to present in the third chapter the required equipment which could improve the measurements, and thus help to adjust the soil erosion model. But we shall not speak about the XINDIAN gully, the testing plot where we saw many interesting biological and engineering measures but where there is no equipment for sediment and water measurements.

*** QIAOGOU gully (runoff plot)**

In a little gully, the area of which is 0.488 km^2, the engineers and technicians of the SUIDE experimental station are studying soil and runoff processes at different scales. There are a few terraces on the top of the mounds, and it is possible to consider that this watershed is in a natural condition because there is no engineering measure like silt-trap dam (check dam). Equipment for sediment and water measurements concerns the outlet of the catchment but also 2 gullies, 2 cultivated fields with different slopes on the top of a mound, and a steep slope below the edge of the mound.

The equipment of the whole basin includes :

- 1 triangular weir, at the outlet of the basin,
- 2 Parshall weirs for the gullies,
- several bed load traps with staff gauges,
- 6 recording raingauges.

The measurements of sediment concentration are made by hand with samplers (horizontal samplers or bottles) of about 1 litre capacity. For water level, the staff gauges are read as many times as necessary. In the past, they tried to use float actuated recording gauges to record the water levels but they had too many problems with this kind of material in muddy water and they have abandoned these recorders.

The observations on this catchment started in 1986. The maximum observed discharge is about 1 $m^3.s^{-1}$ at the outlet of QIAOGOU. The maximum sediment concentration is above 1200 $kg.m^{-3}$. There are about 8 floods each year, and the yearly average of rainfall is 500 mm. The average rise time of the flood is about 15 minutes.

The observations of QIAOGOU gully are not published at present.

*** BEIJIAMAO gully**

The above mentioned catchment, QIAOGOU gully , is part of the catchment of BEIJIAMAO gully . The total area of BEIJIAMAO is 41.2 km^2. There are 2 periods of observations, the first one from 1959 to 1969, the second one from 1986 to present. During the former period, there were 2 hydrometric stations, one at the outlet of the basin and an other one in the middle of the basin (area $\simeq$ 20 km^2). Now, only the outlet station remains.

The outlet station includes staff gauges (see photo 3) and float measurements for water discharge. In this station, there is a stable channel because of the bed rock. Except QIAOGOU, the rainfall equipment includes 6 recording raingauges. The sediment measurements are the same as in QIAOGOU ravine, namely horizontal sampler or bottle.

40 silt-trap dams are built on small gullies of this watershed, but these dams have small capacities and they are nearly filled by sediment depositions. There is no dam on the main river. Many fields are terraced on the top of the mounds. All the historical data of this watershed are published but the recent data are not yet published. The maximum observed discharge is 432 $m^3.s^{-1}$ and the maximum sediment concentration greater than 1000 $kg.m^{-3}$. The long term annual average of sediment delivery is 18000 $t.km^{-2}$.

*** JIUYUANGOU gully**

This ravine has a watershed of 70.1 km^2. The outlet is controlled by a big silt-trap dam (height=31.5 m, capacity=3.5 millions m^3), built in 1953. The hydrometric station is inside the spillway of the dam, and recently a triangular weir has been built for discharge measurements at the extremity of the spillway.

Many engineering measures have been set up for water and soil conservancy on this catchment : 242 silt-trap dams, amongst them 16 dams have a height greater than 20 m, all the gullies with an area greater than 1 km^2 have at least 1 silt-trap dam, many plantations in terraced fields on the tops of mounds ....

At the beginning of the observations 30 years ago, there are 12 hydrometric stations and 30 raingauges. Now, there are only 2 hydrometric stations and 8 raingauges.

Without engineering measures, before 1960, the maximum observed discharge was 400 $m^3.s^{-1}$; during the recent period, only a maximum of 180 $m^3.s^{-1}$ was observed. In 1977, a heavy storm broke down 5 dams and the maximum discharge at the outlet of the catchment was 1100 $m^3.s^{-1}$.

Having regarded the field conditions of SUIDE county, the JIUYUANGOU gully may be considered as representative of the well-managed watersheds with many engineering measures for soil and water conservancy.

*** CHABAGOU gully**

With an area of 187 km^2, CHABAGOU gully is the biggest watershed that we visited. There is an hydrometric station at the outlet of this basin, with staff gauge, cable way system (see photo 4) and currentmeter for discharge measurement, and a horizontal sampler (capacity=1 litre) to measure the sediment concentration. This sampler is set up at the extremity of a 1 meter stick and the sediment concentration is measured on half depth near the left steep bank of the river. In this station, the observations began in 1959 and continue to present.

There is an other hydrometric station (area=90.1 km^2) on the main river with the same kind of equipment and the same period of observations. From 1959 to 1972, there were 15 hydrometric stations on the main river and also on many runoff plots. 21 recording raingauges and amongst them, 13 began in 1959 and 8 in 1981. The papers of these recorders are changed after each rainfall.

Before 1969, there were only 80 small silt-trap dams. Now, there are 430 silt-trap dams in the gullies of this catchment but there is no dam on the main river. Many fields on the top of the mounds are terraced.

At first, with a few engineering measures, water discharges and sediment concentrations were greater than now ; at the outlet station, the maximum observed discharge was 1520 $m^3.s^{-1}$ in 1966 and the maximum observed concentration was 1200 $kg.m^{-3}$. Recently, the maximum peak discharge was 185 $m^3.s^{-1}$ in 1988. There is no stable channel at the outlet station and the degradation of the river bed has been greater than 1 m during the last 20 years.

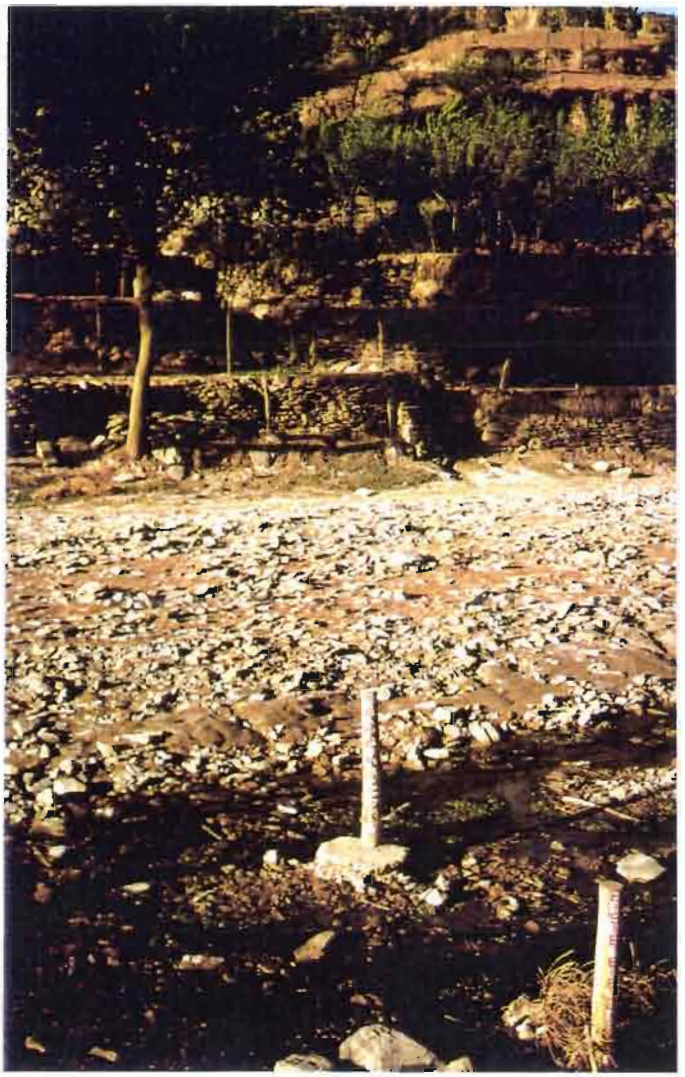
*** Comments**

These visited catchments are representative of the zone of the Loess Plateau with the most severe erosion. There are 2 kinds of catchments : the catchments in nearly natural conditions like BEIJIAMAO gully and the well-managed catchments like JIUYANGOU gully. CHABAGOU gully is intermediate between these 2 types.

The locations for the new hydrological equipment depend on the pilot area for the soil erosion model. But, for the modeling aspects, it would be better to study at first small watersheds, in "natural conditions", to take into account the physically knowledge of erosion process, and to use the existing hydrological data.

Photo 3 : BEIJIAMAO

outlet station with
staff gauge and
stable channel



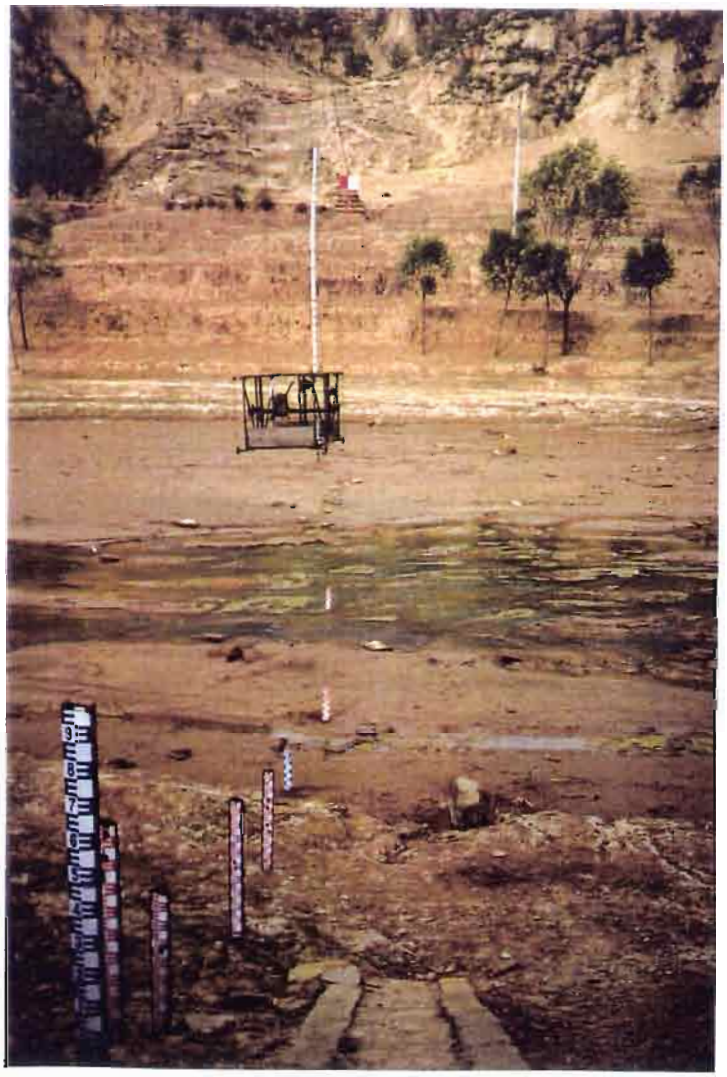


Photo 4 : CHABAGOU

outlet station with
staff gauge and
cable way system

(the river bed scour
has been greater than 1 m
during the last 20 years)

BEIJIAMAO gully is the best catchment to begin the modeling work, because of the data of QIAOGOU gully, and also because of its small area in natural conditions : the smaller the area, the more physical the model ! The model must use , as input, the data from remote sensing and for these data, QIAOGOU is too small.

The outlet station of BEIJIAMAO is a good hydrological station because of the stable channel, but it needs a cable way system for accurate discharge measurements, as in CHABAGOU gully. If BEIJIAMAO gully is selected as the pilot area for modeling work, the required equipment should be install in this basin. A very accurate raingauge recorder and an electronic water level recorder with pressure sensor should improve the measurements in this basin. The third chapter presents the proposals about this equipment.

After calibration of the model with data of BEIJIAMOU gully, it should be interesting to test the model, with the same values of parameters, on the data of CHABAGOU gully. The difference between computed and observed discharges should quantify the influence of engineering measures on soil and water loss.

But one of the main problems of the YRCC staff is to locate the sites of engineering measures (silt-trap dams, terraced fields). Thus, the first work of the project is to recognize and to count these silt-trap dams and terraced fields from remote sensing data. To make an accurate study with SPOT images, the size of the selected zone must be about 1000 km^2, including all these visited catchments.

A last remark could be given on the hydrological uniformity of the small catchments in SUIDE county. The maximum observed sediment concentration is nearly the same for the 4 catchments in natural conditions, about 1200 $kg.m^{-3}$. Many scientific papers about erosion of the Middle Reach note that when the flow discharge surpasses a certain value, the variation of sediment concentration becomes small and gradually tends to a stable value. This maximum value does not depend on the size of the catchment.

2. HYDROLOGICAL MEASUREMENTS IN THE LOWER REACH

Only 2 days of field trips were devoted to the Lower Reach, from HUAYUANKOU to GAOCUN. On this reach, the main task assigned to the staff of the YRCC concerns flood forecasting with conditions of the moving river bed and aggradation/degradation.

On the first draft of the project, the ORSTOM expert was not involved in this reach, because it is not considered in the plan to provide some telemetering equipment on the Lower Reach.

But the problems of hydrological measurements are nearly the same as in the Middle Reach, that is to say :

- difficulties to set up water level recorders with muddy and moving river bed. With a classical float gauge, the problem concerns at first the stilling well which becomes disfunctional after a short period in the field : well outside water, float locked by sediment,...

- impossible to measure automatically the sediment concentration. An automatical sampler would be locked by sediment and a sediment recorder with a gamma sensor cannot be left in the field unattended.

Some electronic recorders could improve the measurements (water level, sediment concentration) on the Lower Reach. In the Hydrological Laboratory of ORSTOM, we now make some experiments about pressure sensors in muddy water. But these experiments are made in the laboratory because there is no river in France to test this equipment. The Yellow River project could be a good opportunity for us to make these experiments in the field.

Thus, as a first step, it is necessary to carry out some field tests and HUAYUANKOU station seems to be the best site for these experiments, because of the proximity of ZHENGZHOU, and also because of the existing bridge where it is possible to fix the water level sensors.

Photo 5 : HUAYUANKOU

staff gauge and
float gauge recorder

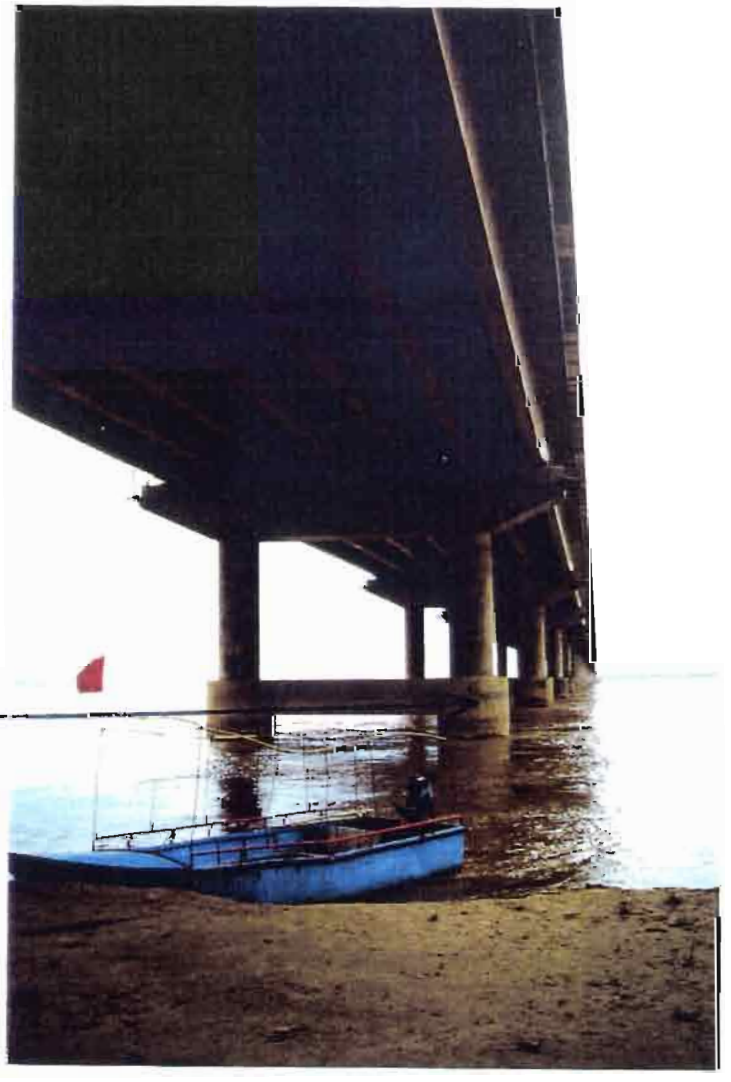


Photo 6 : HUAYUANKOU bridge

possible location
for pressure sensors

The bridge is about 500 m upstream of the staff gauge and float gauge, on the right bank of HUAYUANKOU station (see photos 5 and 6). The maximum velocity near the bridge is about 5 $m.s^{-1}$ and the maximum peak discharge, 22000 $m^3.s^{-1}$. The average difference between maximum and minimum water level is about 2 m.

In Fig. 3, we see 2 cross sections for 2 dates at HUAYUANKOU station. The important difference of level between the 2 cross sections gives an idea of the sediment deposition in the Lower Reach.

3. PROPOSALS FOR NEW HYDROLOGICAL EQUIPMENT

The idea for these proposals is to improve the measurements with new technologies with an objective of advancing the knowledge of the soil and water loss processes.

We describe in this chapter our proposals : material, justification, location, experiment. This equipment is well tested by ORSTOM for several years in France, Africa and South America but the field conditions of the Yellow River need some more experiments, especially for water level recorders.

Four hydrological recorders are required : 1 raingauge recorder and 3 water level recorders. All the collected data will be transmitted by satellite, with the ARGOS system, to the headquarters of YRCC in ZHENGZHOU.

*** for the Middle Reach :**

- a more accurate raingauge recorder : there is a good relationship between soil loss and maximum intensity of rainfall during a short time. With a raingauge recorder like OEDIPE (see enclosure technical papers), the sensor is a classical tipping buckets but the accuracy in time for the recorder is less than 1 minute and the preprocessing of the data is automatically made by a microcomputer. The data from this raingauge recorder could be very useful to set up the soil erosion model, by means of a precise relation between soil loss and intensity of rainfall for different durations. The best location for this raingauge recorder is the center of the QIAOGOU gully where the staff of the SUIDE experimental station made some studies of erosion processes on small areas.

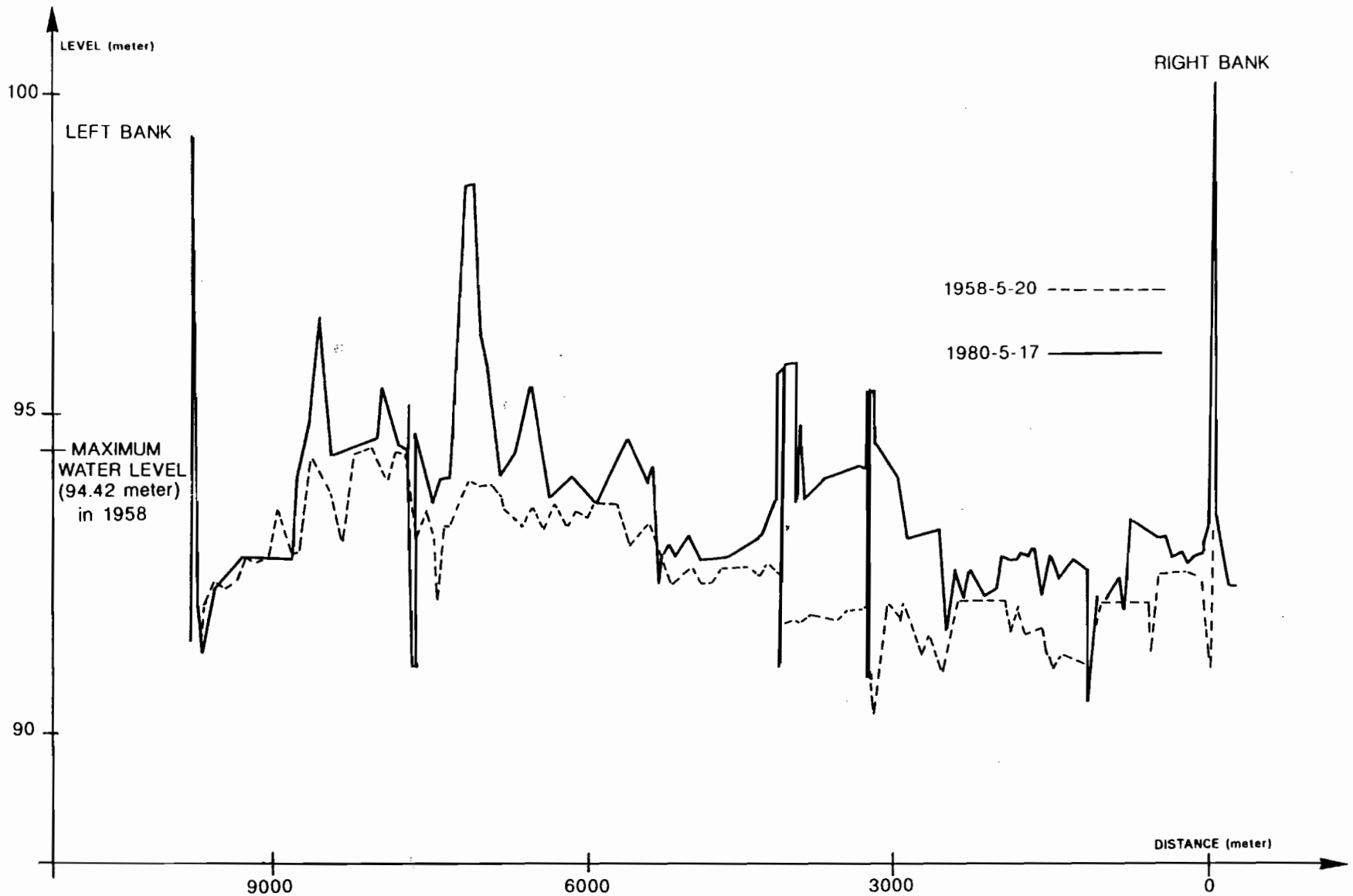


Fig-3- CROSS SECTION IN HUAYUANKOU

- an electronic water level recorder : until now the water levels are read on staff gauges because of the difficulties to install and maintain float actuated recording gauge in the field conditions of the Loess Plateau. It would be interesting to test a water level recorder like CHLOE with its pressure sensor (see enclosure technical papers). The measurements with CHLOE are pressure measurements ; the change from pressure value to water level value needs some field experiments. The simultaneous values from pressure sensor, staff gauges and sediment concentration samplers should allow the plotting of rating curves, pressure value - water level, for different values of sediment concentration. This recorder could be set up on the outlet station of BEIJIAMAO gully.

- complementary equipment : the data from raingauge recorder (OEDIPE) and from water level recorder (CHLOE) are stored in the same kind of EPROM memory. The required equipment includes 4 memories (2 for each recorder). To make a preprocessing of the data in SUIDE, a "memory reader" is also required which can be linked with an IBM compatible micro-computer, and an eraser so the memory can be reused after reading the data. Finally, a terminal is required to test the recorder and to change the parameters of the station.

*** for the Lower Reach :**

- 2 water level recorders : the idea is to set up 2 water level recorders (CHLOE) in HUAYUANKOU station, with a given gap (for instance 2 m) between the 2 pressure sensors. With the difference between both measurements, it will be possible to compute the density of water, and thus to get the values of sediment concentration. With the water density, it will be possible to translate automatically a pressure measurement into water level. The 2 sensors can be very easily fixed on the bridge of HUAYUANKOU, downstream side and on the right bank. The measurements of water density with 2 pressure sensors need some tests. The laboratory experiments were performed in 1989 by the Hydrological Laboratory of ORSTOM in MONTPELLIER and are supported by ORSTOM. The field experiments could be made in HUAYUANKOU, with YRCC and ORSTOM, within the framework of this project.

- complementary equipment : the same as for the Middle reach, that is to say, 4 EPROM memories, a "memory reader", an eraser, and a visualization terminal. It is also necessary to acquire some spare parts : 1 pressure sensor and 1 electronic card for CHLOE.

*** telemetering for the both reaches :**

- the context : this project could be a good opportunity for the staff of YRCC to get an experience with satellite telemetering systems. There are only a few experiments in CHINA with data collection satellite system, and none in the Yellow River basin. Currently, the telemetering system is based on UHF/VHF microwave and telegram for flood forecasting on the Lower Reach. On the Middle Reach, the telemetering system includes only telegram and radio. This existing system needs many hours to collect all the data of the Middle Reach stations and the time for data collection should be improved by ARGOS system.

- the equipment : up to the present, only the ARGOS satellite system allowed direct receiving of telemetering data by a ground station in ZHENGZHOU, without any intermediary. The required equipment includes : 4 electronic cards on the 4 recorders expected on the Middle and Lower Reach. (see enclosure technical papers for more details on these data collection platforms), 1 direct readout station in ZHENGZHOU.

CONCLUDING REMARKS

This French-Chinese project could be a good opportunity to test some new hydrological equipment under the field conditions of the Yellow River. It is a big challenge to try to collect and to transmit by satellite water level and sediment concentration data with so muddy flow. But the interests at stake are very important for flood forecasting and water management of the Yellow River.

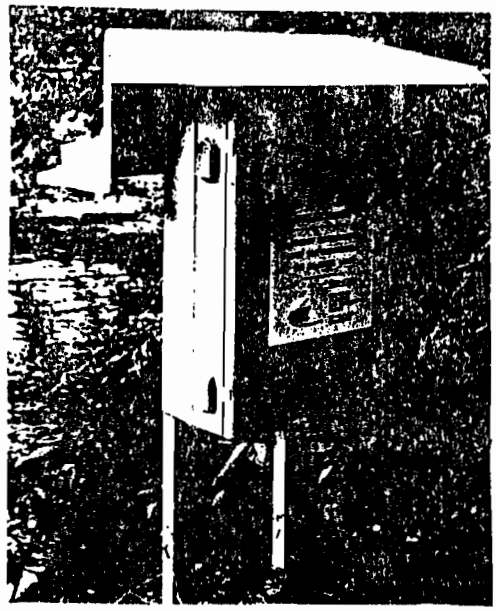
To make some field experiments and to use the telemetering data as input of the soil erosion model, this material would be set up in the field at the beginning of the project. A one month mission for 2 engineers of ORSTOM is needed to install the material and to provide some training. The recorders could be install in HUAYUANKOU, together by ORSTOM and YRCC, as a part of the training course ; the recorders could be install after on the Middle Reach, only by the YRCC.

The objective of the equipment part of this French-Chinese project is to set up specific material, according to the specific field conditions of the Yellow River. Improving hydrological measurements is the first constituent part of the work of harnessing the Yellow River.

APPENDIX

TECHNICAL PAPERS

ABOUT EQUIPMENT



PH 11

Argos Hydrological Data Collection Platform

INTRODUCTION

PH 11 self-powered platforms are designed to acquire hydrometeorological data (water depth and temperature, rainfall) and transmit it via the Argos polar-orbiting spacecraft.

Operated in conjunction with an Argos SRDA 86 direct readout station, the platforms can be used to establish a complete remote monitoring network for river basins, dams, etc.

DESCRIPTION

The PH 11 is compact, rugged, simple to install, and is self-powered (battery charged by solar panel).

The platform comprises:

- limnograph (piezoresistive pressure sensor type) plus water depth sensor, or limnograph (vibrating-wire pressure-gauge type) and barometric pressure sensor,
- tipping-bucket rain-gauge *(option)*,
- ruggedized polyester shelter, containing a leaktight case which in turn houses the sensor data acquisition electronics and Argos Platform Transmitter Terminal (PTT),
- omnidirectional Argos antenna,
- battery, complete with voltage regulator,
- double roof, also supporting solar panel,
- *option: plug-in static 64-kB memory to store water depths over long periods (several months to several years, according to frequency of readings).*

CEIS ESPACE

Z.I. THIBAUD - RUE DES FRÈRES-BOUDE - 31084 TOULOUSE CEDEX (FRANCE)
TÉL. 61 44 39 31 - TÉLEX 521 039F — TELEFAX 61 41 01 30

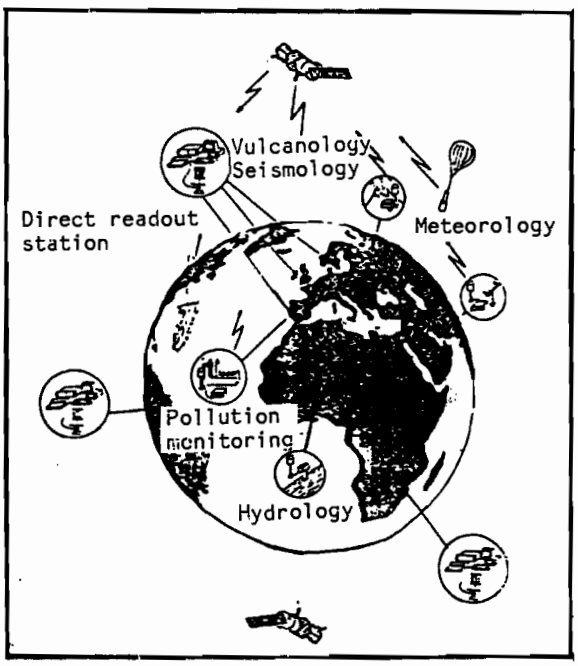
TECHNICAL CHARACTERISTICS

Antenna
Fixed, omnidirectional:
- Frequency range: 135 - 140 MHz
- Gain: 3 dBi
- Acquisition of VHF signal for elevation angles >5°
- Overall height: 3 m
- Weight: 3 kg

Preamp
Fixed to antenna mast
- Tuned to frequency 13
- Noise figure: < 2 dB
- Gain: 30 dB

Telemetry receiver
Integrated in case
- Receive frequencies: 136.77 and 137.77 MHz
- Passband: 27 kHz

Telemetry synchronizer
Integrated on IBM PC format board. Integrates bit sync, frame sync and message regeneration functions
- Bit rate: 8320 bps
- Bit error rate: < 2 dB from theoretical



Data processing subassembly
The hardware comprises:
- IBM PC XT or AT (or compatible) micro-computer
- Color graphics monitor
- High-speed 132-column printer

ENVIRONMENTAL CONDITIONS

External equipment
- Wind speed: 150 km/hr
- Temperature:
  Operational: -30°C to +60°C
  Storage: -40°C to +70°C
- Relative humidity (RH): 0 to 100%

Internal equipment
- Temperature:
  Operational: 10°C to +45°C
  Storage: -20°C to +65°C

POWER SUPPLY
Voltage: 110 or 220 V, ± 10%
Frequency: 47 to 63 Hz
Option: backup power supply with endurance of 15 or 30 minutes

PRINCIPLE OF THE ARGOS SYSTEM
The Argos system comprises:
- two satellites,
- the set of user platforms,
- satellite onboard instruments to receive, process and retransmit data,
- processing centers
- SRDA 86 direct readout stations.

The two satellite orbits are circular, polar and heliosynchronous (i.e. intersecting the Equator at fixed local solar times). At any given instant, the satellites see all platforms situated within a 5000-km-diameter circle.

Number of satellite passes over 24 hours, as a function of latitude:

0°:	4 to 6	65°:	16 to 20
20°:	6 to 8	90°:	20 to 24
45°:	8 to 10		

CEIS ESPACE
Z.I. THIBAUD - RUE DES FRÈRES-BOUDES - 31084 TOULOUSE CEDEX (FRANCE)
TÉL. 61 44 39 31 - TÉLEX 521 039F — TELEFAX 61 41 01 30

Please contact us for any information you may require