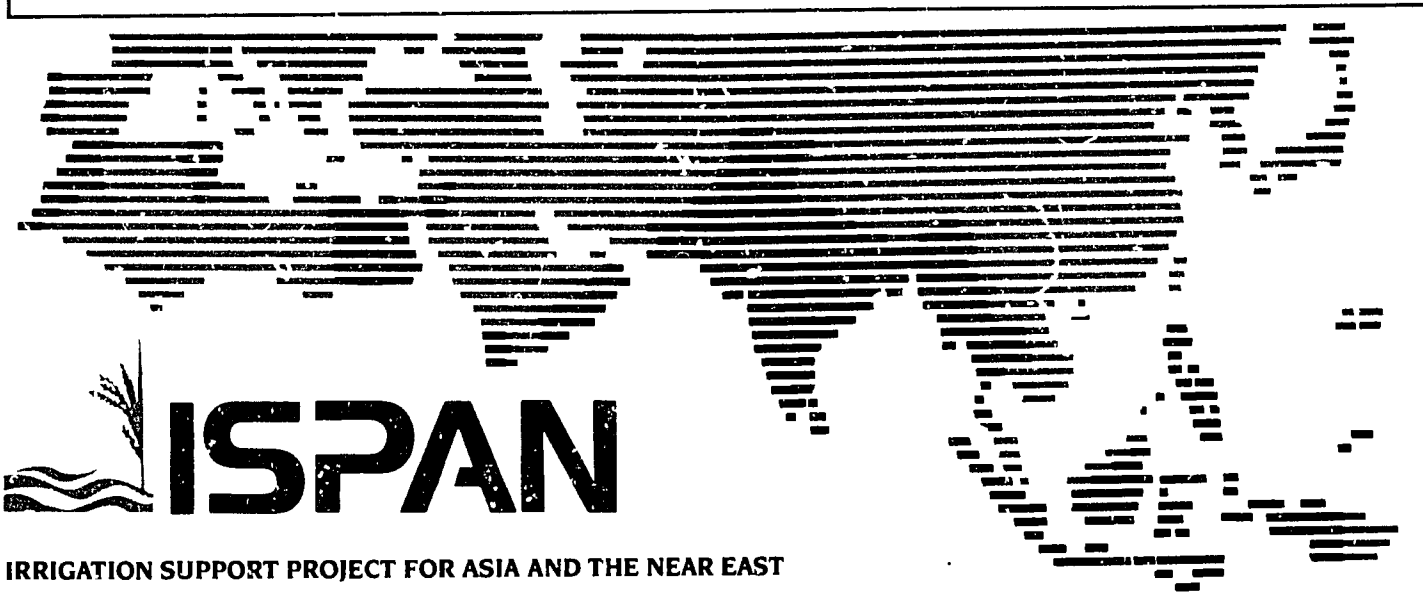
PN-ABK-308

Madhya Pradesh Minor Irrigation Project
Bureau of Design for Hydroelectric and
Irrigation Projects (BODHI)

STRENGTHENING THE CAPABILITIES OF THE HYDRAULIC RESEARCH STATION

ISPAN Activity No. 622A

ISPAN Report No. 33



IRRIGATION SUPPORT PROJECT FOR ASIA AND THE NEAR EAST

Sponsored by the U.S. Agency for International Development

ISPAN

IRRIGATION SUPPORT PROJECT FOR ASIA AND THE NEAR EAST

ISPAN Technical Support Center
Room 1001
1611 North Kent Street
Arlington, Virginia 22209-2111
U.S.A.
Phone. (703) 243-7911
FAX: (703) 525-9137
TELEX: 276532 ISPAN UR

INTEGRATED IRRIGATION MANAGEMENT RESOURCES

Camp Dresser & McKee International Inc. (Prime Contractor)
CARE
Cornell University
Development Alternatives, Inc.
Harza Engineering Company
International Science and Technology Institute, Inc.
Training Resources Group
The University of Arizona

ISPAN Report No. 33

Madhya Pradesh Minor Irrigation Project
Bureau of Design for Hydroelectric and
Irrigation Projects (BODHI)

STRENGTHENING THE CAPABILITIES OF THE HYDRAULIC RESEARCH STATION

Prepared for the USAID Mission to India,
under ISPAN Activity No. 622A

by

S.V. Chitale
and
James E. Borg

February 1990

Irrigation Support Project for Asia and the Near East
Contract No. ANE-0289-C-00-7044-0, Project No. 3-7631510
is sponsored by the Asia/Near East Bureau
U.S. Agency for International Development
Washington, D.C. 20523

TABLE OF CONTENTS

ACRONYMS iii

ACKNOWLEDGEMENTS v

EXECUTIVE SUMMARY vii

1. INTRODUCTION 1

2. BODHI ORGANIZATION. 3

2.1 Structure 3
2.2 Responsibilities 3
2.3 Directorates 4
2.4 Laboratory 5

3. HYDRAULIC LABORATORY EVALUATION. 7

3.1 General 7
3.2 Eighth Five-Year Plan 7
3.3 Infrastructure 9
3.3.1 Existing Facilities 9
3.4 Staffing and Training 10
3.4.1 Present Staff and Experience 10
3.4.2 Future Staff and Training 10
3.5 Equipment 12
3.6 Library 13

CONCLUSIONS AND RECOMMENDATIONS 15
4.1 Conclusions 15
4.2 Recommendations 16

APPENDICES

A. "Research Facilities in Irrigation Department, Madhya Pradesh," Directorate of Irrigation Research, Bureau of Design for Hydroelectric and Irrigation Projects, Government of Madhya Pradesh, February 1990 . . 19

B. Bureau of Design for Hydroelectric and Irrigation Projects, Organization Chart, February 1990 53

C. Madhya Pradesh Budgeted Expenditures for Eighth 5-Year Plan . 55

TABLE OF CONTENTS
(continued)

APPENDICES, continued

D. Salient Features of Major Projects in Madhya Pradesh Requiring Hydraulic Model Studies under Eighth Five-Year Plan 57

E. Details of R & D Schemes proposed during Eighth Plan by Director Irrigation Research (BODHI), Bhopal (M.P.) 59

F. Lay-Out of Hydraulic Research Station Hathaikheda, Index and Detailed Plan Drawings 61

G. Date of Models in Hydraulic Laboratory 65

H. Hydraulic Laboratory Staff, January 1990 67

I. Staff Training, February 1990 69

J. Recommended Equipment Procurements 71

K. Irrigation Research Directorate, Hydraulic References, February 1990 73

L. Recommended References and Journals 75

M. Officials Met During Visits and Discussions 77

N. Hydraulic Research Station Building Requirements 79

O. List of Equipment/Instruments available and under procurement at the Hydraulic Laboratory 81

ACRONYMS

BODHI	Bureau of Design for Hydroelectric and Irrigation Projects
CCA	Culturable Command Area
CPIB	Central Board of Irrigation and Power
CWC	Central Water Commission
GOMP	Government of Madhya Pradesh
IAHR	International Association for Hydraulic Research
ICID	International Commission on Irrigation and Drainage
ICOLD	International Congress on Large Dams
ISI	International Standards Institute
ISPAN	Irrigation Support Project for Asia and the Near East
NVDA	Narmada Valley Development Authority
SID	State Irrigation Department
USAID	U.S. Agency for International Development
USBR	U.S. Bureau of Reclamation

CURRENCY EQUIVALENCIES

U.S. $1 = Rs. 15.25 (as of June 1990)

Rs. 1 crore = Rs. 100

Rs. 1 lakh = Rs. 100,000

ACKNOWLEDGEMENTS

A number of individuals and organizations aided the review effort. Thapar Hydroconsult provided the services of S.V. Chitale, and W.A. Garvey of the Irrigation Support Project for Asia and the Near East (ISPAN) made arrangements for the services of James E. Borg.

At the USAID mission in Delhi, John Grayzel, Chief of the Office of Natural Resources Management, J.R. Khanna, Project Officer, and the mission staff provided the insight and logistical assistance required to undertake this review properly.

In Bhopal, H.N. Ghandi, head of Thapar Hydroconsult's Liaison and Coordination Unit for USAID, assisted in the Madhya Pradesh Minor Irrigation Project and his staff provided the support needed for conducting the review. O.N. Thapar, Chief Engineer, BODHI, graciously supplied all of the information requested and donated much of his valuable time arranging and participating in most of the discussions held with BODHI and Irrigation Department officials and personnel.

G.S. Arora conducted a tour of the Hydraulic Research Station. The Kolar Project tour was hosted by O.P. Malga, Superintending Engineer. The visit to the Halali Project was hosted by Mr. Mathur, Executive Engineer. K.L. Gupta, Superintending Engineer, hosted the tour of the Ghora Pachhat Tank Project.

EXECUTIVE SUMMARY

S.V. Chitale and James E. Borg were retained by the U.S. Agency for International Development (USAID) to evaluate the capabilities of the Hydraulic Research Station of the Irrigation Research Directorate in the Bureau of Design for Hydroelectric and Irrigation Projects (BODHI), Irrigation Department, Government of Madhya Pradesh, India. They interviewed officers of BODHI, inspected the hydraulic laboratory facilities at Hathaikheda, reviewed hydraulic model reports, and visited four irrigation projects. They also held discussions with senior officials of the Madhya Pradesh Irrigation Department.

BODHI expects to see the workload at the Hydraulic Research Station during the Eighth Five-Year Plan increase three to four times that experienced during the previous plan. This increased workload will require a substantial improvement in laboratory facilities and staffing to meet this challenge.

The infrastructure of the Hydraulic Research Station should be upgraded to increase the capacity of the recirculating flow system to allow the testing of more and larger models. Laboratory office space should be expanded to accommodate a larger staff, computer facilities, and a small reference library. A workshop should be constructed to house machinery, equipment, and materials. The station grounds should be further increased a minimum of 50,000 m^2 to allow sufficient work area for moveable bed river models.

The Hydraulic Research Station staff should immediately be brought up to its sanctioned strength and be increased gradually thereafter to meet the demands of an increased workload as required. A formal training program should be initiated. A strategy should be formulated within BODHI to encourage the engineering staff to serve a minimum of five years to maintain continuity of effort.

The amount of basic research instrumentation needs to be increased to allow the simultaneous documentation of more than one model study. Pressure transducers and data acquisition hardware and software are required to collect and analyze dynamic pressure fluctuations.

Additional library references and journals in the areas of hydraulic modeling theory and practice should be purchased and added to the main BODHI and Hydraulic Research Station libraries.

The recommendations made in this report will result in the upgrading of the Hydraulic Research Station facilities to a level found in other state research facilities and are required to meet the challenges of the Eighth Five-Year Plan.

Chapter 1

INTRODUCTION

The Bureau of Design for Hydroelectric and Irrigation Projects (BODHI) was established by the Government of Madhya Pradesh, India, in 1985 to prepare designs and specifications for dams, canals, and appurtenant works required for major and important medium irrigation projects. A major irrigation project is defined as one that has a culturable command area (CCA) of more than 10,000 hectares (25,000 acres). A medium project has a CCA of between 2,000 and 10,000 hectares (5,000 to 25,000 acres).

Madhya Pradesh is a landlocked state in central India. It is the largest state in India and has many opportunities for water resource development. On-going work on the Narmada River is one of the largest resource developments in the world.

In 1989, Pritam Singh, former Chairman of the Central Water Commission of India, and H. Walter Anderson of the Harza Engineering Company, USA, were retained by the U.S. Agency for International Development (USAID) to review the BODHI organization and recommend methods for expanding and strengthening BODHI. Their review comments and recommendations were presented in their February 1989 report, "Organization Review of Bureau of Design for Hydroelectric and Irrigation Projects." One of the recommendations contained in this report was that a team comprised of one Indian specialist and one American specialist be formed to evaluate the capabilities of the Hydraulic Research Station and recommend measures to strengthen BODHI in the area of hydraulic modeling. The evaluation team was entrusted with the following responsibilities:

1) Carry out detailed discussions with Department of Irrigation specialists to review the current methods and available equipment.

2) Assess requirements of equipment and trained staff for the anticipated workload.

3) Prepare a detailed program for on-the-job training for these special fields.

4) Prepare and discuss the draft report with BODHI officers and then finalize report.

In accordance with this recommendation, the assignment was entrusted to the team of S.V. Chitale, a former Joint Director of the Central Water and Power Research Station at Pune, and James E. Borg of Harza Engineering Company, USA.

The team assembled in the USAID mission office in Delhi on February 7, 1990, and was briefed by John Grayzel, Chief of the Office of Natural Resources Management, USAID, and J.R. Khanna, Project Officer. Thereafter, the team was in Bhopal, the capital of Madhya Pradesh, from February 8 through February 21, 1990. During this period the team held discussions with officers at BODHI headquarters in Narmada Bhavan and at the Hydraulic Research Station, Hathaikheda. Background information about the Irrigation Research Station of BODHI was provided at that time to the review team. Discussions were also held with P.C. Agrawal, Engineer in Chief of the Irrigation Department, and J.R. Malhotra, Secretary to the GOMP Irrigation Department. A list of officials met during the team's assignment is provided in Appendix M. The hydraulic laboratory facilities at the Hydraulic Research Station were inspected and visits were made to four irrigation projects completed or under construction.

Chapter 2

BODHI ORGANIZATION

2.1 Structure

Most of the water resource development projects within the state of Madhya Pradesh are under the direction of the Irrigation Department of Madhya Pradesh. One exception is Narmada River projects which are under the direction of the Narmada Valley Development Authority (NVDA).

The head of the Irrigation Department is the Engineer-in-Chief. Reporting to him are 16 chief engineers who supervise various major projects, geographical zones or river basins, and other major activities. Of these Chief Engineers, four have statewide responsibilities:

1) Bureau of Design of Hydroelectric and Irrigation Projects (BODHI)
2) Survey and Investigations
3) Tubewell and Lift Irrigation
4) Electrical and Mechanical

In the past, the designs of a few medium projects and all major projects were performed by the Central Water Commission (CWC) of the Government of India. It is anticipated that in the future BODHI will be able to perform these designs currently done by CWC.

2.2 Responsibilities

The Chief Engineer of BODHI is responsible for preparing the designs for:

1) Major Projects

    a) Dams
    b) Spillways
    c) Appurtenant Works

2) Medium Projects

a) Earth dams above 27 meters in height
b) Masonry or Concrete Spillways with crest heads more than 3 meters and total head more than 8 meters.

3) Canals

a) Typical designs for canal structures of 6 cumecs (210 cfs) and above
b) Canal structures with pile and well foundations
c) Canals with discharges greater than 30 cumecs (1000 cfs)

4) Tunnels

5) Power Stations up to 25 MW

In addition, BODHI updates and issues technical circulars and specifications through the Irrigation Department and examines project reports for medium and major projects. BODHI also processes cases of revised administrative approval of major and medium projects as referred by Government of Madhya Pradesh (GOMP).

2.3 Directorates

The BODHI Organization is shown in Appendix B. The organization is divided into the following eight Directorates:

1) Canals
2) Dams
3) Dam Safety
4) Gates and Valves
5) Hydrology
6) Irrigation Research
7) Rates and Costs
8) Specifications

In addition to the eight Directorates, the following two cells report to the Chief Engineer BODHI:

1) Administration
2) Computers

2.4 Laboratory

BODHI operates a multi-discipline laboratory under the supervision of the Irrigation Research Directorate. The head of the Directorate holds a rank of Superintending Engineer. The laboratory facilities are further divided into four Research Stations under Deputy Director/Research Officers.

1) Hydraulics
2) Soils
3) Concrete and Mortar
4) Chemistry

Chapter 3

LABORATORY EVALUATION

3.1 General

The Irrigation Research Directorate Hydraulic Research Station is located at Hathaikheda approximately 15 km from Bhopal. Established in 1964, the Hydraulic Research Station performs hydraulic model studies for major and medium water projects and research and development studies for the state of Madhya Pradesh. An evaluation of the hydraulic laboratory was made to determine its current capabilities and the level and areas of improvement required to meet projected workloads. The evaluation included a clarification of the goals of the Eighth Five-Year Plan for the Irrigation Department of Madhya Pradesh and how these objectives will effect the hydraulic laboratory. The specific areas of evaluation of the laboratory capabilities included infrastructure, staffing and training, equipment, and library support.

3.2 Eighth Five-Year Plan

In order to evaluate what impact the Eighth Five-Year Plan will have on the hydraulic laboratory, the level of work through the completion of the Seventh Five-Year Plan was assessed. From 1978 to date, 110 hydraulic model studies were conducted at the Hydraulic Research Station. Sixty-six of these studies were completed during the Seventh Five-Year Plan alone. These studies were routine investigations for the confirmation of the hydraulic designs of appurtenant structures of water resource projects within the state of Madhya Pradesh. In addition, 23 research studies sponsored by the Central Board of Irrigation and Power (CBIP) were completed. Historically, studies at the Hydraulic Research Station have been solely in the fields of spillway water surface and piezometric pressure profiles, headworks stage-discharge rating curves, energy dissipation structures, spill channel protection works, riverbed scour, flood protection works, river training, hydraulic performance of staged construction schemes, and spillway gate operation schedules.

The total expenditure for the Irrigation Research Directorate during the Seventh Five-Year Plan was approximately Rs. 250 lakhs. This expenditure was only 66 percent of the amount allocated for use.

The Eighth Five-Year Plan under finalization for the Madhya Pradesh Irrigation Department has tentatively budgeted Rs. 1914 crores for major and medium irrigation projects. This represents a 10 percent increase over the expenditure outlay during the previous plan. The plan includes work on four new major projects (Pench Diversion, Kelo, Mongra and Arpa) and a number of new medium projects. All four of these new major

projects, as well as on-going major projects, routinely require hydraulic model investigations. Some of the medium projects will also be identified for hydraulic research.

The complete breakdown of the tentatively budgeted expenditures for the Eighth Five-Year Plan of the Irrigation Department is provided in Appendix C. Additional studies will be made for NVDA projects which are not indicated in this breakdown. The salient features of the six major projects currently undergoing hydraulic model studies during this plan are given in Appendix D.

In addition to routine hydraulic model studies to confirm hydraulic designs of irrigation projects, the Hydraulic Research Station will be conducting research and development studies for the state of Madhya Pradesh. The National Advisory Committee for Water Resources Development has recently proposed budgets of Rs. 30.2 crores for research and development projects under central and state sectors.

Proposed expenditures for research and development studies totaling Rs. 138 lakhs have been submitted by the Irrigation Research Directorate for consideration. Of this amount, the proposed expenditure for the Hydraulic Research Station is approximately Rs. 45 lakhs. Much of these proposed expenditures is related to the modernization of infrastructure and studies in the field of plasticulture (Appendix E).

In addition, BODHI is currently formulating a program for the further development of the Hydraulic Research Station capabilities. Laboratory facilities will be upgraded to allow for studies of closed conduit systems involving pipelines, tunnels, gates and valves. Modernization of the facilities is also envisaged by obtaining pressure transducers and a computer data-acquisition system to allow a more detailed analysis of cavitation and fluctuating pressure problems.

A provision of $1.03 million has been allotted by a USAID grant for strengthening and expanding the capabilities of the BODHI organization. Rs. 21.3 lakhs has been appropriated for the purchase of equipment. Approval has been received for the purchase of library and reference materials totaling Rs. 2.73 lakhs.

An expenditure of Rs. 0.58 lakhs has been approved for memberships to technical institutes and purchase of periodicals and journals. The purchase of 17 computers has also been approved, two of which would be installed in the BODHI offices on Bhopal. In addition, one mini-computer will be purchased with the assistance of the World Bank and installed in the BODHI office.

In summary, the goals of the Madhya Pradesh Irrigation Department Eighth Five-Year Plan are ambitious and will result in a substantial increase in the workload at the Hydraulic Research Station. However, ample funds are available from BODHI project budgets, research and development projects, and USAID grants for the expansion and modernization of the laboratory facilities and the training of its personnel. The main problem appears to

be that the present station staff is not large enough to effectively utilize the funds allotted to it.

3.3 Infrastructure

3.3.1 Existing Facilities

The Hydraulic Research Station of the Irrigation Research Directorate, shown in Appendix F-1, covers approximately 50,000m^2 and utilizes the outlet works of the Hathaikheda dam for its water supply. Although the maximum discharge available from the outlet is 81 cfs, the inlet channel and gated headworks limit the maximum gravity flow to the station for model studies to 25 cfs. Two tube wells, each having the capacity of 800 liters/minute, are provided to fill the recirculation system sump when the water supply from the outlet works is not available.

The center currently has 70m^2 of office space available for the research station staff. A separate building with an area of 300m^2 is available for lectures and meetings. Equipment for the construction of hydraulic models is being temporarily stored in a 25m^2 shed. At present, no facilities exist for computer or photographic equipment.

The laboratory model test area is divided into three work areas called trays. The lowest, or gravity tray, has an area of 6500m^2 and has a maximum gravity flow of 25 cfs available for model studies. All gravity test flows must ultimately be wasted to the adjacent "nalla" after use. The second tray has an area of 9500m^2, but must be supplied by pumping. The third tray, reserved for the Narmada Sagar Project, also must be supplied by pumping and has an area of 5500m^2. All three trays use a common collection channel which conveys return flows to the pumphouse sump. The detailed layout of the tray areas available for model tests is shown on Appendix F-2.

Water is supplied to the trays via a network of 0.9m high by 0.9m wide concrete-lined channels located around their peripheries. The gravity supply channel has an invert at El 467.1 and the pump supply channel has an invert at El 468.4. The maximum capacity of the supply channel is 14 cfs. The maximum head available for model studies is approximately 1.5 meters.

Three 60-HP horizontal centrifugal pumps are available for supplying recirculating flow to the modeling trays. Although three pumps are available, the 14 cfs capacity of the delivery channels limits pumping to two pumps. Considerations should be given to the construction of a new head box adjacent to the pump house to introduce flow directly into the sectional models gravity tray and allow exit flow to discharge directly into the pump sump. This "short-circuit" system would utilize the additional pump, and the reduction in pumping head would increase flows by 50 to 75 percent without major reconstruction or adding pumps to the system. Another advantage is that sump volume requirements are reduced significantly

the system. Another advantage is that sump volume requirements are reduced significantly because the delivery channels do not need to be filled during system start-up.

The existing office space available for research personnel is inadequate and an expansion of facilities is required. A new office building should be constructed with offices for the Research Officer, assistant research officers, and research assistants. Adequate space should also be provided for a drafting area, a small library, and an air-conditioned area for computer and photographic equipment. The new office building should have a total floor area of 220m^2. Appendix N shows the breakdown of required floor area for the office building.

A separate workshop building is also required to house machinery, store materials and instruments, and provide a model layout and construction area. The total estimated area required for the workshop is 300m^2. Appendix N also contains the breakdown of area requirements for the workshop building.

3.4 Staffing and Training

3.4.1 Present Staff and Experience

The organization of the Irrigation Research Directorate is shown in Appendix A-3. R.D. Ektare is the current Director and is an officer from the State Irrigation Department (SID) having a rank of Superintending Engineer. The Hydraulic Research Station is headed by a Deputy Director/Research Officer, G.S. Arora, an executive engineer, also from the SID. The center's supporting staff is comprised of assistant research officers (assistant engineer), research assistants, laboratory technicians, and laboratory assistants. The current staff at a level of laboratory assistant or higher is only 45 percent of its sanctioned strength. The technical staff at or below the position of research assistant is the core staff of the laboratory and is comprised mainly of scientists.

Appendix H contains a complete list of the Hydraulic Research Station staff by position, number sanctioned, number employed and minimum technical qualifications. Training assignments experience by the present station staff is shown on Appendix I.

3.4.2 Future Staff and Training

Present activities of the Hydraulic Research Station are primarily in the area of spillway studies and energy dissipation. The Eighth Five-Year Plan envisages a more diverse field of studies as indicated in Appendix A and can be summarized as follows:

1) Dams and appurtenant structures
2) River and canal hydraulics
3) Mathematical modeling
4) Field data collection and analysis
5) Central Board of Irrigation and Power sponsored studies.

In addition, service groups will be required to maintain available computer facilities, instrumentation, library references, and precision workshop facilities.

In order to perform workload envisaged by the Irrigation Department's Eighth Five-Year Plan, the sanctioned staff size should gradually be increased as the workload expands.

In order to meet these work goals, immediate efforts should be made to bring the station staff to at least its sanctioned strength. The meeting of the sanctioned staff goal should be achieved by the end of 1990. In addition to hiring personnel, a strategy of incentives should be developed to encourage personnel to remain at the laboratory to maintain continuity. In developing a strategy for retaining staff, BODHI should become familiar with the recommendations made by the Scientific Advisory Sub-committee on manpower development and management in their report "Research and Development in Water Resources, Gearing Up to the Challenges of the Eighth Five-Year Plan, Importance of Manpower." The staff pattern recommended by them for research cadres with 60 percent core cadre and 40 percent floating cadres could be considered for the adoption at the Research Station.

The best incentives for maintaining continuity are promotion and salary increases. During the initial phase of the station's expansion, some promotion and salary increases are certain. However, beyond the initial expansion phase, incentives such as increasing the design allowance and the making it a percentage of salary, continuing the advantage of advance increments for Post Graduate Degrees after promotion, and time-scale salary increases for core personnel may become the most effective means of maintaining staff continuity.

The station staff should be encouraged to participate and attend national and international seminars, symposia, workshops, and annual sessions of various organizations to bring recognition to themselves and to the research station. Since these activities are funded entirely at the station's expense, they may be used to secure a nominal commitment to continue service at the station an additional six months.

On-going training of the station staff is required to improve the quality of existing studies and expand expertise in the proposed new fields of studies. The training avenues envisaged to strengthen the station staff technical capabilities required to meet the goals of the Eighth Five-Year Plan should include but not be limited to:

1) A refresher course or interactive workshop held at the station with specialists covering topics such a model scale determination and design, model construction techniques, model limitations, use of instrumentation and data collection, infrastructure requirements, computer data-acquisition system operation, report preparation and data presentation, etc.

2) As new fields of study are added to the station, the research staff can be prepared for the assignment by working on a similar project at an outside laboratory similar to the Central Water and Power Research Station at Pune.

3) A group of qualifying staff could be sent to visit the U.S. Bureau of Reclamation (USBR) laboratory in Denver, Colorado, the U.S. Army Corps of Engineer Waterways Experiment Station laboratory in Vicksburg, Mississippi, and a number of university and private laboratories. The training tour could be accomplished in about one month. The tour could be arranged for a group of three to five participants and be scheduled every three years. To qualify, a participant must have at least three years of service at the station and have participated in at least one outside working assignment as outlined in goal 2 above.

4) The station staff should be encouraged to participate and attend national and international seminars, symposia, workshops, and annual session of various organizations.

3.5 Equipment

A list of the instrumentation available at the Hydraulic Research Station has been provided by BODHI and is shown in Appendix O. The instrumentation consists of a surveying level, point gauges, Prandtl tubes, and a pygmy current meter. The amount and type of instruments available even for the basic studies currently being undertaken at the station is inadequate. Basic model construction equipment, such as a bandsaw, circular table saw, lathe, air compressor, portable hand drill, and grinder have only recently been procured. Workshop facilities have not yet been provided for this equipment.

The Eighth Five-Year Plan proposes the design and hydraulic model studies of at least six major projects and a number of medium projects within BODHI. This represents a significant increase in the workload over that currently being done at the hydraulic laboratory. The magnitude of the projected increase in workload will in itself require an increase in basic research equipment. This additional equipment should include manometers for pump discharge measurements, piezometer boards for pressure measurements, pygmy current meters and mini-propeller meters for velocity measurements, and point gauges for topographic and flow profile measurements.

The Indira Sagar Project, for example, has a design discharge in excess of 80,000 cumecs and height in excess of 80 meters. As projects increase to this size, so do the concerns in the areas of adequate downstream energy dissipation measures and cavitation damage to chute and submerged structures from high velocity flows. The collection, analysis, and interpretation of dynamic pressure fluctuations become paramount in determining the range and impact of dynamic pressures on the design of hydraulic structures.

Computer data acquisition systems that utilize diaphragm pressure transducers and menu-driven software can easily be programmed to collect, store, analyze, and present in report form the dynamic pressure fluctuations. The systems include input/output data acquisition boards to send and collect data from remote transducers and software packages to control the sampling rate and allow the plotting of pressures for report exhibits.

A complete list of laboratory equipment required to accomplish the goals of the Eighth Five-Year Plan is included in Appendix J.

3.6 Library

Hydraulic laboratories require current and relevant references to determine correct model scale, testing methods, data collection procedures, accurate analysis and interpretation of results. References also pass on the experiences of previous similar studies. The Irrigation Research Directorate has the main BODHI library as well as its own library available as reference sources.

The main BODHI library is located on the fourth floor of the Narmada Bhavan in Bhopal. The main library contains about 2500 books and receives technical journals from 24 institutions, of which 15 are Indian and 9 are foreign. In spite of the number of books in the main library, only 20 books are directly related to hydraulics, fluid mechanics, hydraulic structures or sediment transport. None of the books were dedicated solely to hydraulic modeling theory. In addition to reference books, the library contains ISI Standards, a few USBR publications, CBIP publications, and miscellaneous journals and reports.

Publications and journals or the International Commission on Irrigation and Drainage (ICID), the International Association for Hydraulic Research (IAHR), and the International Congress on Large Dams (ICOLD) total about 300. However, the library does not currently hold memberships with these institutions and as a consequence journals are not received on a regular basis. The library is currently a member of the American Society of Civil Engineers and receives journals of the Hydraulics and Irrigation and Drainage Divisions. An on-going effort should be made to obtain back issues of journals to complete the sets and bring them up-to-date.

The Main BODHI library appears to be competently managed by qualified librarians and their supporting staff. The recording of book loans and cataloging of books and

publications is done manually, however. These manual procedures will eventually be discarded in favor of a computer data base when it becomes available.

The average annual expenditure for the purchase of books and journals during the past Five-Year Plan has been Rs. 25 lakhs, although Rs. 50 lakhs were spent in 1989.

The Irrigation Research Directorate library is also located in the office at the Narmada Bhavan. This library contains 10 books related to hydraulics and hydraulic structures. These 10 books are listed in Appendix K. As was the case encountered in the main library, not one of these books is solely dedicated to hydraulic modeling theory. At present, no technical library exits at the Hydraulic Research Station, Hathaikheda.

In order for the Hydraulic Research Station to more fully utilize the available library facilities, two actions should be taken. First, additional books must be purchased which are dedicated to hydraulic modeling theory and practice and related to the anticipated fields of study. Appendix L contains a recommended list of books and journals which will be needed to meet the modeling goals associated with the Eight Five-Year Plan. Secondly, references must be routinely available to the research and assistant research officers. It is therefore further recommended that two sets of the books listed in Appendix L be made available so that one set of books can be placed at the Research Station and another set of books and recommended journals can be placed at the Main BODHI library.

Chapter 4

CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

The BODHI Hydraulic Research Station is the only hydraulic modeling facility in the State of Madhya Pradesh. The facility conducts model studies for all major projects of the Irrigation Department and Narmada Valley Development Authority, as well as various central, state, and USAID-funded research and development projects.

The tentatively budgeted expenditures for the Irrigation Research Directorate under the Eighth Five-Year Plan should be three or four times the amount of actual expenditures during the Seventh Five-Year Plan.

The Irrigation Research Directorate and Hydraulic Research Station are presently at only half their sanctioned strength. This resulted in limiting the actual expenditures during the Seventh Five-Year Plan to Rs. 250 lakhs, or 66 percent of the expenditures allotted.

The average period of service for laboratory staff at or above the grade of assistant research officer is between three and four years. After this period, staff at these levels usually transfer to other Irrigation Department directorates.

No formal training program is available to laboratory staff. The level of expertise of the laboratory staff is adequate for the studies now being conducted. However, additional training will be required as computer-aided instrumentation becomes available and more complex fields of study are encountered.

The Hydraulic Research Station is well located adjacent to an ample water supply and within easy reach of BODHI officials and laboratory staff.

The maximum recirculating flow available at the laboratory is limited to 14 cfs by the pumping discharge channel capacity. This maximum flow limits operation to only two of the three pumps, and places serious constraints on the selection of model scales. This constraint is crucial in studies of large projects such as the Indira Sagar Project.

The amount and type of equipment and instrumentation at the laboratory is inadequate for the studies currently being conducted. The laboratory has no equipment or instrumentation for the collection and analysis of dynamic pressure fluctuations.

The laboratory office space is inadequate and must be expanded to provide the space requirements for at least the current sanctioned staff.

Although model construction machinery and equipment have recently been procured, no workshop facilities are available at the laboratory.

There is no technical library at the laboratory. The references available to the laboratory staff at the main BODHI and Irrigation Research Directorate libraries are inadequate and no references exist on hydraulic modeling theory or practice.

Sufficient funds are available through Madyha Pradesh Irrigation Department and NVDA study budgets, state, research and development projects, and USAID grants to immediately begin to improve and strengthen the capabilities of the Hydraulic Research Station.

4.2 Recommendations

Immediate efforts should be made to add the personnel required to bring the Hydraulic Research Station staff up to its sanctioned strength. This goal should be accomplished by the end of 1990. The sanctioned staff level should be increased thereafter as the workload increases.

The basic organization of the Hydraulic Research Station should be reconstructed to allow the position of Assistant Research Officer to be filled by a core staff member. The staff pattern recommended by the Scientific Advisory Sub-committee on manpower development and management, in the report for research cadres with 60 percent core cadre and 40 percent floating cadre, could also be considered for adoption at the Research Institute.

A strategy should be developed within BODHI to provide incentives to encourage personnel to remain at the laboratory for a minimum of five years. Some suggestions for consideration are:

1) The amount of the design allowance should be increased and made a percentage of salary instead of a fixed amount.

2) The advantage of increased increments for post graduate degrees should be carried over after promotion to higher cadre.

3) Time-scale salary increases should be provided for core personnel.

4) Other recommendations made by the Scientific Advisory Sub-committee on manpower development should be implemented wherever applicable.

A formal training program should be initiated to increase the technical expertise of the laboratory staff. The training program should include on-the-job training assignments at

other state and national hydraulic laboratories, regularly scheduled workshops held at the laboratory by national and international experts in hydraulic modeling and computer data-acquisition systems, and trips to foreign laboratories by qualified laboratory personnel in charge of work projects.

The laboratory tray area is more than sufficient for spillway sectional and composite models. The laboratory area should be at least doubled to accommodate large moveable bed-river models as they become required.

Additional basic equipment should be purchased to meet the expanded workload proposed by the Eighth Five-Year Plan. In addition to basic equipment, the procurement of pressure transducers and computer data-acquisition hardware and software will be necessary to collect and analyze dynamic pressure fluctuations. Appendix J contains a list of equipment which should be purchased during the Eighth Five-Year Plan.

The capacity of the recirculating flow system must be increased to allow the construction of larger models required for transducer access and increased reliability of results. Immediate measures should be taken to utilize the capacity of the third pump. This can be done by constructing a recirculating system which utilizes the gravity tray adjacent to the pumphouse to reduce the capacity constraints imposed by the delivery pipeline and elevated discharge channels. Other measures, such as increasing the cross-sectional area of the delivery channels and ultimately expanding the number of pumps and size of the sump, should also be carefully planned and enacted during the Eighth Five-Year Plan.

A new office building should be constructed to provide sufficient space at least for the current sanctioned staff as well as facilities for drafting equipment, computer and photographic equipment, and library. It is estimated that a building of at least 220 square meters will be required.

A 300-square-meter workshop should also be constructed to shelter the model construction equipment and machinery, provide a covered model layout and assembly area, and house a locked storage area for tools and materials.

Additional reference books and journals pertaining to hydraulic modeling theory and practice, design of hydraulic structures, sediment transport, and fluid mechanics should also be purchased. One set of reference books should be placed in a library at the Hydraulic Research Station for daily access by research personnel. A second set of reference books and the journals should be placed in the main BODHI library.

Finally, a follow-up review could be made by a USAID-sponsored team of specialists to evaluate the progress of the laboratory development and help identify and suggest means of overcoming hindrances. The review team should again be comprised of Indian and American specialists in the area of hydraulic modeling with qualifications similar to those participating in this assignment. A one-day tour of the Central Water and Power Research

Station at Pune should be arranged for the review team to allow them to become more acquainted with the capabilities of a major hydraulic laboratory in India. The review assignment should last no more than two weeks and be scheduled to occur within two to three years of the submission of this report.

APPENDIX A

GOVERNMENT OF MADHYA PRADESH
BUREAU OF DESIGN FOR HYDEL & IRRIGATION PROJECTS
DIRECTORATE OF IRRIGATION RESEARCH

RESEARCH FACILITIES IN
IRRIGATION DEPARTMENT
MADHYA PRADESH

8TH FEB. 1990

Telegram: ANUSANDHAN
Telephoen: 62504

NARMADA BHAWAN, TULSINAGAR
BHOPAL (M.P.) 462 003

RESEARCH FACILITIES IN IRRIGATION DEPARTMENT, MADHYA PRADESH

1.0 Back ground

1.1 The present Research Organisation in the Irrigation Department came into existence to discharge routine functions of investigations and testing of materials similar to other Central & State Research Institutions of the country. R&D functions were indicated in due course by way of handling some research projects entrusted to it by C.B.I and P. The following account gives, in brief, how the present Organisation got built up.

1.2 The Central Soils Laboratory of the Madhya Pradesh Irrigation Department was started at Raipur in 1956. Earlier the services of research laboratories of other States/Centre like Hirakud Research Station, Irrigation Research Station, Roorkee, Central Water & Power Research Station Pune and the Engineering College, Jabalpur used to be availed of. A soil and material testing laboratory was set up at Tawa project in 1969 mainly to do the work of soil and material testing for Tawa project. In 1964, a hydraulic research station was started at Hathaikheda near Bhopal. In 1967, a Directorate of Irrigation Research was set up with a S.E. appointed as Director; the Hydraulic Research laboratory, Hathaikheda; the soil Laboratory at Raipur and the Soil and Material Testing Laboratory at Tawanagar were placed under its control. Subsequently, in 1970, one Soil and Material Testing Laboratory was established at Hathaikheda. The Laboratory at Tawa was earmarked for quality control and testing of Tawa project when its construction phase came into full swing in 1970. In the year 1984, under USAID ,one Soil and Material Testing laboratory was established at Jabalpur and the Soil and Material Testing Laboratory at Hathaikheda were upgraded.

1.3 The laboratory/Directorate was functioning independently under direct administrative control of Chief Engineer/E-in-C till June,1985 when it was brought under the umbrella of then constituted Bureau of Designs for Hydel and Irrigation projects (BODHI) and started functioning as one of its Directorates (Six in 1985 and 8 at present).

2.0 Existing Organisation

2.1 At present the Directorate of Irrigation Research headed by a Superintending Engineer which has its headquarters at Bhopal has following 4 divisions under its control :-

- Research Officer Soil & Material Testing Laboratory Raipur, in charge of Soil & Material Testing Laboratory, Raipur.

- Research Officer, Hydraulic Models, Bhopal, in charge of Hydraulic Research Station, Hathaikheda.

- Deputy Director, Soil & Material Testing Laboratory, Bhopal, in charge of Soil & Material Testing Laboratory and Chemical Laboratory, Hathaikheda.

- Deputy Director Soil & Material Testing Laboratory Jabalpur, in charge of Soil & Material Testing Laboratory, Jabalpur.

The sanctioned strength consists of 5 class I, 16 class II,152 class III and 32 class IV employees.

2.2 In addition to the four laboratories under the Director, Irrigation Research, there are following five quality Control Laboratories on major projects which cater to the needs of testing during the construction phase and for quality control of the project and are under the control of Chief Engineers of the concerned project.

i. Tawanagar for Tawa project.

ii. Jabalpur for Bargi project.

iii. Rewa for Bansagar project.

iv. Rudri for Mahanadi Reservoir project.

v. Seoni for Upper Waingange project.

2.3 Eight Circle level laboratories have also been set up at the following places which mainly cater to the soil testing of projects both medium and minor in various regions of the State.

i.	Gwalior	v.	Baloghat
ii.	Indore	vi.	Bilaspur
iii.	Hoshangabad	vii.	Ambikapur
iv.	Jabalpur	viii.	Rewa

3.0 Existing Facilties

3.1 The Hydraulic Research station, Hathaikheda has facilities for hydraulic model experiments both 2-dimentional and 3-dimensional and is equipped to tackle the following problems :-

i. Energy dissipation and co-efficient of discharge of spillways.

ii Hydraulic flow properties of barrage and diversion structures.

iii. Stage construction of spillways.

iv. Flood protection (bank erosion) by river training works.

3.2 The other three laboratories (under BODHI) have facilities for carrying out physical and engineering properties of samples of soils as well as of other materials of construction e.g. sand, aggregates, stones, Tiles for lining, water, bricks, cement etc. The laboratories also have facilities for carrying out tests on samples extracted during construction processes on projects. Annexure-I lists the capabilities of different laboratories in terms of types of test.

3.3 The project laboratories and circle level laboratories have the facilities to perform requisite test mentioned in para 2.2 and 2.3 respectively.

4.0 Infra Structure

4.1 Campus area

The Hydraulic model testing and Soil & Material testing units are located in building situated in the campus of laboratory at Hathaikheda which is 15 km away from Bhopal on the down stream of Hathaikheda Dam.

4.2 Accomodation : -

(i) Research Station at Hathaikheda is located in various buildings as shown below :-

-	Hydraulic Lab.Office	70 sq.m.	Plinth area
-	One Hall for meetings & Luctures	300 sq.m.	Plinth area
-	Soil & Material & chemical section	1500 sq,m.	Plinth area
-	Temporary sheds at Model site.	6 Nos.	
-	Workshop shed (150 sq.m.)	yet to be constructed.	

(ii) Office of Director Irrigation Research & that of R.O(H) & Dy.Director(S&M) Bhopal are located in 1st floor of Narmada Bhawan. Against 634 sq.m. plinth area available is only 246 sq.m.

(iii) Staff stationed at Bhopal are residing in the Govt.accomodation alloted to them or the accomodation alloted by Chief Engineer,BODHI on the basis of rent free accomodation.

(iv) Laboratory at Raipur is located in the campus of Irrigation Department Office. The most of the staff is residing in the Govt.accomodation allotted to them.

(v) Laboratory at Jabalpur is located in the campus of Office of the Superintending Engineer, Upper Narmada Circle in one shed. The staff does not have any accomodation and they are residing in private hired accomodation.

4.3 Transport :

There is one mini bus for the laboratory staff at Bhopal for their to and fro journey (15+15 = 30 km) from home to laboratory and back.

There are two diesel jeeps between 3 offices at Bhopal.

4.4 Workshop :

At present there is no workshop and no workshop equipments also.

4.5 Library :

Main library is there in Narmada Bhawan Building under Chief Engineer,BODHI. This is always available for Research staff. There is one small library under D.I.R.where all I.S. codes corresponding to laboratory Test work, journals etc., are kept.

4.6 Computer facility

At present there are only two P.C. installed in BODHI.

4.7 Equipment

Instruments/equipments as available in the Hydraulic testing & Soil & Material testing laboratories are listed and enclosed vide annexure - II.

4.8 Availability of water for model studies

In all there are ten trays for three 'D' models and 30 flumes for two 'D' models available for studies. Out of these four trays and 14 flumes can be run by gravitational flow from the water obtained from Hathaikheda Tank and balance can only be run by pumping water from the sump chamber. Water to the extent of about 15 cusecs can be drawn from Hathaikheda canal which is used for running the models, filling in the gravitational zones and for replenishing the sump chamber. There are three pumps each of 60 HP with pumping capacity of about 7 cusecs of water each. Generally two pumps are run at a time to feed the trays / flumes at high elevations. In addition to this 2 tubewells discharging 800 litres/minute are also drilled and are being used when there is shortage of water.

4.9 Communications :

Telephone connections are available at the following places.

	Office	Residence
C.E.BODHI,Bhopal	61085	550447
D.I.R.Bhopal	65060	554501
R.D.(H)Bhopal	65060 Exten.	-
Dy.Director,Bhopal	65060 Exten.	-
R.D.(S)Raipur	23746	-
Hathaikheda,Laboratory	546785	-
Dy.Director, Jabalpur	-	-

Telegraphic address is ANUSANDHAN, BHOPAL.

4.10 Training :

4.10.1 Training facilities are available to Assistant Engineers at the O.T.C.camp at Tawa Project.

4.10.2 The training is also being imparted at the Academy of Administration Bhopal.

4.10.3 At WALMI Bhopal also the training facility is available.

4.10.4 Apart from above the staff working in Research Station is directed to visit other Research Station such as CWPRS PUNE, CSMRS New Delhi MERI Nasik (MS) etc., as & when needed for acquiring requisite and specialised training.

4.11 Position of staff as sanctioned Y / S as on roll

Annexure III shows position of staff as per sanctioned strength and as per on roll. The core staff is only 20 %.

5.0 Existing Activities

5.1 With the limited available facilities and equipment the works of Soil and Material Testing units are restricted to the following activities :

Soil Test :

Suitability of soils with respect to grain size analysis & limits compaction and Triaxial shear tests, permeability tests, swelling pressure tests etc.,

Materials Test :

- Cement testing for its fineness, setting time, compressive strength. Soundness and accelerated curing .
- Suitability of fine and coarse aggregates
- Suitability of other construction materials viz.stone, brick, tiles for lining (flexural strength test)
- Mix design of concrete and mortar.

Chemical Tests :

- Quality of water for drinking purpose and construction purpose.
- Cement & Soil.
- Proportion of cement in morter & concrete.

5.2 At Hydraulic Research Station, the following studies are undertaken :

Spillway profile studies
Energy dissipation studies
Bed movement/scour studies
Stage construction programme studies
River behaviour , tail water studies
Gates operation schedule studies
Flood protection studies

5.3 The hydraulic model studies so far carried out in Hydraulic Research Station are as per list enclosed vide annexure - IV.

5.4 CBIP Sponsored Studies :

5.4.1 In addition to the above, the research studies sponsored by the CBIP are also undertaken.

The list of studies entrusted before 7th plan which have been completed and those entrusted during 7th plan and are under progress is given in Annexure V.

5.4.2 Plasticulture Development Centre :

Plasticulture Development Centre has been established at Directorate of Irrigation Research, (Bodhi), Bhopal in Jan.1987.

Areas of study allotted are as follows :

a) Minimum thickness of protective earth cover over the film.

b) Assessment of sepage losses for Irrigation canal in various conditions.

c) Suitable thickness of L.D.P.E. film for Lining considering economy.

d) Material and type of sealig and jointing to be provided at the Joints of film.

e) Comparative cost of different types of Lining.

The study is expected to extend over a period of 5 years and an a mount of Rs. 10.55 lakhs has been sanctioned for this centre.

5.5 USAID Sponsored Special Studies :

In addition to the normal Research and Testing activities undertaken by the Diractorate of Irrigation Research (BODHI), the following special studies under USAID have been taken-up by BODHI, other field formations/organisations. These can be considered to form a part of R&D efforts of Irrigation Department.

i. Sedimentation Rate Determiation

This study is meant to develop rate of deposition of sediment in Minor Irrigation Tanks located in different Agro-climatic zones. Study I has already been completed and study II is under progress to confirm results of study -I.

ii. Determination of seepage losses and rugosity co-efficient for canals in M.P, Minor Irrigation Schemes (MIS).

iii. Water Shed Yield Methodology

The objective of the study is to :

- Develop suitable hydrological model for prediction of yield for Tank in different climatological areas of the State.

- Work out rainfall runoff relationship for different Agro-climatic zones of the State.

iv. Recommended Rotational Water supply system and improved basis for water charge to be used on MIS.

v. Socio Economic Baseline studies on representative MIS and on the control Pilot projects- Entrusted to Director of Economics and statistics M.P. Bhopal.

vi. Farmer's Orgaisation for the Operation and Maintenance of Irrigation System- Entrusted to WALMI, Bhopal.

vii. Development of Irrigation Guides - Entrusted to J.N.K.V.V.M.P.

viii. Availability of credits - Entrusted to J.N.K.V.V.M.P.

ix. Agricultural Inputs - Entrusted to J.N.K.V.V.M.P.

x. Manpower assessment for irrigated agriculture- Entrusted to Indian Institute of Management, Bangalore.

5.6 Problems of other departments e.g. N.V.D., PHED etc. are also undertaken as and when referred.

5.7 Miscellaneous activities :

In addition to above, Workshops / Seminars / Trainings on various subjects are also being arranged to strengthen R&D efforts.

6.0 Upgradation proposals taken up under USAID

There is a provision of $1.03M ($ 0.38M Foreign Exchange component) under grant fund of USAID for equipments and books to strengthen BODHI and Training of officers of BODHI.

The assitance from USAID for strengthening of BODHI, which in turn would result in upgradation of Research & Testing facilities is being received for the following activities :

1. Purchase of equipments under grant funds for strengthening of existing testing and research facilities .

Approval for pourchase of equipments under grant funds for strengthening of existing testing and research facilties for Rs. 23.0 lakhs has been received from USAID. The expenditure incurred upto12/89 is Rs.1.70 lakhs. No expenditure during balance period of this financial year is anticipated. During 1990-91 Rs. 21.30 lakhs would be incurred.

ii. Purchase of library books :

Approval for purchase of library books for Rs. 3.28 lakhs has been received from USAID. Expenditure incurred upto 12/89 is Rs. 0.55 lakhs. No expenditure during balance period of this financial year is anticipated. During year 1990-91 Rs. 2.73 lakhs would be incurred.

iii. Institutional membership and journals :

Amount approved by USAID is Rs. 1.0 lakhs against which expenditure of Rs. 0.42 lakh has been incurred upto 12/89. No expenditure during balance period of this financial year is anticipated. During year 1990-91 Rs. 0.58 lakhs. would be incurred.

iv Providing technical assistance through Expatriate/Indian consultants to suggest measures for strengthening of BODHI

One team of consultants (one Expatriate and one Indian) has already made in depth study of functioing of BODHI and has submitted the report. They have suggested inter-alia, that expert in Hydraulic Model and Geo-technical investigations should visit, study in depth & give suggestions for further strengthening of Hydraulic model and material Testing facilities. Necessary proposals would be framed after visit of these consultants.

v. Computers :

An amount of Rs. 13.0 lakhs has been approved by USAID for purchase of ten computers. Out of these, 4 computers would be installed in BODHI and balance, in offices of Chief Ebngineers at Bhopal, Jabelpur, Rewa, Seoni, Raipur and Gwalior.

vi Purchase of equipments under grant funds through L.C.U.:

There is a provision of 50,000 U.S Dollars for purchase of equipment through L.C.U. Against this, list of equipments costing Rs. 8.90 lakhs has been sent to USAID for approval.

7.0 Research programme envisaged for Eighth Plan.

As per details given in S&T chapter for Water Resources Developent as submitted to the Planning Commission , the National Advisory Committee had reviewed the R&D efforts hitherto, considered the suggestions of various Water Resources experts and identified the thrust areas for R&D in 8th plan keeping in view the directions of the National Water Policy ,1987. These R&D Thrust areas are indicated in Annexure VI. The proposed outlay for Madhya Pradesh, in this document is Rs.8.8 Crores under Central Sector- CBIP Centrally Sponsored Research Schemes- and Rs. 21.4 crores under State Sector. The break up of this outlay between various components is as under :-

S.No.	Sector	Basic & Applied Research	Action Research	Infra structure	Education & Training	centres of Excellence	Total
		Rs. Crores					
1.	Central	2.8	1.0	1.2	0.8	3.0	8.8
2.	State	4.6	7.0	3.6	1.2	5.0	21.4
	Total	7.4	8.0	4.8	2.0	8.0	30.2

This is a quantum jump compared to the average annual expenditure of about Rs.0.50 crore (BODHI only) during 7th plan. For full utilisation of this provision, absorption capability (organisational and Infra-structure) of the Research Institute have to be built up very early, possibly within one year.

8.0 Further Activities Envisaged

8.1 In hydraulic model laboratory facilities for studies on problems of flow through pipes, tunnels or gates & valves involving high pressure etc. Instrumentation structures, electrical analogy, photo elastic analysis mathematical modelling are the areas not covered yet and proposed to be envisaged during VIII Plan.

8.2 Similarly Soil & Material testing Laboratories generally meet the normal requirement of routine testing. Petrographic examination unit & unit for insitu rock shear testing are yet to be started & proposed to be envisaged during VIII Plan.

8.3 Modernised and electronic data acquisition & computerised equipment are also proposed to be procured during VIII Plan as per list enclosed at Annexure VII.

8.4 Additional infrastructive facilities viz workshop facility, transport facility, accomodation for staff etc., would further be needed.

Annexure 1
(Refer para 3.2)

FACILITIES AVAILABLE IN TESTING LABORATORIES

Material Testing Laboratory, Bhopal.

The Laboratory caters to the needs of the suitability tests of the building materials like cement, sand, coarse aggregate, bricks, concrete, building stones, hydrated lime and surkhi etc. Determination of proportions of ingredients in hardened mortar and concrete samples is also undertaken. Mix design of mortar and concrete is also done.

In addition, the laboratory is equipped with facilities for taking up chemical tests for - cement, seepage water from drainage galleries of the masonry / concrete dams, knowing pollution in the irrigation water due to various pollution sources in the reservoir catchment and around rivers.

Soil Testing Laboratory, Bhopal.

The soil testing laboratory, Bhopal, is looking after the soil testing work of projects under construction or investigation in the Bhopal region. The laboratory is mainly engaged in determination of physical and engineering properties of soil samples received from various projects.

Central Soil & Material Laboratory, Raipur.

This laboratory is well equipped for soil and material testing and looks after testing work of projects under construction or under investigation in areas not covered by Bhopal laboratory. It is engaged in determining physical and engineering properties of soil samples received from various projects and caters to the needs of the suitability tests of the building materials like cement, sand, aggregate, bricks, concrete, building stones, hydrated lime, pozzolana and other mix design of mortar and concrete is also done.

Soil Testing Laboratory at Jabalpur.

The Soil testing Laboratory at Jabalpur is looking after the Soil & Material testing work of projects under construction or investigation in the Jabalpur region. The laboratory is mainly engaged in determination of physical & engineering properties of Soil samples & suitability of construction materials received from other various projects.

Annexure 2

(Ref. Para 4.7)

List of Equipments / Instruments available with Hydraulic Laboratory at Hathaikheda Research Station.

S.No.	Name of Equipment	Number	Remarks
1	Levelling Instrument	3 Nos.	-
2	Hand Drilling Machine (Wolf make)	1 No.	-
3	Centrifugal Pump (60 H.P.)	3 Nos.	-
4	Centrifugal Pump (5 H.P.)	2 Nos.	-
5	Centrifugal Pump (30 H.P.)	3 Nos.	-
6	Water Pump (1 H.P.)	1 No.	-
7	Compressors	1 No.	-
8	Spray Painting Gun	1 No.	-
9	Slotted Angle Cutter	1 No.	-
10	Pigmy Current Meter	1 No.	-
11	Camera (Yashica 635)	1 No.	-
12	Flash Gun	1 No.	-
13	Oven Big Size for Aorylic Moulding	12 Nos.	-
14	Pointer Gauge	12 Nos.	-
15	Prandtl tubes	6 Nos.	-
16	Mono Meter	1 No.	CBIP
17	Heat sealing equiment	1 No.	CBIP
18	Thickness Gauge	1 No.	CBIP
19	Tensile Strength & Elongation equipment	1 No.	

List of Equipments Available in Bhopal, Raipur and Jabalpur Laboratories.

Soil Testing

S.No.	Name Of Equipments	Soil & Material Testing Laboratory			Remarks
		Bhopal.	Raipur	Jabalpur.	
1	2	3	4	5	6
1	Triaxial Shear Machine	9	10	1	
2	Swell Pressure Apparatus	12	2	-	
3	Compaction Test Apparatus	4	4	4	
4	Limit Test Apparatus	4	2	2	
5	Shrinkage Test Apparatus	2	1	-	
6	Grain Size Analysis Apparatus	2	2	2	
7	Permeability Test Apparatus	4	12	6	
8	Relative Density Test Apparatus	1	-	-	
9	Consolidation Test Apparatus	1	1	-	
10	Box - Shear Machine	1	1	-	
11	Penetrometer	3	1	3	
12	North Decota Cone	-	1	-	
13	Permeability & Settlement Test Apparatus	2	2	-	
14	C.B.R. Test Apparatus				
	(A) Lab. Type	1	-	-	
	(B) Field Type	1	-	-	
15	Puris - Siltometer	-	1	-	
16	Abots Compaction Kit	-	2	-	
17	Unconfined Compression Test Apparatus	1	1	-	
18	Universal Electronic Triaxial Shear Testing Machine	1	-	-	

List of equipments (Misc Disc)

List of Equipments Available in Bhopal, Raipur and Jabalpur Laboratories.

Material Testing.

S.No.	Name Of Equipments	Soil & Material Testing Laboratory Bhopal.	Raipur	Jabalpur.	Remarks
1	2	3	4	5	6
1	Compression Testing Machine.				
	A - 200 Tonne Cap.	1 No.	-	-	
	B - 100 Tonne Cap.	1 No.	1 No.	1 No.	
	C - 50 Tonne Cap.	2 Nos.	-	-	
	D - 25 Tonne Cap.	-	-	1 No.	
2	Abration Testing Machine.	1 No.	-	-	
3	Attrition Testing Machine.	1 No.	1 No.	-	
4	Crushing Value Test Apparatus (7.5, 15 & 30 dia.)	1 Unit.	1 Unit.	1 Unit.	
5	Impact Test Apparatus	2 Nos.	1 No.	1 No.	
6	Ball Mill	1 No.	1 No.	-	
7	Compacting Factor Apparatus	1 No.	-	1 No.	
8	Slump Test Apparatus	2 Nos.	2 Nos.	2 Nos.	
9	Mortar Permeability Test Apparatus	1 No.(Set of Six)	-	-	
10	Concrete Permeability Test Apparatus	1 No.(Set of Three)	-	-	
11	Muffle Furnace	1 No.	1 No.	-	
12	Air - Entrainment Meter				
	A - 0.005 Cum. Cap.	1 No.	-	-	
	B - 0.01 Cum. Cap.	1 No.	-	-	
13	Accelerated Curing Tank	4 Nos.	1 No.	-	
14	Normal Curing Tank	4 Nos.	1 No.	-	
15	Le-Chatilier Flask	4 Nos.	4 Nos.	-	
16	Le-Chatilier Apparatus For Soundness	4 Nos.	4 Nos.	2 Nos.	
17	Blains Air Permeability Test Apparatus	2 Nos.	2 Nos.	2 Nos.	
18	Platinum Crucible	3 Nos.	1 No.	-	
19	Vibrating table	2 Nos.	1 No.	1 No.	
20	Vibrating Needle	1 No.	-	-	
21	Distillation Plant	2 Nos.	2 Nos.	1 No.	
22	Rapid Moisture Meter	1 No.	2 Nos.	1 No.	
23	Concrete Mixer	2 Nos.	1 No.	1 No.	
24	Vee-Bee Consistometer	1 No.	-	-	
25	Laboratory Jaw Crusher	1 No.	-	-	
26	Flow Table For Mortar	2 Nos.	2 Nos.	1 No.	
27	Flow Table For Concrete	1 No.	-	-	

1	2	3	4	5	6
28	Vicat Apparatus	2 Nos.	2 Nos.	3 Nos.	
29	Mortar Mixer	1 No.	1 No.	-	
30	Tensile Testing Machine	1 No.	-	-	
31	Jolting Apparatus	1 No.	-	-	
32	Rock Cutting Saw	1 No.	-	-	
33	Heat Of Hydraulic Apparatus	1 No.	-	-	
34	B. O. D. Incubator	1 No.		-	
35	P. H. Meter	1 No.	-	-	from C.B.I.P.
36	Spectro Colorimeter	1 No.	-	-	from C.B.I.P. & P.
37	Turbidity Meter	1 No.	-	-	from C.B.I.P. & P.
38	Conductivity Meter	1 No.	-	-	
39	Auto Clave	1 No.		-	
40	Aggregate Polishing Machine	1 No.	-	-	
41	Transverse Strength Apparatus	1 No.	-	-	
42	Mortar Penetrometer	1 No.	-	-	
43	Flexure Strength Testing Machine For Canal Lining Tiles	1 No.	-	-	
44	Bactreological Incubator	1 No.	-	-	from C.B.I & P.
45	Pathalkotes Kit for Water Testing	1 No.	-	-	from C.B.I. & P.

List of equipments (Misc Disc)

Annexure 3
(Refer para 4.11)

Position Of Staff As Required And As On Roll On 1.1.90

Sl.No.	Name of post	Sanctioned strength	On roll	Vacancy
1.	Director (S.E. level)	1	1	-
2.	Deputy Director/Research Officers (E.E. level)	4	4	-
3.	A.R.O / A.D (A.E. level)	16	13	3
4.	Research Assistants	47	4	43
5.	Silt Analyists	5	4	1
6.	Embankment Inspectors	5	5	-
7.	Laboratory Techniciens	31	9	22
8.	Laboratory Assistants	16	2	14
9.	Instrument Mechanic	1	1	-
10.	Techanical Staff	19	10	9
11.	Ministrial Staff	28	21	7
12.	Class IV viz. Peon/Drivers etc.	32	14	18

Annexure 4
(Refer Para 5.3)

List of Hydraulic Model Studies Carried out

Sl. No.	Name of the Specific Report	Month/year
1.	Model studies on Bargi Project spillway.	
2.	Model studies for stage construction of Mahanadi Reservoir Project spillway.	
3.	M.R.P. Stage Construction.	
4.	Model studies for Scour below Hasdeo.	
5.	Interim Report on model studies for energy dissipation below Hasdeo Bango spillway.	April' 1978
6.	Model studies of Harsi Waste Weir.	
7.	Bargi Dam spillway	
8.	Bansagar spillway.	
9.	M.R.P.Spillway.	Nov' 1979
10.	Bansagar Supplement No.II	Dec' 1979
11.	Tawa River Bridge.	Jan' 1980.
12.	Model studies for Reservoir Operation for M.R.P.	May' 1981
13.	Sondur Dam spillway	Aug' 1981
14.	Bansagar.	
15.	Mand diversion Scheme.	March' 1981.
16.	Bargi Dam spillway	
17.	Energy dissipation Bansagar.	May' 1981
18.	Pari pick up weir.	Jul' 1981.
19.	Bansagar	
20.	Bansagar	
21.	Bansagar	Dec' 1981.
22.	Bargi Dam.	Feb' 1982.
23.	Ranayar flood protection	May' 1982.

24.	Bansagar	Jun' 1982
25.	Sondur Dam spillway	
26.	Bansagar spillway	Oct' 1982.
27.	Bargi Dam	Dec' 1982
28.	Kolar Dam spillway	April' 1983
29.	Kolar Dam spillway	Sept' 1983.
30.	Hasdeo Bango spillway	Aug' 1983.
31.	Kolar Barrage spillway	
32.	Bansagar spillway	Oct' 1983
33.	Hasdeo Bango	Nov' 1983.
34.	Hasdeo Bango	Nov' 1983.
35.	Kanhan river training	Dec' 1983
36.	Kaliasote	Dec' 1983.
37.	Bhimgarh	Jan' 1984.
38.	Mahan spillway	April' 1984.
39.	Sondur	May' 1984.
40.	Tailrace Channel of Bargi	Jan' 1984.
41.	Bansagar	Jun' 1984
42.	Narmada Sagar	Aug.' 1984
43.	Kaliasote Dam spillway	Oct' 1984.
44.	Kaliasote Waste Weir	Oct' 1984.
45.	Model study of Man project	March' 1985.
46.	Model study of Kolar spillway	March' 1985.
47.	Model study of Sikasar.	March' 1985.
48.	Model study of Narmada Sagar	March' 1985.
49.	Stage construction study of Bansagar spillway	April' 1985.

50.	Bargi stage construction for June 85.	Jun' 1985.
51.	Stage Construction study for Hasdeo Bango.	May' 1985.
52.	Hy.Model study for Maheshwar	Aug' 1985.
53.	D.R.P.Report on Maheshwar 2 - D	Feb' 1986
54.	Model studies of Bansagar(Interim Report)	Sept' 1985.
55.	Spill channel of Kolar Dam	Oct' 1985.
56.	Brief Report on Sondur Dam spillway with revised tail water level.	Oct' 1985.
57.	Bansagar stage construction June - 86	Dec' 1985.
58.	Supplement Report No.I.	Jan' 1986.
59.	Mahan model with EDA as solid Roller Bucket.	Nov' 1985.
60.	Hasdeo Banço	May' 1986.
61.	Model studies for Bercher tank project(3-D)	May' 1986.
62.	Gambhir project	
63.	Model study of Ruthiai	June' 1987.
64.	Back water effect on Bhadbhada spillway	June' 1987.
65.	Hasdeo Bango project(stage construction)	July' 1987.
66.	Hasdeo Bango	March' 1988.
67.	Gambhir project	Oct' 1988.
68.	Model study of Maheshwar Hydro Electric project.	Nov' 1988.
69.	Model Studies of Sondur	Oct' 1988.
70.	Model study of Narmada Sagar(Intrim report)	
71.	Model study of Mahan project	June - 89.
72.	Model study of Dudhi project.	July - 89.
73.	Model study of Sikasar	July - 89.
74.	Model study of Indira Sagar	Nov' 1989.
75.	Model study of Mahan	Feb' 1990.

76. Study for downstream divide wall of Hasdeo Barrage.

77. Study for Waste Weir of Chitorie tank.

78. Studies for energy dissipation below Bile Pick-up weir (Interim)

79. Studies for energy dissipation below Bhadbhada weir (Interim)

80. Studies for rigid bed model for Anti-river erosion scheme of flood protection to Mungeli town.

81. Training of Kanhan river in Chhindwara district (Interim)

82. Study on Bile pick up weir(final)

83. Studies on Bile Dam spillway.

84. Studies of Tawa dam spillway(On sectional model)(Interim)

85. Studies on determination of co-efficient of discharge of Dhuti-Weir.

86. Study of Chute fall of Keoramunda tank.

87. Studies on Chute fall of Karhi project.

88. Study on Chandrakeshar dam spillway.

89. Studies for Sagar nadi dam spillway.

90. Mobile bed model studies for training of Kanhar river (final)

91. Study for spillway at Tawa dam (final).

92. Studies for Mahanadi Canal fall at Ch.600.

93. Studies for protection below Bhadbhada spillway (final).

94. Studies for stage construction at spurs for flood protection of Mungeli town.

95. Model studies for Maniari Canal fall at R.D.362.92.

96. Field studies for canal losses and rugosity co-efficient of Harsi Main canal.

97. Model study for Bargi dam spillway(on sectional model).

98. Field studies for canal losses and rugosity co-efficient of Tandula Main Canal.

99. Field studies for canal losses and rugosity co-efficient of Harsi main canal.

100. Field studies for canal losses and rugosity co-efficient of Kharkhara Main Canal.

101. Model studies for different construction stages of Tawa dam.

102. Studies for Sindh project spillway phase - I (Interim).

103. Studies for training of Mahanadi River protection of Rajim temple.

104. Studies for flood protection of Mandla town.

105. Studies for stage construction of Tawa spillway for the working season.

106. Studies for stage construction of Tawa.

107. Studies for Sindh project spillway(final).

108. Field studies for canal losses, rugosity co-efficient in Harisi and Bhind Canal system.

109. Studies for Mahanadi Reservoir project falling apron.

110. Studies for Mahanadi Reservoir Project Spillway.

Annexure 5
(Refer para 5.4.1)

LIST OF RESEARCH STUDIES ALLOTTED TO DIRECTORATE OF IRRIGATION RESEARCH, M.P. BY CENTRAL BOARD OF IRIGATION AND POWER

A- Studies entrusted before VII plan and completed.

1. Studying Engineering properties of swelling soils and their performance in Earthen Dams.
2. Study of suitability of Flyash from various Thermal power stations in M.P.
3. Study of Pore pressure in Earth Dams with reference to design criteria.
4. To estimate probable depth of scour below ski jump bucket.
5. Study of field equipment for compaction of different soils in projects of M.P.
6. Sedimentation studies in Gandhisagar Reservoir.
7. Collection of data of scour below spillways of selected dams in M.P. and their comparison with design assumptions.
8. Instrumentation in Masonry dams in Madhya Pradesh.
9. Control and Distribution of Irrigation supplies beyond outlet, present practices and improvement required.
10. Design of open channel transitions for Hydraulic structures.
11. To assess seepage losses in Irrigation canals of M.P.
12. Sedimentation studies in Tawa Reservoir.
13. Water pollution.
14. Correlation of Engineering properties of swelling soils.
15. Behaviour of C.N.S soil in canal lining in the foundation of C.D.Works and retaining structures.

B. Studies entrusted during VII Plan and under progress

S.No.	Name of problem	Date of start	period	Remarks
1.	Sedimentation studies at Tawa Reservoir	4/86	3 years	Repeat study
2.	Training of small streams at hydraulic structure	4/86	2 years	Spill over from VI plan

3.	A study of water quality and remedial measures for pollution	4/86	3 years	
4.	Sedimentation studies at Gandisagar Reservoir	1/87	2 years	Repeat study
5.	Study of effects of floods on morphology of incised rivers in M.P.	4/86	3 years	
6.	Studies on environmental impact of utilisation of Trecl Element contaminated water in Irigation and Development of Relevent water quality criteria.	4/89	3 years	
7.	Leaching of lime from Gandisagar, Barna and Tawa reservoirs in M.P.	4/89	3 years	
8.	Setting up of plastic culture Development centre.	15.1.87	5 years	

R&D Thrust Areas for VIII Five Year Plan S&T Programme

Sl. No.	NACRD Subject	Thrust Areas Basic and Applied Research	Thrust Areas Action Research
1.	2.	3.	4.
1.	Management of Floods	1. River Behaviour 2. Flood Hyrology & Hydrometry 3. Agronomical aspects related to Flood Management 4. Reservoir Sedimentation 5. Flood Management	On specific problems to be identified in consultation with field engineers Project authorities
2.	Hydraulic Structures	1. Cavitation, abrasion & attrition 2. Flow measurement/Control systems & Mathematical modelling/analysis of flow in Hydraulic Structures 3. Scour/energy dissipation problems 4. Sediment exclusion devices 5. Improved design of hydraulic structures 6. Repair/Rehabilitation of hydraulic structures 7. Thermal behaviour/chemical susceptibility of concrete/masonry structures 8. Risk/economic/performance analysis of hydraulic structures	1. Model prototype confirmity studies on cavitation abrasion & attrition problems in Hydraulic Structures 2. Scour/energy dissipation problems 3. Sediment exclusion devices - model prototype confirmity studies 4. Improved design of hydraulic structures - post application performance studies
3.	River & Estuarine Hydraulics	1. Fluvial & Coastal processes 2. Hydrodynamics 3. Sediment transport 4. Documentation, preparation of manuals, quidelines and data base & retrieval systems.	1. Scour around hydraulic structures 2. Stability of coastal structures
4.	Ground Water	1. Estimation of groundwater potential and its utilisation; flow in saturated state & recharge to groundwater; 2. Ground water, Quality; computerised data base retrievel system; Groundwater Management through design of wells/tubewells pumps 3. Groundwater inter-basin transfer; losses to sea & reclamation; use of Radio-active tracers in groundwater hydrology	1. Artificial recharge 2. Design aspects of well tubewells 3. Design of Low cost Ground Water structures and indigenous lifts

1.	2.	3.	4.
5.	Hydrology & Drought Management	1. Mountain hydrology 2. Data collection, Data base & retrievel systems 3. Hydrology of special areas 4. Hydrological aspects of dam safety/flood and hydrological forecasting 5. Hydrological modelling Systems studies 6. Human influence on hydrologic regime 7. Hydrological aspects of Drought & Drought Management	1. Dambreak studies 2. Flood Plain Zoning 3. Mountain hydrology 4. Water Harvesting and Water conservation
6.	Irrigation & Drainage	1. Water Management and water use efficiency (including on-farm development studies) 2. Drainage requirement for cropping systems/drainage studies (including salinity prevention studies) 3. Equity under scarce water conditions 4. Weed control and removal 5. Conjunctive use modelling/ studies of surface & ground water systems studies 6. Effect of rainfall characteristics on irrigation and water management 7. Dynamic regulation of irrigation systems 8. Canal Lining Efficacy and Economy	1. Water Management & water use efficiency (including onfarm development studies) 2. Drainage requirement for cropping systems drainage studies (including salinity prevention studies) 3. Effect of rainfall characteristics on irrigation and Water Management 4. Dynamic regulation of irrigation systems 5. Farmers participation in water management
7.	Environmental Impact & Socio-economic Aspects of Water Resources Projects	1. Development of methodology for environmental impact assessment & data base establishment 2. Studies on micro-climatic changes due to water resources projects 3. Impact of Water Resources Projects on environmental sanitation 4. Effect of water resources projects on flora and faune 5. Effect of Reservoirs on river regime 6. Development of appropriate methodology for socio-economic analysis and equity assessment	1. Evolving methodology for most suitable cropping pattern 2. Organising community participation at micro-level

1.	2.	3.	4.
8.	Soils & Materials	1. Innovations in materials; design and construction techniques for earth/masonry/concrete structures 2. Field and laboratory studies on residual/problematic soils 3. Studies on Rockfill for high dams 4. Durability for concrete & correction of steel in R.C.C. 5. Dynamic characteristics including liquification studies 6. Concrete mix design economising binders	1. Roller compacted concrete 2. Rockfill test embankment & field quality control 3. Ferro cement/geosynthetics lining 4. Field liquification studies/dynamic characteristics 5. Performance studies of new materials against cavitation & abrasion 6. Prepacked masonry/sprayed concrete/cuicrete
9.	Rock Mechanics	1. Drilling & blasting including directional blasting 2. Rock-mass behaviour (classification, strength & deformation) 3. Ground improvement 4. Foundations of dams barrages & weirs 5. Underground structures 6. Modelling & simulation 7. Stress measurement techniques	1. Field evaluation of blasting patterns 2. Evaluation of geotechnical classification of rock mass to link laboratory and field rock responsees to the applied and induced stresses 3. Assessment of the effect of high pressure jet on rock masses and requisite correlation with rock parameters
10.	Application of High Technology and Instrumentation and Measurement Techniques	1. Applications of remote sensing techniques in water resource sector 2. Hydraulic instrumentation (Model & prototype) 3. Hydrological instrumentation 4. Structural and geotechnial instrumentation 5. Seismological instrumentation	1. Field and prototype studies on topics related to thrust areas 1 to 5 of basic applied research
11.	Construction Methods, Planning & Management (including Hydraulic Machinery & Construction equipment	1. Modern construction techniques & management for tunnels, rockfill dams, grouting, dewatering, diverstion arrangements & canal systems 2. Development of computer applications in construction management (including use of MIS/PERT/CPM & advanced techniques) 3. Up grading quality control techniques including instrumentation & preparation of manuals for water resources projects	

1.	2.	3.	4.
		4. Man power development for equipment operation & maintenance, cost Management 5. Development of Pre-cast structures in water resources distribution systems 6. Improving performance characteristics of pumps & pumping systems & Development of pump turbines 7. Cavitation & Abrasion of Hydraulic Machinery Components 8. Improvement of efficiency at partial loads in Francis Turbines	
12. Education and Training in Water Resources			1. (a) Categorisation of Man power & Job specifications Aspects for Study Major, medium & minor irrigation projects (i) Investigation & Planning (ii) Design (iii) Construction (iv) Operation, maintenance & management (b) Evaluation of approximate ratio between different categories 2. Man power projection for (1) above for existing & for envisaged condition of aspects as above 3. Curriculam development-case studies of curriculam and instruction methods 4. Studies on methodology/its improvement for students (4 levels) and for trainers of trainees 5. Instructional material development for technical personnel and the public (conventional/audio-video/ through media)
13. Evaporation Control		1. Parameters affecting evaporation and techniques/methods of evaporation control (including on-farm irrigation)	1. Application of water evaporation retardants (methods/ techniques in chemical/ biological physical)

1.	2.	3.	4.
		2. Techniques for measurement of evaporation retardents on water quality and acquatic life 3. Development/improvement of water evaporation retardants (including standards/specifications manuals etc.) 4. Effect of evaporation retardants on water quality and acquatic life	2. Alternate methods of evaporation control such as compartmentalisation/ wind brakers etc. 3. On farm-evaporation control 4. Pilot studies on evaporation from reservoirs of different sizes 5. Development of Data-base and retrievel systems
14.	Plasticulture Development	1. Performance studies (durability, exposure to sun, high temperatures salinity etc.) 2. Manufacture of different types of film (serrated/composite/fibre - reinforced/fibre-fabric etc.) 3. Laying and Sealing of films and bonding strength of films 4. Techniques for prevention of rodent damage, weed growth etc. 5. Measurement of seepage in unlined channels and channels lined with LDPE film 6. Economics of composite lining for seepage control	1. Performance evaluation of LDPE lining with respect to bond strength, rodent attack and weed growth in different types of soils at micro level 2. Case studies of canal reaches having problematic soils, soils with aggressive chemicals, soils subject to termites/insect attack etc.

Annexure 7
(Refer para 8.3)

Strengthening of BODHI - Upgrading of Hydraulic Model and Soil and Material Testing Laboratories At Hathaikheda, BHOPAL

General Abstract

Sl. No.	Particulars	Purpose	Quantity	Amount in Rs. Lakhs	Remarks
1.	Equipments	For Soil testing laboratory	As per details enclosed	13.35	
2	.Equipment	For Material testing Lab.	-do-	35.65	
3.	Miscellaneous item	For Hydraulic S&M Laboratory	-do-	3.95	
4.	Computer equipments.	-do -	-dO-	1.50	
		Total :-		54.45.	
5.	Extra 5%	for freight Transport chamber.	% charges on B 54.45 lakhs.	2.72	
6.	Extra 4%	For Sales Tax	-do-	2.18.	
7.	Extra 1%	For installation demonstration etc.	- dO -	0.55.	
		Grand Total :-		59.90.	
		Say Rs. 60 Lakhs.			

Strengthening of BODHI - Upgrading of Hydraulic Model and Soil and Material Testing Laboratories At Hathaikheda, BHOPAL

Abstract

Sl. No.	Particulars	Purpose	Quantity	Amount in Rs. Lakhs	Remarks
	Soil Testing Laboratory.				
1.	Consolidation Apparatus for consolidation tests of Soils with digital display & electronic date loger.	For consolidation tests of soils.	1 No	0.60	
2.	Dynamic cone Penetrometer with 'A' type drill rod engine driver with Tripod & extension rods etc.	For bearing Capacity of Soils (In Situ test)	1 No	1.30	
3.	Triaxial shear test machine with digital display and date loger.	For shear tests on soils.	1 No	1.50	
4.	Pressure meter 100 bar capacity for Ax + Bx Probe out fit.	In situ test of soil load deformation	1 No	2.00	
5.	Universal automatic compaction test apparatus.	For compaction test on soils (Heavy compaction)	2 Nos	0.20	
6.	Dead weight pressure gauge tester for calibration of gauge.	For caliberation of gauge in the laboratory.	1 No	0.25	
7.	Triaxial Testing system computerised.	For shear Tests on soils	1 No	7.50	
			Total :-	13.35	

Strengthening of BODHI - Upgrading of Hydraulic Model and Soil and Material Testing Laboratories At Hathaikheda, BHOPAL

Abstract

Sl. No.	Particulars	Purpose	Quantity	Amount in Rs. Lakhs	Remarks
	Material Testing Laboratory.				
1.	Compression Testing Machine 200 M.T.capacity.	For compression tests on 60 cm. diameter specimen of concrete.	1 No	14.00	11/2" 200 T we have.)
2.	Atomic Absortio meter	For determining of different elements in water.	1 No	3.00	To determine Na,K,Cal Li t
3.	Core drilling machine electrically operated for core size Ex, Ax,Bx & Nx.	For taking cores of rock & concrete.	1 No	2.00	In field.
4.	Point load tester for rock testing.	For Index test for strength classification of rock.	1 No	0.25	Type of rock (In field & Lab.also.)
5.	Slake durability test apparatus	To determine the resistance offered by rock/concrete samples when subjected to drying & wetting in a slaking fluid.	1 No	0,20	Cycle of drying & welling is slaking.
6.	Nuclear moisture density gauge.	For In situ measurement of density and water content in soils.	1 No	0.75	Field.
7.	Three axis bore hole deformation gauge	For measurement of Insitu stress in rocks.	1 No	3.00	-do-
8.	Maturity meter using relationship of time & temperature.	For assessing the maturity strength of concrete.	1 No	0.40	Lab.
			C O	23.60.	

Sl. No.	Particulars	Purpose	Quantity	Amount in Rs. Lakhs	Remarks
9.	Equipment for specific heat & themal conductivity of concrete.	For determination of specific heat & thermal conductivity of concrete.	1 No	2.00	
10.	Heating over thermostatically controlled for tiles of size 50 cm x 50 cm.x 5 cm. inside clear space 75 cm x 75 cm x 50 cm for keeping tiles temperature range between Ambient to 150 ° c.	For water absorption of concrete tiles.	1 No	0.50	
11.	Litra-sonic pulse velocity test meter.	For elastic property of rock & concrete.	1 No	1.50	
12.	Resonant frequency tester.	For dynamic modulous of elasticity & dynamic modulous of rigidity for rock & concrete.	1 No	2.00	
13.	Rock cutting saw.	For cutting specimen to size of rock.	1 No	0.30	
14.	Concreate mixer for aggregate size of 150 mm.	For mixing concrete.	1 No	0.40	
15.	Air entrainment meter capacity 0.10 cu.m.	For determining air content of concrete.	1 No	0.20	
16.	Tile testing machine size 50 cm x 50 cm. x 5 cm.	To determine flexural strength of concrete tiles.	1 No	0.20	
			C O	30.70.	

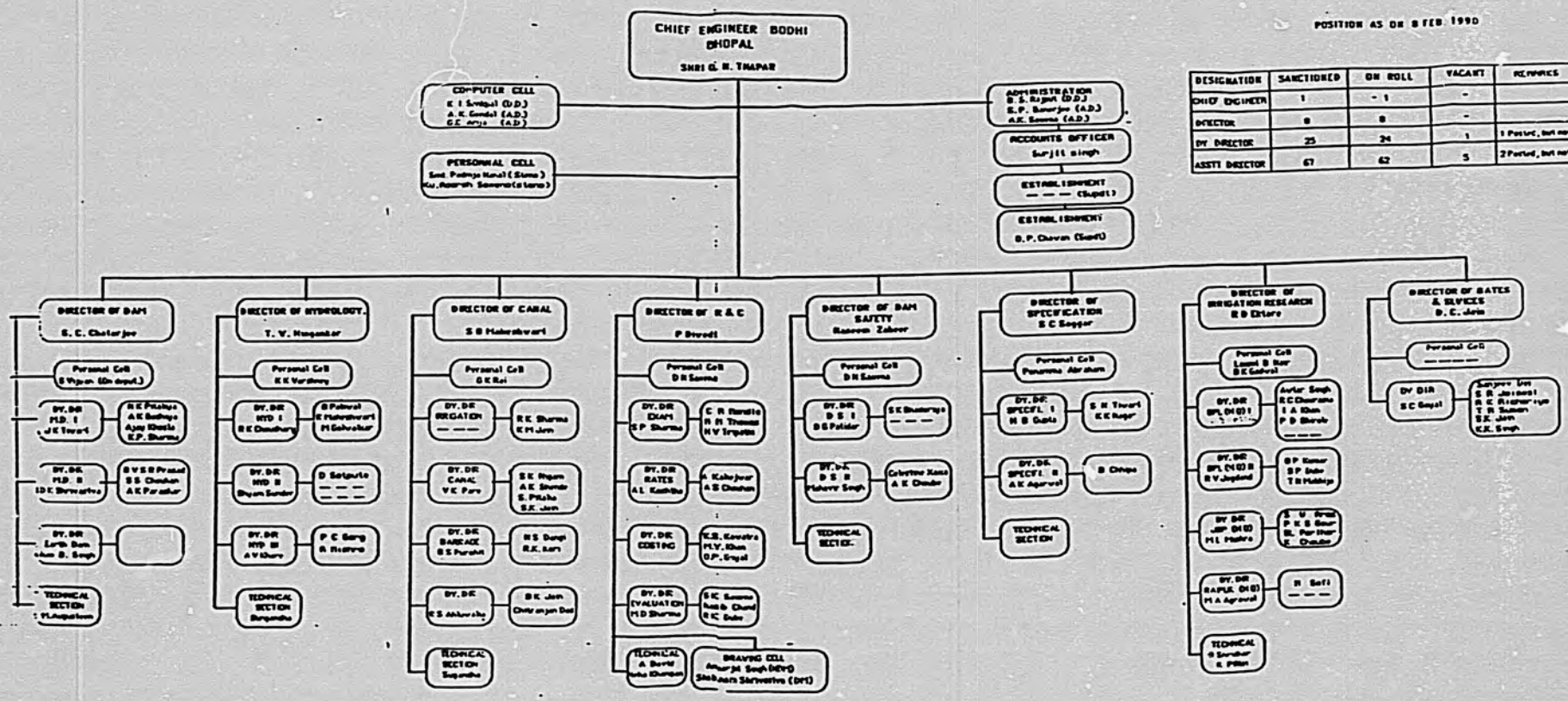
Sl. No.	Particulars	Purpose	Quantity	Amount in Rs. Lakhs	Remarks
17.	Tri axial shear testing machine for rock specimen size of 100 mm .	For rock shear tests	1 No	2.50	
18.	Laboratory auto cleve zous/cm^2 pressure.	For conducting soundness acclerated test on cement.	1 No	0.25	
19.	Dorry abrasion testing machine.	For resistance of aggregate to wear by abrasion.	1 No	0.20	
20.	Humidity controlled For keeping concrete condition environment chamber size 1 cm	samples at desired humidity.	1 No	1.75	
21.	Equipment for pull out test.	For pull out test for rock specimen.	1 No	0.25	
			Total:-	35.65	

Strengthening of BODHI - Upgrading of Hydraulic Model and Soil and Material Testing Laboratories At Hathaikheda, BHOPAL

Abstract

Sl. No.	Particulars	Purpose	Quantity	Amount in Rs. Lakhs	Remarks
	Miscellaneous Items :-				
1.	Air conditioner (1 1/2T.Cap.) for Triaxial system & cement testing apparatus.	For tests to be conducted at desired temperature.	4 No	1.0	
2.	Refrigerator (300 lit.cap.)	For keeping chemicals.	1 No	0.15	
3.	Stabilisers 4 KVA	For testing machines & refrigerator & air condition.	10 Nos	0.20	
4.	Water cooler (200 litres)	For drinking water for staff in laboratory.	2 Nos	0.60	
5.	Mobile van	For transportation of materials since the laboratory is 15 km. away from Bhopal city.	1 No	2.00	
			Total :-	3.95.	
	Computer equipments :-				
1.	Micro computers PC/XT	For acquiring and storing data and analysing the same.	1 No	0.80	
2.	Software packages	For computer	6 Nos	0.30	
3.	Accessories	For computer	L.S.	0.40	
			Total :-	1.50.	

APPENDIX B



POSITION AS ON 8 FEB 1990

DESIGNATION	SANCTIONED	ON ROLL	VACANT	REMARKS
CHIEF ENGINEER	1	1	-	
DIRECTOR	8	8	-	
DY DIRECTOR	25	24	1	1 Posted, but not joined
ASSTT DIRECTOR	67	62	5	2 Posted, but not joined

APPENDIX C

MADHYA PRADESH IRRIGATION DEPARTMENT
BUDGETED EXPENDITURES (TENTATIVE)
FOR
EIGHTH 5-YEAR PLAN

DETAILS OF PROJECTS TO BE COMPLETED IN VIIth & VIIIth PLAN

Major and Medium Irrigation (Rs .Crores)

S.NO	PROJECTS	Spillover Cost to VIII Plan	Proposed Outlay VIII Plan	Proposed Outlay 1990-91
1	2	3	4	5
1.	Major Projects			
(i)	Externally Aided (2 nos) Hasdeo Bango & Mahanadi	1134.82	400.00	75.00
(ii)	Inter-state projects (4 Nos.)			
	-Multi purpose (2 Nos.) Rajghat & Bansagar	901.86	56.72	36.00
	-Major (2 Nos.) (Urmil to be completed in VIIIth Plan)	92.53	18.61	2.00
		994.39	375.33	38.00
(iii)	Pre Vth Plan (5 Nos.) Kolar,Pairi,Sindh Phase-I, Rangwan,Jonk (All expected to be completed in VIII Plan)	99.89	99.89	18.15
(iv)	Other projects Multipurpose (1 No) Bargi	312.17	195.03	18.50
	Major (7 No) Upperwaingan, Kodar,Halali & Thanwar likely to be completed in VIII Plan and Bariarpur LBC & Mahi to be completed in IX Plan	239.24	203.04	25.80
(v)	Nearing completion (4 NOS) Tawa,Barna,Sukta,Bhander to be completed in VIII Plan	20.01	20.01	3.70
(vi)	New Projects (4 No) Pench Diversion, Kelo, Mongra & Arpa	482.44	69.88	2.05
(vii)	Modernization (2 No.) (Harsi & Sindh Reva Link)	64.61	28.00	1.35

1	2	3	4	5
(viii)	Restoration and improvement of existing Irrigation Project (5 No .) Chambal lift, balance work of Chambal Phase-II Improvement of Chambal canal, rehabilitation of Pagara, Kotwal, Pillowa Dam and rehabilitation of Tigra Dam (Chambal lift to be completed in VIII Plan)	67.33	60.95	1.00
	Total I (i to viii)	3414.90	1452.13	183.55
II	Medium project (For Details Refer Note-I)			
(i)	Ongoing projects (30 No)	446.57	336.06	50.07
(ii)	Nearing completion (12 No)	14.31	11.21	4.60
(iii)	Nearing completion (33 No)	8.07	8.07	1.40
(iv)	Water Management & other item decretal payment etc.	0.25	1.25	0.30
(v)	New Schemes (1 No) (Sank Swaran Rekha Link to be completed by VIII Plan) & Provision for new medium projects	11.17	31.17	0.60
	Total II (i to v)	480.37	397.76	56.97
III	Water Development Services		64.00	4.40
	Total (I + II + III)	3895.27	1913.89	244.92

SALIENT FEATURES OF MAJOR PROJECTS IN MADHYA PRADESH
UNDER EIGHTH 5-YEAR PLAN

S.N.	Projects	District	Cost, Rs. Crores	Height Dam, M	Irrigation Area, Ha.	Hydelpower MW	Spillway capacity cfs.
1.	Mand Diversion Works	Raigarh	4.95	2.5	14569	Nil	11726 (SPF)
2.	Narmada Sagar	Khandwa	622.78	83	123000	1000	65670 (SPF) 83366 (PMF)
3.	Kotwal	Gwalior	--	--	--	--	--
4.	Barna	Raisen	15	48	55000	Nil	11480
5.	Kunwar Chain Sagar	Rajgarh	2.9	5	4048	Nil	1210
6.	Bargi	Jabalpur	123	17.5	97000	105	38500 (SPF)

APPENDIX E

DETAILS OF R & D SCHEMES PROPOSED DURING VIII PLAN BY DIRECTOR IRRIGATION RESEARCH (BODHI) BHOPAL (M.P.)

a) R&D SCHEMES SPONSORED BY C.B.I.P.

S NO.	Name of scheme for R&D study	Estimated cost, Rs. lakhs.	Expenditure proposed during VIII Plan. Rs. lakhs
SPILLOVER FROM VII PLAN			
R.S.K.V.P.			
1.	Training of small streams across Hyd. structures.	2.03	1.23
2.	Leaching of lime at Gandhi Sagar, Tawa & Barna Dams.	4.96	3.89
R.S.F.C.			
3.	Study of effects of floods on morphology of incise rivers.	4.56	2.79
P.D.C.			
4.	Setting of plasticulture centre.	6.53	6.40
NEW SCHEMES OF VIII PLAN SUBMITTED TO CBIP			
5.	Instrumentation at Gandhi Sagar Dam.	5.46	5.46
6.	Studey of Kopra soils.	5.63	5.63
7.	Rock mechanics.	5.84	5.84
8.	Evaporation losses.	2.20	2.20
		19.13	19.13
		37.21	33.44 say Rs. 34 lakhs

(b) Infrastructural development of Research Institute Modernization & Computerization	85
(c) Special study under USAID.	19
Total a,b & c	138

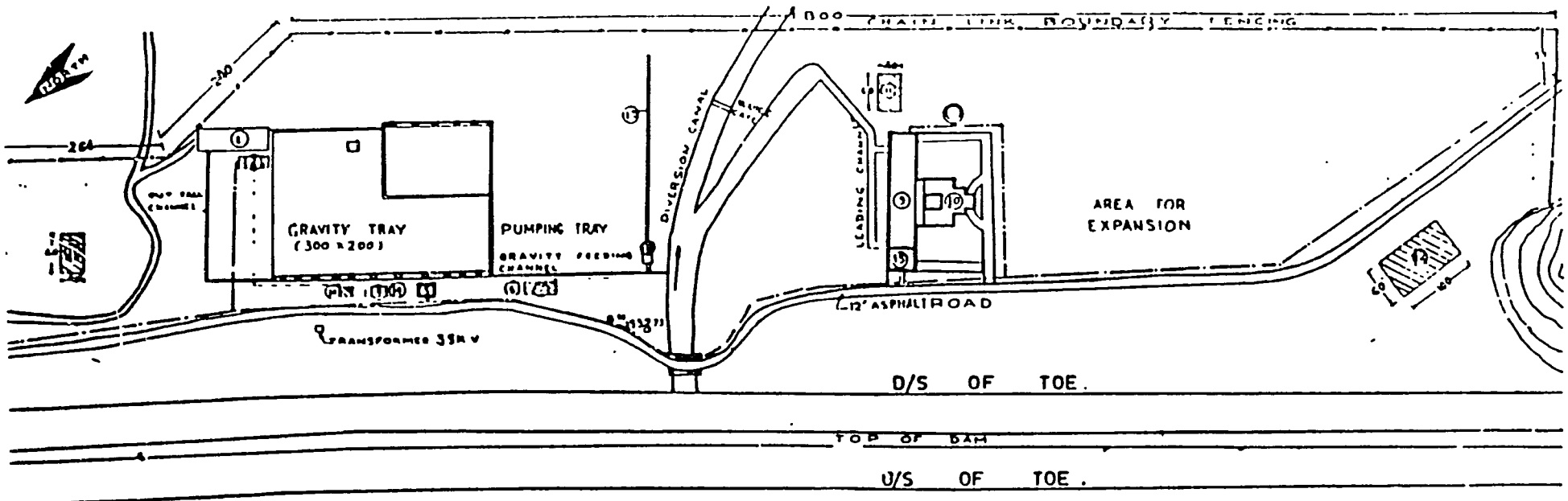
d) Running and Maintenance of laboratories

In addition to above state budget provisation as follows would also be spent on the running & maintenance of laboratories & routine work under Research Directorate.

Plan	Budget provision Rs. lakhs	Allotment Rs. lakhs	Actual Expenditures. Rs. lakhs
VIIth Plan	371	291	192
VIII Plan (Tentative)	400	400	400

NEW SCHEMES OF 8TH PLAN UNDER CONSIDERATIONS

1. Sedimentation studies of Barna, Bargi, Mahanadi & Bango Reservoirs	(On the basis of similar study of Tawa, Gandhi-sagar Reservoirs being done at present)
2. Water pollution and remedial measures in Barna, Bargi, Mahanadi & Bango Projects	(On the basis of similar study of Tawa Projects)
3. Leaching of line from Bargi, Sukta & Mahanadi Dams (Water sample study)	(On the basis of similar study being done at Tawa, Gandhisagar, Barna Dams at present)
4. Use of puzzolana and its effect on leaching from body of Dam at Barna, Tawa, Gandhisagar, Bargi, Sukta & Mahanadi Dams	(New study)
5. Scour around hydraulic structures - scour near the floors of stilling basins of falls in spill channel of ten Medium and Minor Projects	(New study)
6. Coeffficient of discharge on the basis of actual data and comparision with design assumptions of ten Medium and Minor Projects	(New study)



SKETCH NOT TO SCALE.

REFERENCES

MP FOR PUMP HOUSE 100'x30'
MP HOUSE 40'x15
ORE 65'-9"x16'
CARPENTER SHED 9'x16
OBSERVATION SHED 24'-9"x16'-9"

6 GARAGE 16'x16
7 MEETING HALL & LIBRARY 24'x50'
8 SUMP FOR PUMPING TRAY 10'x20'
9 INDOOR LABORATORY 40'x200'
10. OFFICE BUILDING 45'x90'

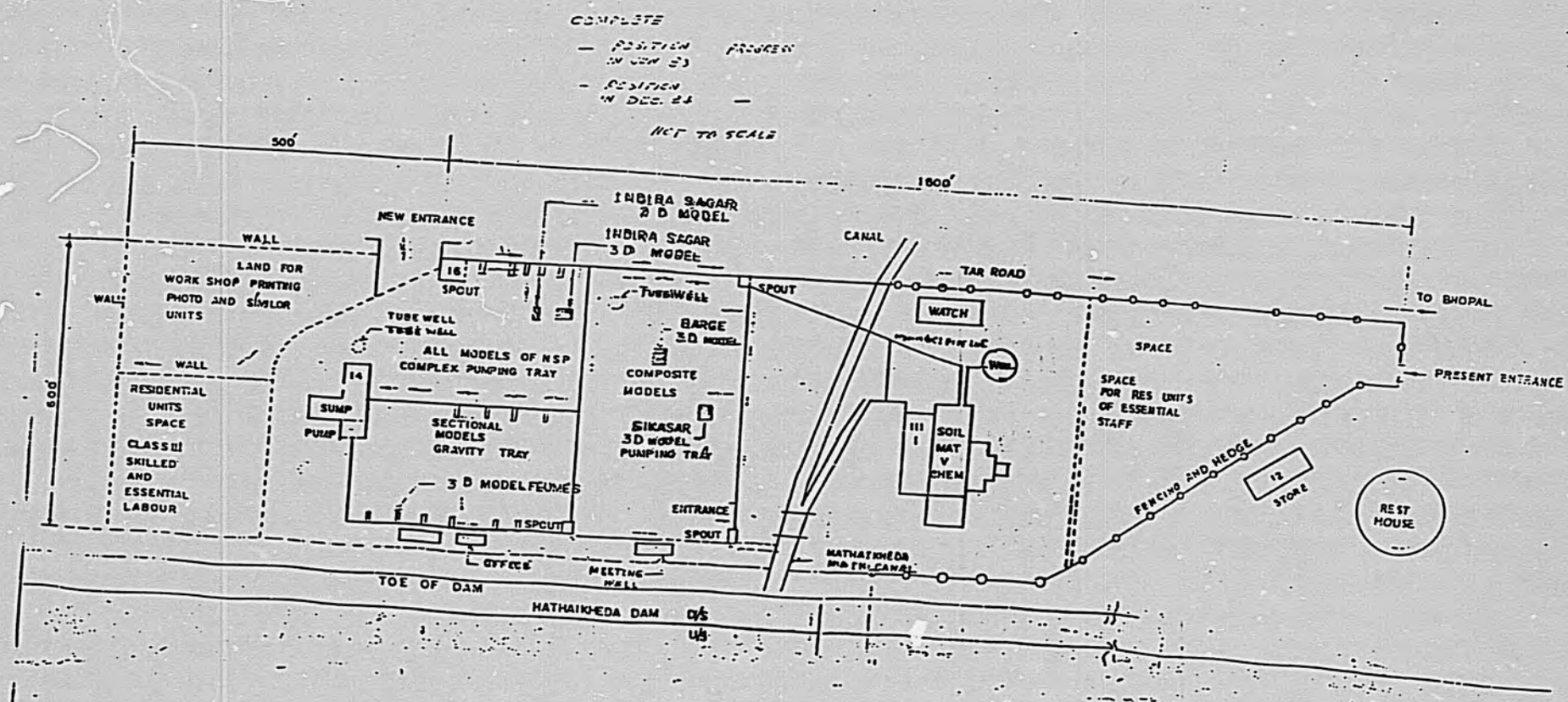
11 ONE BLOCK FOR WATCH & WARD 60'x40 (41 TYPE QUARTERS)
12. STORE YARD 100'x60'
13 LEADING CHANNEL FOR PUMPING TRAY 300' LONG
14 EXTENSION OF STORE 30'x16'
15 SOIL LABORATORY 40'x40'

PROPOSED CONSTRUCTION
PROPOSED PIPE LINE
PROPOSED L.T. LINE
FENCING

S.C. MEHRA

INDEX PLAN

Lay-Out of Hydraulic Research Station-Hathaikheda



INDEX PLAN

Lay-Out of Hydraulic Research Station
Hathaikheda

Previous Page Blank

APPENDIX G

DATA OF MODELS IN HYDRAULIC LABORATORY

S.No	Project	Model Scale	Maximum Dishcarge cfs	Maximum Head m
1.	Narmada Sagar (2D)	1:80	8.4	1.0 to 1.5
2.	Mand Diversion Works(2D)	1:40	5.0	1.0 to 1.5
3.	Kunwar Chain Sagar (2D)	1:20	6.1	1.0 to 1.5
4.	Gambhir Dam (2D)	1:50	5.9	1.0 to 1.5
5.	Mahan Dam (2D)	1:50	5.5	1.0 to 1.5
6.	Narmada Sagar (3D)	1:150	8.5	1.0 to 1.5
7.	Barna Dam (3D)	1:80	7.0	1.0 to 1.5
8.	Bargi Dam (3D)	1:120	7.0	1.0 to 1.5
9.	Sikasar Dam (3D)	1:60	6.0	1.0 to 1.5

APPENDIX H

HYDRAULIC LABORATORY STAFF
JANUARY 1990

S.N.	POSITION	SANC-TIONED STRENGTH	CURRENT STRENGTH	REMARKS
1.	Director	1	1	Engineering Graduate
2.	Dy. Director/ Research Officer	1	1	Engineering Graduate
3.	Asst. Director Asst. Research Officer	6	3	Engineering Graduate/ Science Graduate Promoted from Research Assistant
4.	Research Asst.	10	3	B.Sc. 1st class or M.Sc. in Physics, Chemistry, Maths or Geology
5.	Laboratory Technician A grade	5	3	B.Sc. Part I in Physics & Chemistry or Inter Science in Physics & Chemistry
6.	Laboratory Asst. B grade	5	1	Matric with Phy., Chemistry, Higher Mathematics
7.	Embankment Inspector (on loan)	3	2	Civil Engg. Diploma & 3 years experience or B.Sc. with Physics, Chemistry, Maths or Lab Tech. A grade of 4 years experience
8.	Technical Staff with Draftsman	6	6	-
9.	Ministerial Staff	7	7	-
10.	Class IV Staff (Peons)	8	4	-
11.	Carpenter	3	3	-
12.	Mason	4	4	-

APPENDIX I

STAFF TRAINING

1. All Assistant Research Officers and Research Offiers have visited Research Stations viz. C.W.P.R.S, Pune, MERI Nasik (M.S), GERI Vadodara (Gujarat), U.P.I.R.I Roorkee from time to time.

2. Training at Roorkee (U.P.) in W.R.D.T.C for 16 months obtained by Shri R.C. Chauraisa (M.E.), ARO.

RECOMMENDED EQUIPMENT PROCUREMENTS

S.N	Description	Quantity	Unit Price in $	Total Cost in $
1.	*Point gauge, 1m*	12	350	4200
2.	*U-Tube Manometers*	4	200	800
3.	Transducers Validyne Model DP15-22-N-1-S-4-A	12	450	5400
4.	Additional Diaphrams for Validyne Transducers			
	Dash No. 26	6	50	300
	Dash No. 30	6	50	300
5.	Validyne Transducer Indicator	1	-	500
6.	*IBM PS/2 - Model 50Z* 8550-031 8 MB standard memory 80286 co-processor Calender clock 3 expansion slots Parallel/Serial ports One 1.44 MB 3.5" floppy disk drive 30 MB hard disk VGA Graphics 12" color monitor Enhanced keyboard (101 keys) MS-DOS 3.3 80287 math co-processor Mouse	2	4500	9000
7.	National Instruments Data Acquisition Board MC-MIO-16H-25 p/n 776213-13	2	1195	2390
8.	National Instruments LabWindows Software with Advanced Analysis p/n 776191-01	1	-	1390
9.	National Instruments CB-50 I/O Connector Block p/n 776164-01	2	150	300
10.	HP LaserJet IIP Laser Printer	1	-	970
11.	*Miscellaneous Cables*	8	50	400
12.	*Voltage Stabilizer*	2	200	400
13.	Pygmy Current Meter Teledyne Gurley Model 645 TSM	2	2450	4900
14.	Delft Mini Propeller Meter	2	2500	5000
	Total			36250

Note: * Equivalent equipment indigenous to India may

APPENDIX K

IRRIGATION RESEARCH DIRECTORATE
HYDRAULIC RESEARCH REFERENCES
February, 1990

1. "Hydraulic Design of Stilling Basins and Energy Dissipators", USBR Monograph No. 25

2. "Design of Small Dams", USBR, 1985

3. Indian Standard Codes

4. "Open Channel Hydraulics", V.T. Chow, McGraw-Hill, 1959

5. Central Board of Irrigation and Power Journals

6. "Engineering Hydraulics", H. Rouse, J. Wiley and Sons, 1950

7. "Symposium on Stilling Basins and Energy Dissipators", ASCE Publication

8. "Theory and Design of Irrigation Structures", R.S.Varshney

9. "Studies of Crests for Overfall Dams", USBR

10. "Handbook of Applied Hydraulics", Calvin V. Davis

APPENDIX L

RECOMMENDED REFERENCES AND JOURNALS

1. HYDRAULIC MODELLING

   a. "Hydraulic Models", ASCE Manual of Engineering Practice No. 25, 1942 (may be out of print)

   b. "Theory of Hydraulic Models", M. Selim Yalin, MacMillian, 1971

   c. "Hydraulic Modelling", Helmit Kobus, ed., IAHR Bulletin No. 7, German Association for Water Resources and Land Improvement, 1980

   d. "Hydraulic Laboratory Techniques," United States Department of the Interior, 1980

2. SEDIMENT TRANSPORT (MOVEABLE BED)

   a. "Hydraulics of Sediment Transport", W.H. Graf McGraw-Hill, 1971

   b. "Sedimentation Engineering", V.A. Vanoni, ASCE Manual, 1975

3. HYDRAULICS

   a. "Engineering Hydraulics", H. Rouse, J. Wiley and Sons, 1950

   b. "Open Channel Hydraulics", V.T. Chow, McGraw-Hill, 1959

   c. "Hydraulic Design of Stilling Basins and Energy Dissipators", USBR Monograph No. 25

   d. "Hydraulic Design Criteria", U.S Army Corps of Engineers Waterways Experimentation Station, 1989

   e. "Hydraulic Design of Spillways", Engineering Manual, U.S. Army Corps of Engineers

4. GENERAL

   a. "Design of Small Dams", USBR, 1985

   b. "Manual on River Training and Behaviour", CBIP Publication No. 60, 1990

   c. "Stream Gauging", Harshy, WMO Publication

5. JOURNALS

a. International Association for Hydraulic Research (IAHR)

b. International Committee on Large Dams (ICOLD)

c. International Commission on Irrigation and Drainage (ICID)

OFFICIALS MET DURING VISITS AND DISCUSSIONS

PROJECT VISITS

1. Kolar Dam Project (Feb. 9, 1990)	Mr. O. P. Malya, S. E. Mr. V. K. Dixit, E. E. Mr. B. P. Asanti, E. E. Mr. S. P. Jain, E. E.
2. Halali Project (Feb. 10, 1990)	Mr. V. K. Mathur, E. E. Mr. O. P. Datta, A. E.
3. Ghora Tank Project (Feb. 12, 1990)	Mr. K. L. Gupta, S. E. Mr. C. K. Khanna, E. E.

MADHYA PRADESH IRRIGATION DEPARTMENT

Mr. J. R. Malhotra	Secretary to Government of Mahdra Pradesh Irrigation Department
Mr. P. C. Agarwal	Engineer-in-Chief Irrigation Department
Mr. O. N. Thapar	Chief Engineer Bureau of Design for Hydel & Irrigation Projects
Mr. P. Dwiveda	Director of Rates and Costs (BODHI Library Supervisor)
Mr. R. D. Ektare	Director Irrigation Research
Mr. G. S. Arora	Dy. Director Irrigation Research Research Officer, Hydraulic Research Station
Mr. R. V. Jogdand	Dy. Director Irrigation Research Research Officer, Soils and Concrete Research Station
Mr. R. C. Chourasia	Asst. Research Officer. Hydraulic Research Station

USAID MISSION OFFICE (NEW DELHI)

Mr. John Grayzel	Chief of the Office of Natural Resources Management
Mr. J. R. Khanna	Project Officer

HYDRAULIC RESEARCH STATION
BUILDING REQUIREMENTS

A. OFFICE BUILDING

COMPONENT	UNIT	UNIT AREA m^2	TOTAL AREA m^2
1. RESEARCH OFFICER	1	25	25
2. ASST. R.O.	6	25/2	75
3. Research Assistants	10	16/2	80
4. Drafting Area	1	16	16
5. Computer/Phot	1	16	16
6. Library	1	9	9
		TOTAL	219 m^2

B. WORKSHOP

COMPONENT	UNIT	UNIT AREA m^2	TOTAL AREA m^2
1. Machinery	10	16	160
2. Storage	1	25	25
3. Layout/Construction	1	100	100
		TOTAL	285 m^2

APPENDIX O

LIST OF EQUIPMENTS/INSTRUMENTS AVAILABLE AND UNDER PROCUREMENT AT THE HYDRAULIC LABORATORY

S.N	Name of Equipment	Number	Remarks
1.	Levelling Instrument	3	-
2.	Hand Drilling Machine (Wolf make)	1	-
3.	Centrifugal Pump (60 H.P)	3	-
4.	Centrifugal Pump (5 H.P)	2	-
5.	Centrifugal Pump (30 H.P)	3	-
6.	Water Pump (1 H.P)	1	-
7.	Compressors	1	-
8.	Spray Painting Gun	1	-
9.	Slotted Angle Cutter	1	-
10.	Pigmy Current Meter	1	-
11.	Camera (Yashica 635)	1	-
12.	Flash Gun	1	-
13.	Oven Big Size for Acrylic Moulding	1	-
14.	Painter Gauge	12	-
15.	Prandtl tubes	12	-
16.	Mono Meter	6	-
17.	Heat sealing equipment	1	CBIP
18.	Thickness Gauge	1	CBIP
19.	Tensile Strength & Elongation equipment	1	CBIP

Instruments/Equipments ordered

Instruments

1.	Current Meter with Strip Chart Recorder	6	-
2.	Auto Water Level Recorder	6	-

Equipments

1.	Band Saw	1	-
2.	Circular Table Saw	1	-
3.	Portable Drill Machine	1	-
4.	Bench Drill	1	-
5.	Compressor	1	-
6.	Grinder	1	-